



# FORMAN CHRISTIAN COLLEGE

(A CHARTERED UNIVERSITY)

MS Computer Science Admission Test

Admission test consists two equally-weighted parts. Part I is modelled after quantitative reasoning section of GRE general test. Part II is modelled after GRE subject test for Computer Science. Samples for both types are provided on the following pages.

# Part I

## Sample Questions

# GRE Practice test

## ***Quantitative Reasoning.***

### **Section Directions**

For each question, indicate the best answer, using the directions given.

**Notes:** All numbers used are real numbers.

All figures are assumed to lie in a plane unless otherwise indicated.

Geometric figures, such as lines, circles, triangles, and quadrilaterals, **are not necessarily** drawn to scale. That is, you should **not** assume that quantities such as lengths and angle measures are as they appear in a figure. You should assume, however, that lines shown as straight are actually straight, points on a line are in the order shown, and more generally, all geometric objects are in the relative positions shown. For questions with geometric figures, you should base your answers on geometric reasoning, not on estimating or comparing quantities from how they are drawn in the geometric figure.

Coordinate systems, such as  $x$   $y$  planes and number lines, **are** drawn to scale; therefore, you can read, estimate, or compare quantities in such figures from how they are drawn in the coordinate system.

Graphical data presentations, such as bar graphs, circle graphs, and line graphs, **are** drawn to scale; therefore, you can read, estimate, or compare data values from how they are drawn in the graphical data presentation.

**For each of Questions 1 through 9, compare Quantity A and Quantity B, using the additional information given, if any. Select one of the following four answer choices. A symbol that appears more than once in a question has the same meaning throughout the question.**

- A. Quantity A is greater.
- B. Quantity B is greater.
- C. The two quantities are equal.
- D. The relationship cannot be determined from the information given.

### Example 1:

Quantity A:  $(2)(6)$  2 times 6

Quantity B:  $2 + 6$

**Solution:** Quantity A is equal to 12 and Quantity B is equal to 8, so the correct answer for Example 1 is answer choice A, Quantity A is greater.

### Example 2:

Refer to the figure.

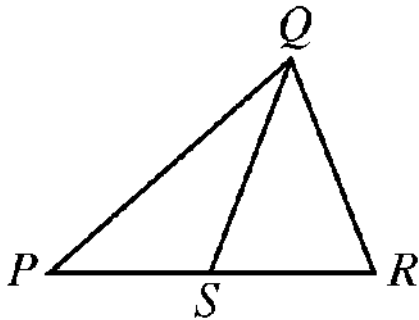


Figure for Example 2

Quantity A:  $PS$

Quantity B:  $SR$

**Solution:** The correct answer for Example 2 is answer choice D. The relationship between  $PS$  and  $SR$  cannot be determined from the information given since equal measures cannot be assumed, even though  $PS$  and  $SR$  appear to be equal in the figure.

### Question 1.

Refer to the figure.

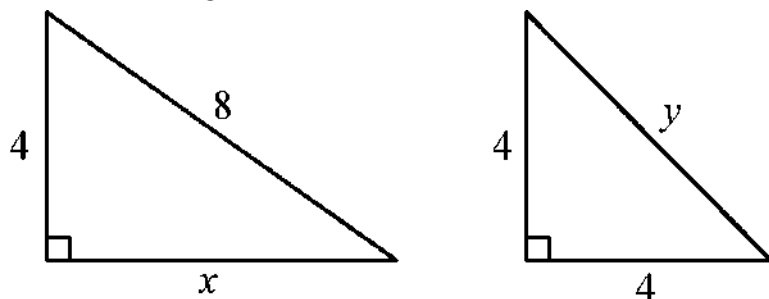


Figure for Question 1

Quantity A:  $x$

Quantity B:  $y$

- A. Quantity A is greater.
- B. Quantity B is greater.
- C. The two quantities are equal.
- D. The relationship cannot be determined from the information given.

From the answer choices given, select and indicate the **one** that describes the relationship between quantity A and quantity B.

### Question 2.

It is given that

$$(x - 2y)(x + 2y) = 4$$

open parenthesis,  $x$  minus  $2y$ , close parenthesis, times open parenthesis,  $x + 2y$ , close parenthesis,  $= 4$

Quantity A:  $x^2 - 4y^2$   $x$  squared, minus, 4 times the quantity  $y$  squared

Quantity B: 8

- A. Quantity A is greater.
- B. Quantity B is greater.
- C. The two quantities are equal.
- D. The relationship cannot be determined from the information given.

From the answer choices given, select and indicate the **one** that describes the relationship between quantity A and quantity B.

### Question 3.

A certain recipe requires  $\frac{3}{2}$  **three halves** cups of sugar and makes 2 dozen cookies.  
(1 dozen = 12)

Quantity A: The amount of sugar required for the same recipe to make 30 cookies

Quantity B: 2 cups

- A. Quantity A is greater.
- B. Quantity B is greater.
- C. The two quantities are equal.
- D. The relationship cannot be determined from the information given.

From the answer choices given, select and indicate the **one** that describes the relationship between quantity A and quantity B.

#### Question 4.

A power station is located on the boundary of a square region that measures 10 miles on each side. Three substations are located inside the square region.

Quantity A: The sum of the distances from the power station to each of the substations

Quantity B: 30 miles

- A. Quantity A is greater.
- B. Quantity B is greater.
- C. The two quantities are equal.
- D. The relationship cannot be determined from the information given.

From the answer choices given, select and indicate the **one** that describes the relationship between quantity A and quantity B.

#### Question 5.

It is given that

$6 < x < 7$  6 is less than  $x$ , which is less than 7,

and

$y = 8$

Quantity A:  $\frac{x}{y}$  the fraction  $x$  over  $y$

Quantity B: 0.85

- A. Quantity A is greater.
- B. Quantity B is greater.
- C. The two quantities are equal.
- D. The relationship cannot be determined from the information given.

From the answer choices given, select and indicate the **one** that describes the relationship between quantity A and quantity B.

#### Question 6.

Refer to the figure.

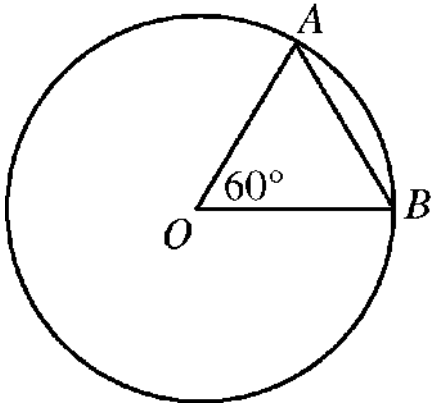


Figure for Question 6

It is given that  $O$  is the center of the circle and the perimeter of triangle  $BOA$  is 6.

Quantity A: The circumference of the circle

Quantity B: 12

- A. Quantity A is greater.
- B. Quantity B is greater.
- C. The two quantities are equal.
- D. The relationship cannot be determined from the information given.

From the answer choices given, select and indicate the **one** that describes the relationship between quantity A and quantity B.

### Question 7.

Quantity A: The standard deviation of a set of 5 different integers, each of which is between 0 and 10

Quantity B: The standard deviation of a set of 5 different integers, each of which is between 10 and 20

- A. Quantity A is greater.
- B. Quantity B is greater.
- C. The two quantities are equal.
- D. The relationship cannot be determined from the information given.

From the answer choices given, select and indicate the **one** that describes the relationship between quantity A and quantity B.

### Question 8.

It is given that  $x$  is greater than 1.



Quantity A:  $x(x^2)^4$   $x$  times, the fourth power of, open parenthesis,  $x$  squared, close parenthesis

Quantity B:  $(x^3)^3$  open parenthesis,  $x$  cubed, close parenthesis, to the third power

- A. Quantity A is greater.
  - B. Quantity B is greater.
  - C. The two quantities are equal.
  - D. The relationship cannot be determined from the information given.
- From the answer choices given, select and indicate the **one** that describes the relationship between quantity A and quantity B.

### Question 9.

It is given that  $x$  is not equal to 0.

Quantity A:  $|x| + |-2|$  the absolute value of  $x$  + the absolute value of negative 2

Quantity B:  $|x - 2|$  the absolute value of the quantity  $x$  minus 2

- A. Quantity A is greater.
  - B. Quantity B is greater.
  - C. The two quantities are equal.
  - D. The relationship cannot be determined from the information given.
- From the answer choices given, select and indicate the **one** that describes the relationship between quantity A and quantity B.

**Questions 10 through 25 have several different answer formats, including both selecting answers from a list of answer choices and numeric entry. With each question, answer format instructions will be given.**

### **Numeric Entry Questions**

These questions require a number to be entered by marking entries in a grid according to the following instructions

Your answer may be an integer, a decimal, or a fraction, and it may be negative.

Equivalent forms of the correct answer, such as 2.5 and 2.50, are all correct. Although fractions do not need to be reduced to lowest terms, they may need to be reduced to fit in the grid.

Enter the exact answer unless the question asks you to round your answer.

If a question asks for a fraction, the grid will have a built-in division slash. Otherwise, the grid will have a decimal point.

The instructions for marking the entries will depend on whether a regular print or a large print test is being used to record your answers. If your answers are being entered into a regular print edition of the test, the following instructions apply:

Start your answer in any column, space permitting. Fill in no more than one entry in any column of the grid. Columns not needed should be left blank.

Write your answer in the boxes at the top of the grid and fill in the corresponding circles. You will receive credit only if your grid entries are clearly marked, regardless of the number written in the boxes at the top.

If your answers are being entered into a large print edition of the test, instead of filling in circles on the grid in steps 5 and 6, you will be asked to circle those entries.

### Question 10.

This question has five answer choices, labeled A through E. Select the best **one** of the answer choices given.

The system of equations

$$7x + 3y = 12, \text{ and}$$

$$3x + 7y = 6$$

is given.

If  $x$  and  $y$  satisfy the system of equations given, what is the value of  $x - y$ ?  $x$  minus  $y$ ?

- A.  $\frac{2}{3}$  two thirds
- B.  $\frac{3}{2}$  three halves
- C. 1
- D. 4
- E. 6

Select and indicate the best **one** of the answer choices given.

### Question 11.

This question has five answer choices, labeled A through E. Select **all** the answer choices that apply.

In triangle  $ABC$ , the measure of angle  $A$  is  $25^\circ$  and the measure of angle  $B$  is greater than  $90^\circ$ . Which of the following could be the measure of angle  $C$ ?

Indicate **all** such measures.

- A.  $12^\circ$
- B.  $15^\circ$
- C.  $45^\circ$
- D.  $50^\circ$
- E.  $70^\circ$

Select and indicate **all** the answer choices that apply. The correct answer to a question of this type could consist of as few as one, or as many as all five of the answer choices.

### Question 12.

This question has five answer choices, labeled A through E. Select the best **one** of the answer choices given.

What is the least integer  $n$  such that  $\frac{1}{2^n}$  the fraction with numerator 1, and denominator 2 to the power  $n$  is less than 0.001 ?

- A. 10
- B. 11
- C. 500
- D. 501
- E. There is no such least integer.

Select and indicate the best **one** of the answer choices given.

### Question 13.

This question has five answer choices, labeled A through E. Select the best **one** of the answer choices given.

In the sunshine, an upright pole 12 feet tall is casting a shadow 8 feet long. At the same time, a nearby upright pole is casting a shadow 10 feet long. If the lengths of the shadows are proportional to the heights of the poles, what is the height, in feet, of the taller pole?

- A. 10
- B. 12

- C. 14
- D. 15
- E. 18

Select and indicate the best **one** of the answer choices given.

### Question 14.

This question has five answer choices, labeled A through E. Select the best **one** of the answer choices given.

If  $k$  is the smallest prime number greater than 21 and  $b$  is the largest prime number less than 16, then  $kb =$

- A. 299
- B. 323
- C. 330
- D. 345
- E. 351

Select and indicate the best **one** of the answer choices given.

### Question 15.

This question does not have any answer choices; it is a numeric entry question.

To answer this question, enter a number in the answer space provided. The number entered cannot be a fraction.

The total amount of Judy's water bill for the last quarter of the year was \$40.50. The bill consisted of a fixed charge of \$13.50 plus a charge of \$0.0075 per gallon for the water used in the quarter. For how many gallons of water was Judy charged for the quarter?

To answer this question, enter a number in the answer space provided. The number can include a decimal point, and can be positive, negative, or 0. The number entered cannot be a fraction.

### Question 16.

This question has five answer choices, labeled A through E. Select the best **one** of the answer choices given.

List  $R$ : 28, 23, 30, 25, 27

List  $S$ : 22, 19, 15, 17, 20

The median of the numbers in list  $R$  is how much greater than the median of the numbers in list  $S$ ?

- A. 8

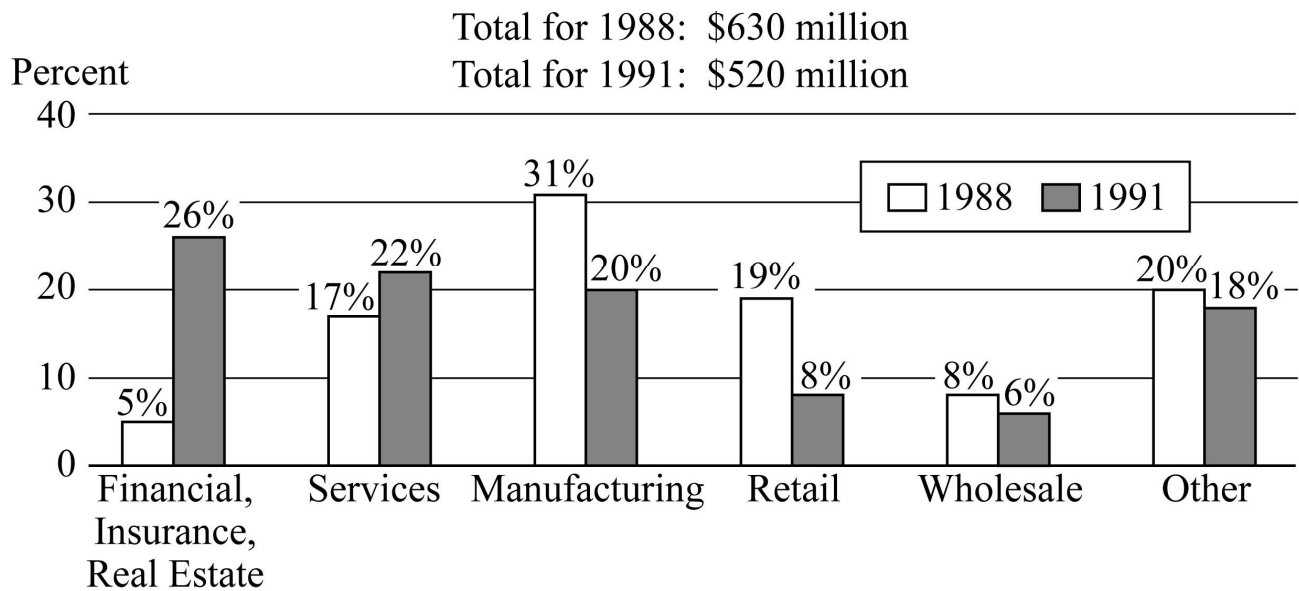
- B. 10
- C. 12
- D. 13
- E. 15

Select and indicate the best **one** of the answer choices given.

**Questions 17 through 20 are based on the following data.**

Refer to the figure.

Corporate Support for the Arts by Sector in 1988 and 1991



Data for Questions 17 through 20

**Question 17.**

This question does not have any answer choices; it is a numeric entry question.

To answer this question, enter a number in the answer space provided. The number entered cannot be a fraction.

The two corporate sectors that increased their support for the arts from 1988 to 1991 made a total contribution in 1991 of approximately how many million dollars?

Give your answer to the nearest 10 million dollars.

To answer this question, enter a number in the answer space provided. The number can include a decimal point, and can be positive, negative, or 0. The number entered cannot be a fraction.

**Question 18.**

This question has five answer choices, labeled A through E. Select the best **one** of the answer choices given.

How many of the six corporate sectors listed each contributed more than \$60 million to the arts in both 1988 and 1991 ?

- A. One
- B. Two
- C. Three
- D. Four
- E. Five

Select and indicate the best **one** of the answer choices given.

### Question 19.

This question has five answer choices, labeled A through E. Select the best **one** of the answer choices given.

From 1988 to 1991, which corporate sector decreased its support for the arts by the greatest dollar amount?

- A. Services
- B. Manufacturing
- C. Retail
- D. Wholesale
- E. Other

Select and indicate the best **one** of the answer choices given.

### Question 20.

This question has five answer choices, labeled A through E. Select the best **one** of the answer choices given.

Of the retail sector's 1991 contribution to the arts,  $\frac{1}{4}$  **one fourth** went to symphony

orchestras and  $\frac{1}{2}$  **one half** of the remainder went to public television. Approximately how many million dollars more did the retail sector contribute to public television that year than to symphony orchestras?

- A. 5.2
- B. 6.3
- C. 10.4

- D. 13.0
- E. 19.5

Select and indicate the best **one** of the answer choices given.

### Question 21.

This question has three answer choices, labeled A through C. Select **all** the answer choices that apply.

The total number of recording titles distributed by music distributors L and M is 9,300. The number of recording titles distributed by L is 7,100, and the number of recording titles distributed by M is 5,200. Which of the following statements must be true?

Indicate **all** such statements.

- A. More than half of the titles distributed by L are also distributed by M.
- B. More than half of the titles distributed by M are also distributed by L.
- C. No titles are distributed by both L and M.

Select and indicate **all** the answer choices that apply. The correct answer to a question of this type could consist of as few as one, or as many as all three of the answer choices.

### Question 22.

This question has five answer choices, labeled A through E. Select the best **one** of the answer choices given.

If  $c$  and  $d$  are positive integers and  $m$  is the greatest common factor of  $c$  and  $d$ , then  $m$  must be the greatest common factor of  $c$  and which of the following integers?

- A.  $c + d$
- B.  $2 + d$
- C.  $cd$
- D.  $2d$
- E.  $d^2$   $d$  squared

Select and indicate the best **one** of the answer choices given.

### Question 23.

This question does not have any answer choices; it is a numeric entry question.

To answer this question, enter a number in the answer space provided. The number entered cannot be a fraction.

The average (arithmetic mean) of the 11 numbers in a list is 14. If the average of 9 of the numbers in the list is 9, what is the average of the other 2 numbers?

To answer this question, enter a number in the answer space provided. The number can include a decimal point, and can be positive, negative, or 0. The number entered cannot be a fraction.

### Question 24.

This question has five answer choices, labeled A through E. Select the best **one** of the answer choices given.

Of the 750 participants in a professional meeting, 450 are female and  $\frac{1}{2}$  **one half** of the female and  $\frac{1}{4}$  **one fourth** of the male participants are less than thirty years old. If one of the participants will be randomly selected to receive a prize, what is the probability that the person selected will be less than thirty years old?

- A.  $\frac{1}{8}$  1 eighth
- B.  $\frac{1}{3}$  1 third
- C.  $\frac{3}{8}$  3 eighths
- D.  $\frac{2}{5}$  2 fifths
- E.  $\frac{3}{4}$  3 fourths

Select and indicate the best **one** of the answer choices given.

### Question 25.

This question has five answer choices, labeled A through E. Select the best **one** of the answer choices given.

In the  $x y$  plane, what is the slope of the line whose equation is  $3x - 2y = 8$ ? **3x minus 2y = 8 ?**

- A.  $-4$  negative 4



B.  $-\frac{8}{3}$  negative 8 thirds

C.  $\frac{2}{3}$  2 thirds

D.  $\frac{3}{2}$  3 halves

E. 2

Select and indicate the best **one** of the answer choices given.

This is the end of Section 3 of Revised GRE Practice Test Number 1. In an actual test, once you complete a section you may not return to it. The answer key for this section is in a separate document.

## Part II

### Sample Questions

## Major Field Test in Computer Science Sample Questions

The following questions illustrate the range of the test in terms of the abilities measured, the disciplines covered, and the difficulty of the questions posed. They should not, however, be considered representative of the entire scope of the test in either content or difficulty. The notation pages and the answer key follow the questions.

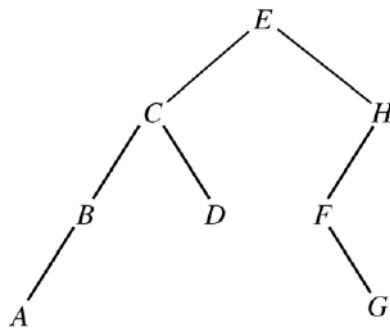
1. Consider the following pseudocode fragment, where  $x$  is an integer variable that has been initialized.

```
int i ← 1
int j ← 1

while ( i < 10 )
    j ← j * i
    i ← i + 1
    if ( i == x )
        break
    end if
end while
```

Which of the following statements is (are) true at the end of the **while** loop?

- I.  $( i == 10 )$  or  $( i == x )$
  - II. If  $x > 10$ , then  $i == 10$ .
  - III. If  $j == 6$ , then  $x == 4$ .
- (A) None  
(B) I only  
(C) III only  
(D) II and III only  
(E) I, II, and III



2. In the binary search tree above, finding node  $E$  requires one comparison and finding node  $A$  requires four comparisons. What is the expected number of comparisons required to find a node chosen at random?

- (A) 1.75
- (B) 2
- (C) 2.75
- (D) 3
- (E) 3.25

3. A stack can be implemented with an array  $A[0..N-1]$  and a variable  $pos$ . The `push` and `pop` operations are defined by the following code.

```

push (x)
    A[pos] ← x
    pos ← pos - 1
end push

pop ( )
    pos ← pos + 1
    return A[pos]
end pop
  
```

Which of the following will initialize an empty stack with capacity  $N$  for this implementation?

- (A)  $pos \leftarrow -1$
- (B)  $pos \leftarrow 0$
- (C)  $pos \leftarrow 1$
- (D)  $pos \leftarrow N - 1$
- (E)  $pos \leftarrow N$

4. A processor with a word-addressable memory has a two-way set-associative cache. A cache line is one word, so a cache entry contains a set of two words. If there are  $M$  words of memory and  $C$  cache entries, how many words of memory map to the same cache entry?

- (A)  $\frac{C}{2}$
- (B)  $\frac{M}{2C}$
- (C)  $\frac{M}{C}$
- (D)  $\frac{2M}{C}$
- (E)  $\frac{M}{2}$

5. Which of the following regular expressions will not generate a string with two consecutive 1s? (Note that  $\epsilon$  denotes the empty string.)

- I.  $(1 + \epsilon)(01 + 0)^*$
- II.  $(01 + 10)^*$
- III.  $(0 + 1)^*(0 + \epsilon)$

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

6. Consider the following recursive function.

```
int Fun ( int n )
  if ( n == 4 )
    return 2
  else
    return 2 * Fun ( n + 1 )
  end if
end Fun
```

What is the value returned by the function call `Fun ( 2 )` ?

- (A) 2
  - (B) 4
  - (C) 8
  - (D) 16
  - (E) 24
7. If  $A[0..n-1]$  is an array with  $n$  elements and procedure `Swap` exchanges its arguments, then the following code sorts  $A$  in descending order.

```
int j ← 0
while ( j < n - 1 )
  int k ← 0
  while ( k < n - j - 1 )
    if ( A[k] < A[k + 1] )
      Swap ( A[k], A[k + 1] )
    end if
    k ← k + 1
  end while
  j ← j + 1
end while
```

If  $A$  initially contains  $n$  different elements sorted in ascending order, how many calls to `Swap` are made in total?

- (A)  $n - 1$
- (B)  $n$
- (C)  $n(n - 1)/2$
- (D)  $(n - 1)(n - 2)$
- (E)  $n(n - 1)$

8. If  $A$ ,  $B$ , and  $C$  are Boolean variables, which of the following is (are) true?

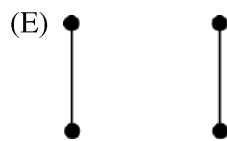
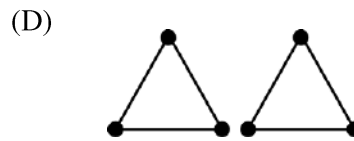
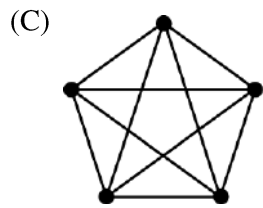
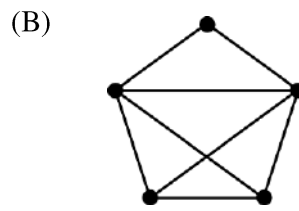
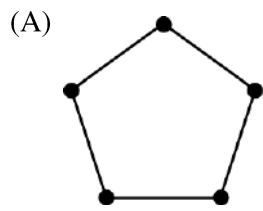
I.  $A \wedge (B \vee C) = (A \wedge B) \vee (A \wedge C)$

II.  $A \vee (B \wedge C) = (A \vee B) \wedge (A \vee C)$

III.  $(A \wedge B) \vee C = C \vee (B \wedge A)$

- (A) I only  
(B) II only  
(C) I and II only  
(D) II and III only  
(E) I, II, and III
9. A personal identification number (PIN) that opens a certain lock consists of a sequence of 3 different digits from 0 through 9, inclusive. How many possible PINs are there?
- (A) 120  
(B) 360  
(C) 720  
(D) 729  
(E) 1,000

10. Consider the statement “Every connected graph has one or more vertices of degree 2.”  
Each of the five graphs below has one or more connected components. Which of the five graphs is a counterexample to the statement?





11. Following is a definition of a `widget` and a declaration of an array `A` that contains 10 `widgets`. The sizes of a **byte**, **short**, **int**, and **long** are 1, 2, 4, and 8 bytes, respectively. Alignment is restricted so that an  $n$ -byte field must be located at an address divisible by  $n$ . The fields in a **struct** are not rearranged; padding is used to ensure alignment. All `widgets` in `A` must have the same size.

```
struct widget
    short s
    byte b
    long l
    int i
end widget
```

```
widget A[10]
```

Assuming that `A` is located at a memory address divisible by 8, what is the total size of `A`, in bytes?

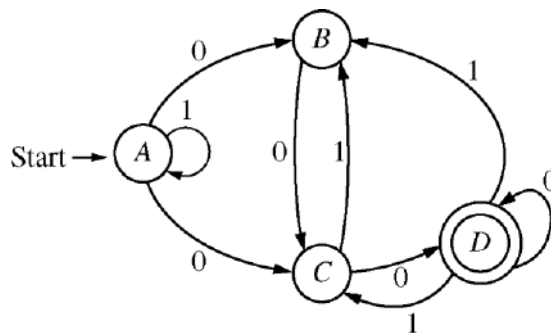
- (A) 150
  - (B) 160
  - (C) 200
  - (D) 240
  - (E) 320
12. Consider a virtual memory system running on a RISC CPU. Page tables are not locked in memory and may be swapped to disk. An `lw` (load word) instruction reads one data word from memory; the address is the sum of the value in a register and an immediate constant stored in the instruction itself. Neither machine instructions nor page-table entries nor data words can cross a page boundary. In the worst case, how many page faults could be generated as a result of the fetch, decode, and execution of an `lw` instruction?
- (A) 2
  - (B) 3
  - (C) 4
  - (D) 5
  - (E) 6

13. Four processes— $P_1$ ,  $P_2$ ,  $P_3$ , and  $P_4$ —are scheduled to use a single processor. The following table shows the arrival time and duration of each of the four processes.

Process	Arrival Time (seconds)	Duration (seconds)
$P_1$	0	7
$P_2$	2	4
$P_3$	4	1
$P_4$	5	4

If the system uses a preemptive shortest-job-first scheduling algorithm, what is the average waiting time for the four processes, in seconds?

- (A) 2
- (B) 3
- (C) 4
- (D) 5
- (E) 6



14. The figure above represents a nondeterministic finite automaton with accepting state  $D$ . Which of the following strings does the automaton accept?

- (A) 001
- (B) 1101
- (C) 01100
- (D) 000110
- (E) 100100

15. Given that

$B(x)$  means “ $x$  is a bear”,

$F(x)$  means “ $x$  is a fish”, and

$E(x, y)$  means “ $x$  eats  $y$ ”,

what is the best English translation of

$$\forall x [F(x) \rightarrow \forall y (E(y, x) \rightarrow B(y))]$$

- (A) All fish eat bears.
- (B) Every fish is eaten by some bear.
- (C) Bears eat only fish.
- (D) Every bear eats fish.
- (E) Only bears eat fish.

16. Consider the following table in a relational database.

Last Name	Rank	Room	Shift
Smith	Manager	234	Morning
Jones	Custodian	33	Afternoon
Smith	Custodian	33	Evening
Doe	Clerical	222	Morning

According to the data shown in the table, which of the following could be a candidate key of the table?

- (A) {Last Name}
- (B) {Room}
- (C) {Shift}
- (D) {Rank, Room}
- (E) {Room, Shift}

# Major Field Test in Computer Science

## 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  $g(n) \leq Cf(n)$  for all  $n > N$ .  
 $g(n) = \Omega(f(n))$  denotes “ $g(n)$  has order at least  $f(n)$ ” and means that there exist positive constants  $C$  and  $N$  such that  $g(n) \geq Cf(n)$  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  $C_1f(n) \leq g(n) \leq C_2f(n)$  for all  $n > N$ .
5.  $\exists$  denotes “there exists”.  
 $\forall$  denotes “for all”.  
 $\rightarrow$  denotes “implies”.  
 $\neg$  denotes “not”; “ $\bar{A}$ ” is also used to mean “ $\neg A$ ”.  
 $\vee$  denotes “inclusive or”;  $+$  also denotes “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  $Q$ ”.
6.  $\emptyset$  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  $B$ ;

$A - B$  is the set of all elements in  $A$  that are not in  $B$ ;

$A \subseteq B$  means  $A$  is a subset of  $B$  (that is, any element in  $A$  is also in  $B$ );

$A \subset B$  means  $A$  is a proper subset of  $B$  (that is,  $A \subseteq B$  and there is at least one element in  $B$  that is not in  $A$ );

$\bar{A}$  is the set of all elements not in  $A$  that are in some specified universal set; and

$|A|$  is the cardinality of  $A$ .

7.  $\epsilon$  denotes the empty string.

If  $x$  and  $y$  are strings,  $x + y$  denotes the set  $\{x\} \cup \{y\}$  and  $xy$  denotes the concatenation of  $x$  and  $y$ .

If  $S$  and  $T$  are sets of strings, then

$ST = \{xy \mid x \in S \text{ and } y \in T\}$  denotes the concatenation of  $S$  and  $T$ ;

$S + T$  denotes  $S \cup T$ ;

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

$S^+$  denotes  $S \cup S^2 \cup S^3 \cup \dots$ ; and

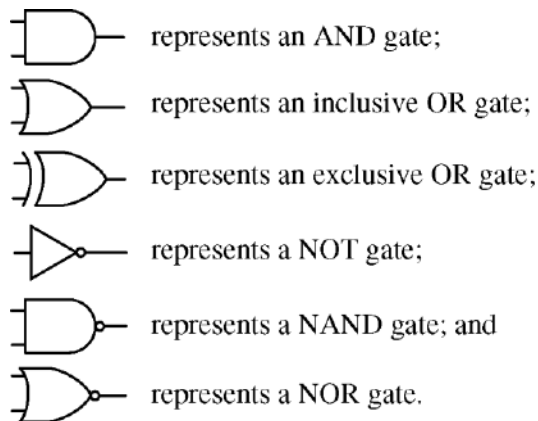
$S^*$  denotes  $\{\epsilon\} \cup S^+$ .

8. In a grammar,  $\alpha \rightarrow \beta$  represents a production rule.

Unless otherwise specified,

- (i) symbols appearing on the left-hand side of productions are nonterminal symbols, and 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



10. In a finite automaton diagram, states are represented by circles, where final (or accepting) states are 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  $a$ .

11. Unless specified otherwise, all code segments are written in pseudocode, where  $\leftarrow$  indicates assignment.

**Answer Key**

1. E	5. A	9. C	13. B
2. C	6. C	10. C	14. E
3. D	7. C	11. D	15. E
4. C	8. E	12. C	16. E



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