

**COMPUTER SCIENCE & INFORMATION TECHNOLOGY**

**Q. No. 1 to 25 Carry One Mark Each**

1. Which one of the following kinds of derivation is used by LR parsers?
- (A) Rightmost
  - (B) Rightmost in reverse
  - (C) Leftmost
  - (D) Leftmost in reverse

**Answer: (B)**

2. Consider the following C program:

```
#include <stdio.h>
int main(){
int arr[]={1,2,3,4,5,6,7,8,9,0,1,2,5}, *ip=arr+4;
printf("%d \n", ip[1]);
return 0;
}
```

The number that will be displayed on execution of the program is \_\_\_\_\_.

**Answer: (6)**

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3. For  $\Sigma = \{a,b\}$ , let us consider the regular language  $L = \{x \mid x = a^{2+3k} \text{ or } x = b^{10+12k}, k \geq 0\}$ . Which one of the following can be a pumping length (the constant guaranteed by the pumping lemma) for  $L$ ?
- (A) 5
  - (B) 24
  - (C) 9
  - (D) 3

**Answer: (B)**

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4. Let  $U = \{1, 2, \dots, n\}$ . Let  $A = \{(x, X) \mid x \in X, X \subseteq U\}$ . Consider the following two statements on  $|A|$ .

I.  $|A| = n2^{n-1}$

II.  $|A| = \sum_{k=1}^n k \binom{n}{k}$

Which of the above statements is/are TRUE?

- (A) Only II                      (B) Only I                      (C) Neither I nor II                      (D) Both I and II

**Answer: (D)**

5. A certain processor uses a fully associative cache of size 16 kB. The cache block size is 16 bytes. Assume that the main memory is byte addressable and uses a 32-bit address. How many bits are required for the *Tag* and the *Index* fields respectively in the addresses generated by the processor?

- (A) 28 bits and 4 bits  
(B) 24 bits and 4 bits  
(C) 24 bits and 0 bits  
(D) 28 bits and 0 bits

**Answer: (D)**

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6. Consider the grammar given below:

$$S \rightarrow Aa$$

$$A \rightarrow BD$$

$$B \rightarrow b \mid \epsilon$$

$$D \rightarrow d \mid \epsilon$$

Let a, b, d, and \$ be indexed as follows:

a	b	d	\$
3	2	1	0

Compute the FOLLOW set of the non-terminal B and write the index values for the symbols in the FOLLOW set in the descending order. (For example, if the FOLLOW set is {a, b, d, \$}, then the Key should be 3210)

**Answer: (31)**

7. Let  $X$  be a square matrix. Consider the following two statements on  $X$ .

- I.  $X$  is invertible
- II. Determinant of  $X$  is non-zero.

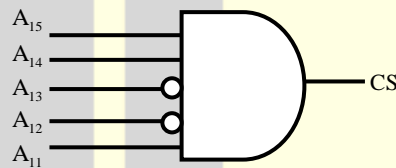
Which one of the following is TRUE?

- (A) I implies II; II does not imply I
- (B) I does not imply II; II does not imply I
- (C) I and II are equivalent statements
- (D) II implies I; I does not imply II

**Answer:** (C)

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8. The chip select logic for a certain DRAM chip in a memory system design is shown below. Assume that the memory system has 16 address lines denoted by  $A_{15}$  to  $A_0$ . What is the range of addresses (in hexadecimal) of the memory system that can get enabled by the chip select (CS) signal?



- (A) C800 to CFFF
- (B) C800 to C8FF
- (C) DA00 to DFFF
- (D) CA00 to CAFF

**Answer:** (A)

9. Consider a sequence of 14 elements:  $A = \{-5, -10, 6, 3, -1, -2, 13, 4, -9, -1, 4, 12, -3, 0\}$ . The subsequence sum  $S(i, j) = \sum_{k=i}^j A[k]$ . Determine the maximum of  $S(i, j)$ , where  $0 \leq i \leq j < 14$ . (Divide and conquer approach may be used.)

**Answer:** (29)

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10. An array of 25 distinct elements is to be sorted using quicksort. Assume that the pivot element is chosen uniformly at random. The probability that the pivot element gets placed in the worst possible location in the first round of partitioning (rounded off to 2 decimal places) is

**Answer:** (0.08)

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11. The value of  $3^{51} \bmod 5$  is \_\_\_\_\_.

**Answer: (2)**

12. Consider the concurrent processes P1, P2 and P3 as shown below, which access a shared variable D that has been initialization to 100.

P1	P2	P3
:	:	:
:	:	:
D = D + 20	D = D - 50	D = D + 10
:	:	:
:	:	:

The processes are executed on a uniprocessor system running a time-shared operating system. If the minimum and maximum possible values of D after the three processes have completed execution are X and Y respectively, then the value of Y-X is \_\_\_\_\_.

**Answer: (80)**

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13. Compute  $\lim_{x \rightarrow 3} \frac{x^4 - 81}{2x^2 - 5x - 3}$

(A) 108/7

(B) 1

(C) 53/12

(D) Limit does not exist

**Answer: (A)**

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14. Consider the following C program:

```
#include <stdio.h>

int jumble(int x, int y){
    x=2*x+y;
```

```

return x;}

int main(){
int x=2, y=5;
y= jumble(y,x);
x= jumble(y,x);
printf("%d \n", x);
return 0;
}

```

The value printed by the program is \_\_\_\_\_.

**Answer: (26)**

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**15.** Let  $G$  be an arbitrary group. Consider the following relations on  $G$ :

$R_1 : \forall a, b \in G, aR_1b$  if and only if  $\exists g \in G$  such that  $a = g^{-1}bg$

$R_2 : \forall a, b \in G, aR_2b$  if and only if  $a = b^{-1}$

Which of the above is/are equivalence relation/relation(s)?

(A) Neither  $R_1$  nor  $R_2$

(B)  $R_2$  only

(C)  $R_1$  only

(D)  $R_1$  and  $R_2$

**Answer: (C)**

**16.** Consider the following two statements about database transaction schedules:

**I.** Strict two-phase locking protocol generates conflict serializable schedules that are also recoverable.

**II.** Timestamp-ordering concurrency control protocol with Thomas' Write Rule can generate view serializable schedules that are not conflict serializable.

Which of the above statements is/are TRUE?

(A) I only

(B) II only

(C) Neither I or II

(D) Both I and II

**Answer: (D)**

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17. Let  $G$  be an undirected complete graph on  $n$  vertices, where  $n > 2$ . Then, the number of different Hamiltonian cycles in  $G$  is equal to

- (A)  $n!$                       (B)  $\frac{(n-1)!}{2}$                       (C) 1                      (D)  $(n-1)!$

**Answer: (B & C)**

18. Which of the following protocol pairs can be used to send and retrieve e-mails (in that order)?

- (A) SMTP, MIME      (B) IMAP, POP3      (C) IMAP, SMTP      (D) SMTP, POP3

**Answer: (D)**

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19. The following C program is executed on a Unix/Linux system:

```
# include <unistd.h>
int main ( )
{
int i;
for (i = 0; i < 10; i++)
if (i % 2 == 0) fork ( );
return 0;
}
```

The total number of child processes created is \_\_\_\_\_.

**Answer: (31)**

20. Consider  $Z = X - Y$ , where  $X$ ,  $Y$  and  $Z$  are all in sign-magnitude form.  $X$  and  $Y$  are each represented in  $n$  bits. To avoid overflow, the representation of  $Z$  would require a minimum of:

- (A)  $n$  bits                      (B)  $n + 1$  bits                      (C)  $n + 2$  bits                      (D)  $n - 1$  bits

**Answer: (B)**

21. Which one of the following is NOT a valid identity?

- (A)  $(x \oplus Y) \oplus z = x \oplus (y \oplus z)$                       (B)  $x \oplus y = (xy + x'y)'$   
 (C)  $(x + y) \oplus z = x \oplus (y + z)$                       (D)  $x \oplus y = x + y$ , if  $xy = 0$

**Answer:** (C)

22. Which one of the following statements is NOT correct about the B+ tree data structure used for creating an index of a relational database table?

- (A) Key values in each node are kept in sorted order  
 (B) B+ Tree is a height-balanced tree  
 (C) Each leaf node has a pointer to the next leaf node  
 (D) Non-leaf nodes have pointers to data records

**Answer:** (D)

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23. If  $L$  is a regular language over  $\Sigma = \{a, b\}$ , which one of the following languages is NOT regular?

- (A)  $\{ww^R \mid w \in L\}$   
 (B)  $Prefix(L) = \{x \in \Sigma^* \mid \exists y \in \Sigma^* \text{ such that } xy \in L\}$   
 (C)  $L.L^R = \{xy \mid x \in L, y^R \in L\}$   
 (D)  $Suffix(L) = \{y \in \Sigma^* \mid \exists x \in \Sigma^* \text{ such that } xy \in L\}$

**Answer:** (A)

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24. In 16-bit 2's complement representation, the decimal number -28 is:

- (A) 1000 0000 1110 0100                      (B) 0000 0000 1110 0100  
 (C) 1111 1111 0001 1100                      (D) 1111 1111 1110 0100

**Answer:** (D)

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25. Two numbers are chosen independently and uniformly at random from the set  $\{1, 2, \dots, 13\}$ . The probability (rounded off to 3 decimal places) that their 4-bit (unsigned) binary representations have the same most significant bit is \_\_\_\_\_.

**Answer: (0.503)**

**Q. No. 26 to 55 Carry Two Marks Each**

26. Consider the following relations P(X, Y, Z), Q(X, Y, T) and R(Y, V)

P		
X	Y	Z
X1	Y1	Z1
X1	Y1	Z2
X2	Y2	Z2
X2	Y4	Z4

Q		
X	Y	T
X2	Y1	2
X1	Y2	5
X1	Y1	6
X3	Y3	1

R	
Y	V
Y1	V1
Y3	V2
Y2	V3
Y2	V2

How many tuples will be returned by the following relational algebra query?

$$\Pi_x \left( \sigma_{(P.Y=R.Y \wedge R.V=V2)} (P \times R) \right) - \Pi_x \left( \sigma_{(Q.Y=R.Y \wedge Q.T > 2)} (Q \times R) \right).$$
 Answer \_\_\_\_\_.

**Answer: (1)**

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27. Which one of the following languages over  $\Sigma = \{a, b\}$  is NOT a context free?

- (A)  $\{ww^R \mid w \in \{a, b\}^*\}$
- (B)  $\{wa^n w^R b^n \mid w \in \{a, b\}^*, n \geq 0\}$
- (C)  $\{a^n b^i \mid i \in \{n, 3n, 5n\}, n \geq 0\}$
- (D)  $\{wa^n b^n w^R \mid w \in \{a, b\}^*, n \geq 0\}$

**Answer: (B)**

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28. Consider the following c-program

```
#include <stdio.h>
int r(){
static int num=7;
return num --;}
int main(){
for (r();r();r())
printf("%d",r());
return 0;}
```

Which one of the following values will be displayed on execution of the programs?

- (A) 52                      (B) 630                      (C) 41                      (D) 63

**Answer:** (A)

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29. There are  $n$  unsorted arrays:  $A_1, A_2, \dots, A_n$ . Assume that  $n$  is odd. Each of  $A_1, A_2, \dots, A_n$  contains  $n$  distinct elements. There are no common elements between any two arrays. The worst-case time complexity of computing the median of the medians of  $A_1, A_2, \dots, A_n$  is

- (A)  $O(n)$                       (B)  $O(n \log n)$                       (C)  $O(n^2)$                       (D)  $\Omega(n^2 \log n)$

**Answer:** (C)

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30. A relational database contains two tables Student and Performance as shown below:

Student		Performance		
Roll_no.	Student name	Roll_no.	Subject_code	Marks
1	Amit	1	A	86
2	Priya	1	B	95
3	Vinit	1	C	90
4	Rohan	2	A	89
5	Smita	2	C	92
		3	C	80

The primary key of the student table is Roll\_no. For the performance table, the columns Roll\_no and Subject\_code together form the primary key. Consider the SQL query given below:

```
Select S. Student_name, sum (P. Marks)
FROM Student S, Performance P
WHERE P. Marks >84
GROUP BY S.Student_name;
```

The number of rows returned by the above SQL query is\_\_\_\_\_.

**Answer: (5)**

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**31.** Consider the following C program

```
#include <stdio.h>
int main(){
float sum = 0.0, j = 1.0, i = 2.0;
while (i/j > 0.0625){
j= j+j;
sum = sum + i/j;
printf("%f\n", sum);
}
return 0;}
```

The number of times the variable sum will be printed, when the above program is executed, is \_\_\_\_\_.

**Answer: (5)**

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**32.** Let the set of functional dependencies  $F = \{QR \rightarrow S, R \rightarrow P, S \rightarrow Q\}$  hold on a relation schema  $X = (PQRS)$ .  $X$  is not in BCNF. Suppose  $X$  is decomposed into two schemas  $Y$  and  $Z$ , where  $Y = (PR)$  and  $Z = (QRS)$ .

Consider the two statements given below.

- I.** Both  $Y$  and  $Z$  are in BCNF
- II.** Decomposition of  $X$  into  $Y$  and  $Z$  is dependency preserving and lossless

Which of the above statements is/are correct?

- (A) II only (B) Both I and II  
(C) Neither I nor II (D) I only

**Answer:** (A)

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**33.** The index node (inode) of a Unix-like file system has 12 direct, one single-indirect and one double-indirect pointers. The disk block size is 4 kB, and the disk block address is 32-bits long. The maximum possible file size is (rounded off to 1 decimal place) \_\_\_\_\_ GB.

**Answer:** (4)

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**34.** In a RSA cryptosystem, the value of the public modulus parameter  $n$  is 3007. If it is also known that  $\phi(n) = 2880$ , where  $\phi()$  denotes Euler's Totient function, then the prime factor of  $n$  which is greater than 50 is \_\_\_\_\_.

**Answer:** (97)

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**35.** Assume that in a certain computer, the virtual addresses are 64 bits long and the physical addresses are 48 bits long. The memory is word addressable. The page size is 8 kB and the word size is 4 bytes. The Translation Look-aside Buffer (TLB) in the address translation path has 128 valid entries. At most how many distinct virtual addresses can be translated without any TLB miss ?

- (A)  $256 \times 2^{10}$  (B)  $16 \times 2^{10}$  (C)  $4 \times 2^{20}$  (D)  $8 \times 2^{20}$

**Answer:** (A)

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**36.** Consider the following grammar and the semantic actions to support the inherited type declaration attributes. Let  $X_1, X_2, X_3, X_4, X_5,$  and  $X_6$  be the placeholders for the non-terminals D, T, L or  $L_1$  in the following table:

Production rule	Semantic action
$D \rightarrow TL$	$X_1.type = X_2.type$
$T \rightarrow int$	$T.type = int$
$T \rightarrow float$	$T.type = float$

$L \rightarrow L1, id$	$X_3.type = X_4.type$ $addType(id.entry, X_5.type)$
$L \rightarrow id$	$addType(id.entry, X_6.type)$

Which one of the following are the appropriate choices for  $X_1, X_2, X_3$  and  $X_4$ ?

- (A)  $X_1 = T, X_2 = L, X_3 = T, X_4 = L_1$
- (B)  $X_1 = L, X_2 = L, X_3 = L_1, X_4 = T$
- (C)  $X_1 = T, X_2 = L_1, X_3 = L_1, X_4 = L_1$
- (D)  $X_1 = L, X_2 = T, X_3 = L_1, X_4 = L$

**Answer: (D)**

**37.** Consider the following matrix

$$R = \begin{bmatrix} 1 & 2 & 4 & 8 \\ 1 & 3 & 9 & 27 \\ 1 & 4 & 16 & 64 \\ 1 & 5 & 25 & 125 \end{bmatrix}$$

The absolute value of the product of Eigen values of R is\_\_\_\_\_.

**Answer: (12)**

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**38.** Consider the following C function.

```
void convert(int n){
    if(n<0)
        printf("%d",n);
    else {
        convert(n/2);
        printf("%d",n%2);
    }
}
```

Which one of the following will happen when the function `convert` is called with any positive integer  $n$  as argument?

- (A) It will not print anything and will not terminate
- (B) It will print the binary representation of  $n$  and terminate
- (C) It will print the binary representation of  $n$  in the reverse order and terminate
- (D) It will print the binary representation of  $n$  but will not terminate

**Answer:** (A)

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39. Suppose  $Y$  is distributed uniformly in the open interval  $(1,6)$ . The probability that the polynomial  $3x^2 + 6xY + 3Y + 6$  has only real roots is \_\_\_\_\_. (rounded off to 1 decimal place).

**Answer:** (0.8)

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40. Let  $\Sigma$  be the set of all bijections from  $\{1, \dots, 5\}$  to  $\{1, \dots, 5\}$ , where  $\text{id}$  denotes the identity function, i.e.  $\text{id}(j) = j, \forall j$ . let  $\circ$  denote composition on functions. For a string

$$x = x_1 x_2 \dots x_n \in \Sigma^n, n \geq 0, \text{ let } \pi(x) = x_1 \circ x_2 \circ \dots \circ x_n.$$

Consider the language  $L = \{x \in \Sigma^* \mid \pi(x) = \text{id}\}$ . The minimum number of states in any DFA accepting  $L$  is \_\_\_\_\_.

**Answer:** (120)

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41. Let  $T$  be a full binary tree with 8 leaves. (A full binary tree has every level full.) Suppose two leaves  $a$  and  $b$  of  $T$  are chosen uniformly and independently at random. The expected value of the distance between  $a$  and  $b$  in  $T$  (i.e., the number of edges in the unique path between  $a$  and  $b$ ) is (rounded off to 2 decimal places) \_\_\_\_\_

**Answer:** (4.25)

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42. Consider the following statements:

- I. The smallest element in a max-heap is always at a leaf node
- II. The second largest element in a max-heap is always a child of the root node
- III. A max-heap can be constructed from a binary search tree in  $\theta(n)$  time



- (A) I only
- (B) II only
- (C) Neither I nor II
- (D) Both I and II

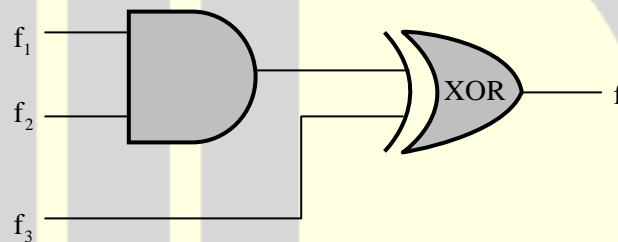
**Answer: (D)**

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46. Consider three 4-variable functions  $f_1, f_2,$  and  $f_3,$  which are expressed in sum-of-minterms as

$$f_1 = \Sigma(0, 2, 5, 8, 14), f_2 = \Sigma(2, 3, 6, 8, 14, 15), f_3 = \Sigma(2, 7, 11, 14)$$

For the following circuit with one AND gate and one XOR gate, the output function  $f$  can be expressed as:



- |                               |   |
|-------------------------------|---|
| (A) $\Sigma(7, 8, 11)$        | (B) $\Sigma(2, 14)$                           |
| (C) $\Sigma(2, 7, 8, 11, 14)$ | (D) $\Sigma(0, 2, 3, 5, 6, 7, 8, 11, 14, 15)$ |

**Answer: (A)**

47. Consider the following snapshot of a system running  $n$  concurrent processes. Process  $i$  is holding  $X_i$  instances of a resource  $R, 1 \leq i \leq n$ . Assume that all instances of  $R$  are currently in use. Further, for all  $i,$  process  $i$  can place a request for at most  $Y_i$  additional instances of  $R$  while holding the  $X_i$  instances it already has. Of the  $n$  processes, there are exactly two processes  $p$  and  $q$  such that  $Y_p = Y_q = 0$ . which one of the following conditions guarantees that no other process apart from  $p$  and  $q$  can complete execution ?

- (A)  $X_p + X_q < \text{Min} \{Y_k \mid 1 \leq k \leq n, k \neq p, k \neq q\}$
- (B)  $\text{Min}(X_p, X_q) \leq \text{Max} \{Y_k \mid 1 \leq k \leq n, k \neq p, k \neq q\}$
- (C)  $X_p + X_q < \text{Max} \{Y_k \mid 1 \leq k \leq n, k \neq p, k \neq q\}$
- (D)  $\text{Min}(X_p, X_q) \geq \text{Min} \{Y_k \mid 1 \leq k \leq n, k \neq p, k \neq q\}$

**Answer: (A)**

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48. A certain processor deploys a single-level cache. The cache block size is 8 words and the word size is 4 bytes. The memory system uses a 60-MHz clock. To service a cache miss, the memory controller first takes 1 cycle to accept the starting address of the block, it then takes 3 cycles to fetch all the eight words of the block, and finally transmits the words of the requested block at the rate of 1 word per cycle. The maximum bandwidth for the memory system when the program running on the processor issues a series of read operations is \_\_\_\_\_  $\times 10^6$  bytes/sec.

**Answer: (160)**

49. Consider the augmented grammar given below:

$$S' \rightarrow S$$

$$S \rightarrow \langle L \rangle \mid id$$

$$L \rightarrow L, S \mid S$$

Let  $I_0 = \text{CLOSURE}(\{[S' \rightarrow \bullet S]\})$ . The number of items in the set  $\text{GOTO}(I_0, \langle \rangle)$  is: \_\_\_\_\_

**Answer: (5)**

50. Consider the following four processes with arrival times (in milliseconds) and their length of CPU bursts (in milliseconds) as shown below:

Process	P1	P2	P3	P4
Arrival time	0	1	3	4
CPU burst time	3	1	3	Z

These processes are run on a single processor using preemptive shortest remaining time first scheduling algorithm. If the average waiting time of the processes is 1 millisecond, then the value of Z is \_\_\_\_\_.

**Answer: (2)**

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51. Consider that 15 machines need to be connected in a LAN using 8-port Ethernet switches. Assume that these switches do not have any separate uplink port. The minimum number of switches needed is \_\_\_\_\_.

**Answer: (3)**

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52. Consider the first order predicate formula  $\phi$  :

$$\forall x \left[ \left( \forall z z | x \Rightarrow ((z = x) \vee (z = 1)) \right) \Rightarrow \exists w (w > x) \wedge \left( \forall z z | w \Rightarrow ((w = z) \vee (z = 1)) \right) \right]$$

Here 'a | b' denotes that 'a divides b' where a and b are integers. Consider the following sets:

- S1 {1,2,3,.....,100}
- S2 Set of all positive integers
- S3 Set of all integers

Which of the above sets satisfy  $\phi$  ?

- (A) S1 and S3
- (B) S1 and S2
- (C) S2 and S3
- (D) S1, S2 and S3

**Answer: (C)**

53. Consider the following C program

```
#include <stdio.h>
int main(){
int a[] = {2, 4, 6, 8, 10};
int i, sum = 0, *b = a + 4;
for (i = 0; i < 5; i++)
sum = sum + (*b - i) - *(b - i);
printf("%d\n", sum);
return 0;
}
```

The output of the above C-program is \_\_\_\_\_.

**Answer: (10)**

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54. Suppose that in an IP-over Ethernet network, a machine X wishes to find the MAC address of another machine Y in its subnet. Which one of the following techniques can be used for this?

- (A) X sends an ARP request packet to the local gateway's MAC address which then finds the MAC address of Y and sends to X
- (B) X sends an ARP request packet with broadcast IP address in its local subnet

- (C) X sends an ARP request packet to the local gateway's IP address which then finds MAC address of Y and sends to X
- (D) X sends an ARP request packet with broadcast MAC address in its local subnet

**Answer: (D)**

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- 55.** What is the minimum number of 2-input NOR gates required to implement a 4-variable function expressed in sum-of minterms form as  $f = \Sigma(0,1,5,7,8,10,13,15)$ ? Assume that all the inputs and their complements are available.

**Answer: (3)**

