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Q. 1 – Q. 25 carry one mark each.

Q.1 Consider the following C program segment.

```
#include <stdio.h>

int main()
{
      char s1[7] = "1234", *p;
      p = s1 + 2;
      *p = '0';
      printf("%s", s1);
}
```

What will be printed by the program?

(A) 12 (B) 120400 (C) 1204 (D) 1034

Q.2 Suppose U is the power set of the set $S = \{1,2,3,4,5,6\}$. For any $T \in U$, let $|T|$ denote the number of elements in T and T' denote the complement of T. For any $T, R \in U$, let $T \setminus R$ be the set of all elements in T which are not in R. Which one of the following is true?

(A) $\forall X \in U\ (|X| = |X'|)$
(B) $\exists X \in U\ \exists Y \in U\ (|X| = 5, |Y| = 5 \text{ and } X \cap Y = \emptyset)$
(C) $\forall X \in U\ \forall Y \in U\ (|X| = 2, |Y| = 3 \text{ and } X \setminus Y = \emptyset)$
(D) $\forall X \in U\ \forall Y \in U\ (X \setminus Y = Y' \setminus X')$

Q.3 Consider the relation $X(P, Q, R, S, T, U)$ with the following set of functional dependencies

$$F = \{ \{P, R\} \rightarrow \{S, T\}, \{P, S, U\} \rightarrow \{Q, R\} \}$$

Which of the following is the trivial functional dependency in F^+, where F^+ is closure of F ?

(A) $\{P, R\} \rightarrow \{S, T\}$ (B) $\{P, R\} \rightarrow \{R, T\}$ (C) $\{P, S\} \rightarrow \{S\}$ (D) $\{P, S, U\} \rightarrow \{Q\}$

Q.4 The maximum number of processes that can be in *Ready* state for a computer system with n CPUs is

(A) n (B) n^2 (C) 2^n (D) Independent of n

Q.5 Among simple LR (SLR) , canonical LR, and look-ahead LR (LALR), which of the following pairs identify the method that is very easy to implement and the method that is the most powerful , in that order?

(A) SLR, LALR
(B) Canonical LR, LALR
(C) SLR, canonical LR
(D) LALR, canonical LR

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Q.6 Let # be a binary operator defined as

$X \# Y = X' + Y'$ where X and Y are Boolean variables.

Consider the following two statements.

(S1) $(P \# Q)\#R = P\#(Q \# R)$
(S2) $Q\#R = R\#Q$

Which of the following is/are true for the Boolean variables P, Q and R?

(A) Only S1 is true
(B) Only S2 is true
(C) Both S1 and S2 are true
(D) Neither S1 nor S2 are true

Q.7 Consider a software project with the following information domain characteristics for calculation of function point metric.

Number of external inputs (I) = 30
Number of external outputs (O) = 60
Number of external inquiries (E) = 23
Number of files (F) = 08
Number of external interfaces (N) = 02

It is given that the complexity weighting factors for I, O, E, F and N are 4, 5, 4, 10 and 7, respectively. It is also given that, out of fourteen value adjustment factors that influence the development effort, four factors are not applicable, each of the other four factors have value 3, and each of the remaining factors have value 4. The computed value of function point metric is _____.

Q.8 In a web server, ten WebPages are stored with the URLs of the form http://www.yourname.com/var.html; where, var is a different number from 1 to 10 for each Webpage. Suppose, the client stores the Webpage with $var = 1$ (say W1) in local machine, edits and then tests. Rest of the WebPages remains on the web server. W1 contains several relative URLs of the form "var.html" referring to the other WebPages. Which one of the following statements needs to be added in W1, so that all the relative URLs in W1 refer to the appropriate WebPages on the web server?

(A) <a href: "http://www.yourname.com/", href: "...var.html">
(B) <base href: "http://www.yourname.com/">
(C) <a href: "http://www.yourname.com/">
(D) <base href: "http://www.yourname.com/", range:"…var.html">

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Q.9 Consider the following statements.

I. TCP connections are full duplex
II. TCP has no option for selective acknowledgement
III. TCP connections are message streams

(A) Only I is correct
(B) Only I and III are correct
(C) Only II and III are correct
(D) All of I, II and III are correct

Q.10 Consider the equality $\sum_{i=0}^{n} i^3 = X$ and the following choices for X

I. $\Theta(n^4)$
II. $\Theta(n^5)$
III. $O(n^5)$
IV. $\Omega(n^3)$

The equality above remains correct if X is replaced by

(A) Only I
(B) Only II
(C) I or III or IV but not II
(D) II or III or IV but not I

Q.11 Consider a binary tree T that has 200 leaf nodes. Then, the number of nodes in T that have exactly two children are _____.

Q.12 Given a hash table T with 25 slots that stores 2000 elements, the load factor α for T is _____.

Q.13 In the given matrix $\begin{bmatrix} 1 & -1 & 2 \\ 0 & 1 & 0 \\ 1 & 2 & 1 \end{bmatrix}$, one of the eigenvalues is 1. The eigenvectors corresponding to the eigenvalue 1 are

(A) $\{\alpha(4,2,1) | \alpha \neq 0, \alpha \in \mathbb{R}\}$
(B) $\{\alpha(-4,2,1) | \alpha \neq 0, \alpha \in \mathbb{R}\}$
(C) $\{\alpha(\sqrt{2},0,1) | \alpha \neq 0, \alpha \in \mathbb{R}\}$
(D) $\{\alpha(-\sqrt{2},0,1) | \alpha \neq 0, \alpha \in \mathbb{R}\}$

Q.14 The value of $\lim_{x\to\infty}(1+x^2)^{e^{-x}}$ is

(A) 0
(B) $\frac{1}{2}$
(C) 1
(D) ∞

Q.15 The number of 4 digit numbers having their digits in non-decreasing order (from left to right) constructed by using the digits belonging to the set {1, 2, 3} is_____.

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Q.16 In a room there are only two types of people, namely Type 1 and Type 2. Type 1 people always tell the truth and Type 2 people always lie. You give a fair coin to a person in that room, without knowing which type he is from and tell him to toss it and hide the result from you till you ask for it. Upon asking, the person replies the following

"The result of the toss is head if and only if I am telling the truth."

Which of the following options is correct?

(A) The result is head
(B) The result is tail
(C) If the person is of Type 2, then the result is tail
(D) If the person is of Type 1, then the result is tail

Q.17 While inserting the elements 71, 65, 84, 69, 67, 83 in an empty binary search tree (BST) in the sequence shown, the element in the lowest level is

(A) 65 (B) 67 (C) 69 (D) 83

Q.18 The result evaluating the postfix expression 10 5 + 60 6 / * 8 − is

(A) 284 (B) 213 (C) 142 (D) 71

Q.19 Consider the following relation

Cinema(*theater*, *address*, *capacity*)

Which of the following options will be needed at the end of the SQL query

SELECT P1.*address*
FROM Cinema P1

such that it always finds the addresses of theaters with maximum capacity?

(A) WHERE P1.*capacity* >= All (select P2.*capacity* from Cinema P2)
(B) WHERE P1.*capacity* >= Any (select P2.*capacity* from Cinema P2)
(C) WHERE P1.*capacity* > All (select max(P2.*capacity*) from Cinema P2)
(D) WHERE P1.*capacity* > Any (select max(P2.*capacity*) from Cinema P2)

Q.20 Consider the following array of elements.

$$\langle 89, 19, 50, 17, 12, 15, 2, 5, 7, 11, 6, 9, 100 \rangle$$

The minimum number of interchanges needed to convert it into a max-heap is

(A) 4 (B) 5 (C) 2 (D) 3

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Q.21 Two processes X and Y need to access a critical section. Consider the following synchronization construct used by both the processes

Process X	Process Y

`/* other code for process X */`
`while(true)`
`{`
`  varP = true;`
`  while(varQ == true)`
`  {`
`  /* Critical Section */`
`  varP = false;`
`  }`
`}`
`/* other code for process X */`
	`/* other code for process Y */`
	`while(true)`
	`{`
	`  varQ = true;`
	`  while(varP == true)`
	`  {`
	`  /* Critical Section */`
	`  varQ = false;`
	`  }`
	`}`
	`/* other code for process Y */`

Here, `varP` and `varQ` are shared variables and both are initialized to false. Which one of the following statements is true?

(A) The proposed solution prevents deadlock but fails to guarantee mutual exclusion
(B) The proposed solution guarantees mutual exclusion but fails to prevent deadlock
(C) The proposed solution guarantees mutual exclusion and prevents deadlock
(D) The proposed solution fails to prevent deadlock and fails to guarantee mutual exclusion

Q.22 Let L be the language represented by the regular expression $\Sigma^*0011\Sigma^*$ where $\Sigma = \{0, 1\}$. What is the minimum number of states in a DFA that recognizes $\bar{L}$ (complement of L)?

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

Q.23 Consider a software program that is artificially seeded with 100 faults. While testing this program, 159 faults are detected, out of which 75 faults are from those artificially seeded faults. Assuming that both real and seeded faults are of same nature and have same distribution, the estimated number of undetected real faults is _____.

Q.24 Consider a machine with a byte addressable main memory of 2^{20} bytes, block size of 16 bytes and a direct mapped cache having 2^{12} cache lines. Let the addresses of two consecutive bytes in main memory be $(E201F)_{16}$ and $(E2020)_{16}$. What are the tag and cache line address (in hex) for main memory address $(E201F)_{16}$?

(A) E, 201 (B) F, 201 (C) E, E20 (D) 2, 01F

Q.25 Consider a CSMA/CD network that transmits data at a rate of 100 Mbps (10^8 bits per second) over a 1 km (kilometer) cable with no repeaters. If the minimum frame size required for this network is 1250 bytes, what is the signal speed (km/sec) in the cable?

(A) 8000 (B) 10000 (C) 16000 (D) 20000

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Q. 26 – Q. 55 carry two marks each.

Q.26 The velocity v (in kilometer/minute) of a motorbike which starts from rest, is given at fixed intervals of time t (in minutes) as follows:

t	2	4	6	8	10	12	14	16	18	20
v	10	18	25	29	32	20	11	5	2	0

The approximate distance (in kilometers) rounded to two places of decimals covered in 20 minutes using Simpson's 1/3rd rule is _____.

Q.27 Assume that a mergesort algorithm in the worst case takes 30 seconds for an input of size 64. Which of the following most closely approximates the maximum input size of a problem that can be solved in 6 minutes?

(A) 256 (B) 512 (C) 1024 (D) 2048

Q.28 Consider the following recursive C function.

```
void get(int n)
 {
      if (n<1) return;
      get(n-1);
      get(n-3);
      printf("%d", n);
 }
```

If `get(6)` function is being called in `main()` then how many times will the `get()` function be invoked before returning to the `main()`?

(A) 15 (B) 25 (C) 35 (D) 45

Q.29 Consider a B+ tree in which the search key is 12 bytes long, block size is 1024 bytes, record pointer is 10 bytes long and block pointer is 8 bytes long. The maximum number of keys that can be accommodated in each non-leaf node of the tree is _____.

Q.30 Given the function $F = P' + QR$, where F is a function in three Boolean variables P, Q and R and $P' = !P$, consider the following statements.

(S1) $F = \sum(4, 5, 6)$
(S2) $F = \sum(0, 1, 2, 3, 7)$
(S3) $F = \prod(4, 5, 6)$
(S4) $F = \prod(0, 1, 2, 3, 7)$

Which of the following is true?

(A) (S1)- False, (S2)- True, (S3)- True, (S4)- False
(B) (S1)- True, (S2)- False, (S3)- False, (S4)- True
(C) (S1)- False, (S2)- False, (S3)- True, (S4)- True
(D) (S1)- True, (S2)- True, (S3)- False, (S4)- False

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Q.31 Language L_1 is polynomial time reducible to language L_2. Language L_3 is polynomial time reducible to L_2, which in turn is polynomial time reducible to language L_4. Which of the following is/are true?

I. if $L_4 \in P$, then $L_2 \in P$

II. if $L_1 \in P$ or $L_3 \in P$, then $L_2 \in P$

III. $L_1 \in P$, if and only if $L_3 \in P$

IV. if $L_4 \in P$, then $L_1 \in P$ and $L_3 \in P$

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

Q.32 Consider the following C program.

```
#include<stdio.h>
int f1(void);
int f2(void);
int f3(void);
int x = 10;

int main( )
 {
   int x = 1;
   x += f1( ) + f2( ) + f3( ) + f2( );
   printf("%d", x);
   return 0;
 }

int f1() { int x = 25; x++; return x;}
int f2() { static int x = 50; x++; return x;}
int f3() { x *= 10; return x};
```

The output of the program is _____.

Q.33 Consider the following C program.

```
#include<stdio.h>
int main( )
{
   static int a[ ] = {10, 20, 30, 40, 50};
   static int *p[ ] = {a, a+3, a+4, a+1, a+2};
   int **ptr = p;
   ptr++;
   printf("%d%d", ptr-p,**ptr);
}
```

The output of the program is _____.

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Q.34 Which of the following languages are context-free?

$L_1 = \{a^m b^n a^n b^m \mid m, n \geq 1\}$
$L_2 = \{a^m b^n a^m b^n \mid m, n \geq 1\}$
$L_3 = \{a^m b^n \mid m = 2n + 1\}$

(A) L_1 and L_2 only (B) L_1 and L_3 only (C) L_2 and L_3 only (D) L_3 only

Q.35 Consider the following policies for preventing deadlock in a system with mutually exclusive resources.

I. Processes should acquire all their resources at the beginning of execution. If any resource is not available, all resources acquired so far are released
II. The resources are numbered uniquely, and processes are allowed to request for resources only in increasing resource numbers
III. The resources are numbered uniquely, and processes are allowed to request for resources only in decreasing resource numbers
IV. The resources are numbered uniquely. A process is allowed to request only for a resource with resource number larger than its currently held resources

Which of the above policies can be used for preventing deadlock?

(A) Any one of I and III but not II or IV
(B) Any one of I, III, and IV but not II
(C) Any one of II and III but not I or IV
(D) Any one of I, II, III, and IV

Q.36 In the network 200.10.11.144/27, the fourth octet (in decimal) of the last IP address of the network which can be assigned to a host is _____.

Q.37 Consider a network connecting two systems located 8000 kilometers apart. The bandwidth of the network is 500×10^6 bits per second. The propagation speed of the media is 4×10^6 meters per second. It is needed to design a Go-Back-N sliding window protocol for this network. The average packet size is 10^7 bits. The network is to be used to its full capacity. Assume that processing delays at nodes are negligible. Then, the minimum size in bits of the sequence number field has to be _____.

Q.38 Consider the following reservation table for a pipeline having three stages S_1, S_2 and S_3.

$Time \rightarrow$

	1	2	3	4	5
S_1	X				X
S_2		X		X	
S_3			X		

The minimum average latency (MAL) is _____.

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Q.39 Consider the following code sequence having five instructions I_1 to I_5. Each of these instructions has the following format.

OP Ri, Rj, Rk

where operation OP is performed on contents of registers Rj and Rk and the result is stored in register Ri.

I_1: ADD R1, R2, R3
I_2: MUL R7, R1, R3
I_3: SUB R4, R1, R5
I_4: ADD R3, R2, R4
I_5: MUL R7, R8, R9

Consider the following three statements.

S1: There is an anti-dependence between instructions I_2 and I_5
S2: There is an anti-dependence between instructions I_2 and I_4
S3: Within an instruction pipeline an anti-dependence always creates one or more stalls

Which one of above statements is/are correct?

(A) Only S1 is true
(B) Only S2 is true
(C) Only S1 and S3 are true
(D) Only S2 and S3 are true

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Q.40 Consider the following two C code segments. Y and X are one and two dimensional arrays of size n and $n \times n$ respectively, where $2 \leq n \leq 10$. Assume that in both code segments, elements of Y are initialized to 0 and each element X[i][j] of array X is initialized to i+j. Further assume that when stored in main memory all elements of X are in same main memory page frame.

Code segment 1:

```
//initialize elements of Y to 0
//initialize elements X[i][j] of X to i+j

   for(i = 0; i < n; i++)
       Y[i] += X[0][i];
```

Code Segment 2:

```
//initialize elements of Y to 0
//initialize elements X[i][j] of X to i+j

     for(i = 0; i < n; i++)
       Y[i] += X[i][0];
```

Which of the following statements is/are correct?

S1: Final contents of array Y will be same in both code segments
S2: Elements of array X accessed inside the for loop shown in code segment 1 are contiguous in main memory
S3: Elements of array X accessed inside the for loop shown in code segment 2 are contiguous in main memory

(A) Only S2 is correct
(B) Only S3 is correct
(C) Only S1 and S2 are correct
(D) Only S1 and S3 are correct

Q.41 Consider the following partial Schedule *S* involving two transactions *T1* and *T2*. Only the *read* and the *write* operations have been shown. The *read* operation on data item *P* is denoted by *read(P)* and the *write* operation on data item *P* is denoted by *write(P)*.

Time instance	Transaction-id	
	T1	*T2*
1	*read(A)*	
2	*write(A)*	
3		*read(C)*
4		*write(C)*
5		*read(B)*
6		*write(B)*
7		*read(A)*
8		*commit*
9	*read(B)*	

Schedule *S*

Suppose that the transaction *T1* fails immediately after time instance 9. Which one of the following statements is correct?

(A) *T2* must be aborted and then both *T1* and *T2* must be re-started to ensure transaction atomicity
(B) Schedule *S* is non-recoverable and cannot ensure transaction atomicity
(C) Only *T2* must be aborted and then re-started to ensure transaction atomicity
(D) Schedule *S* is recoverable and can ensure atomicity and nothing else needs to be done

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Q.42 If the following system has non-trivial solution,

$$px + qy + rz = 0$$
$$qx + ry + pz = 0$$
$$rx + py + qz = 0,$$

then which one of the following options is TRUE?

(A) $p - q + r = 0$ or $p = q = -r$
(B) $p + q - r = 0$ or $p = -q = r$
(C) $p + q + r = 0$ or $p = q = r$
(D) $p - q + r = 0$ or $p = -q = -r$

Q.43 Consider the following C program:

```
#include<stdio.h>
int main( )
{
    int i, j, k = 0;
    j = 2 * 3 / 4 + 2.0 / 5 + 8 / 5;
    k -= --j;
    for(i = 0; i < 5; i++)
      {
         switch(i + k)
         {
            case 1:
            case 2: printf("\n%d", i+k);
            case 3: printf("\n%d", i+k);
            default: printf("\n%d", i+k);
         }
      }
    return 0;
}
```

The number of times printf statement is executed is _____.

Q.44 If for non-zero x, $af(x) + bf\left(\frac{1}{x}\right) = \frac{1}{x} - 25$ where $a \neq b$ then $\int_1^2 f(x)dx$ is

(A) $\frac{1}{a^2 - b^2}\left[a(\ln 2 - 25) + \frac{47b}{2}\right]$
(B) $\frac{1}{a^2 - b^2}\left[a(2\ln 2 - 25) - \frac{47b}{2}\right]$
(C) $\frac{1}{a^2 - b^2}\left[a(2\ln 2 - 25) + \frac{47b}{2}\right]$
(D) $\frac{1}{a^2 - b^2}\left[a(\ln 2 - 25) - \frac{47b}{2}\right]$

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Q.45 Let G be a connected undirected graph of 100 vertices and 300 edges. The weight of a minimum spanning tree of G is 500. When the weight of each edge of G is increased by five, the weight of a minimum spanning tree becomes _____.

Q.46 Two hosts are connected via a packet switch with 10^7 bits per second links. Each link has a propagation delay of 20 microseconds. The switch begins forwarding a packet 35 microseconds after it receives the same. If 10000 bits of data are to be transmitted between the two hosts using a packet size of 5000 bits, the time elapsed between the transmission of the first bit of data and the reception of the last bit of the data in microseconds is_____.

Q.47 For the processes listed in the following table, which of the following scheduling schemes will give the lowest average turnaround time?

Process	Arrival Time	Processing Time
A	0	3
B	1	6
C	4	4
D	6	2

(A) First Come First Serve
(B) Non-preemptive Shortest Job First
(C) Shortest Remaining Time
(D) Round Robin with Quantum value two

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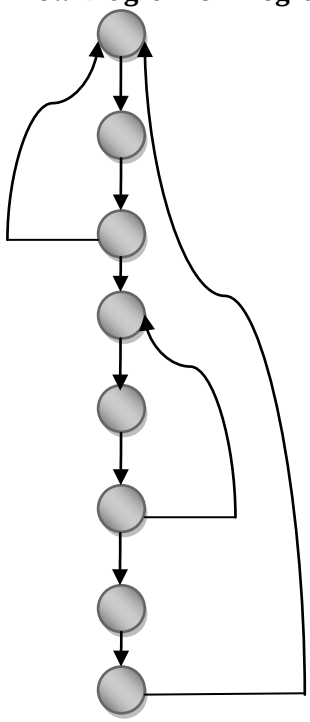
Q.48 Consider three software items: Program-*X*, Control Flow Diagram of Program-*Y* and Control Flow Diagram of Program-*Z* as shown below

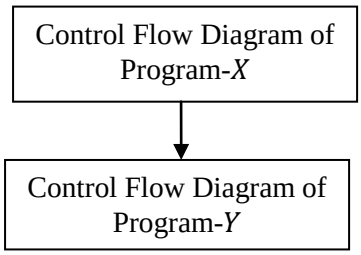
Program-*X*:

```
sumcal(int maxint, int value)
{
    int result=0, i=0;
    if (value <0)
    {
      value = -value;
    }
    while((i<value) AND (result
<= maxint))
    {
       i=i+1;
      result = result + 1;
    }
    if(result <= maxint)
    {
       printf(result);
    }
    else
    {
      printf("large");
    }
    printf("end of program");
}
```

Control Flow Diagram of Program-*Y*:



Control Flow Diagram of Program-*Z*:



The values of McCabe's Cyclomatic complexity of Program-*X*, Program-*Y*, and Program-*Z* respectively are

(A) 4, 4, 7 (B) 3, 4, 7 (C) 4, 4, 8 (D) 4, 3, 8

Q.49 Consider the equation $(43)_x = (y3)_8$ where x and y are unknown. The number of possible solutions is _____

Q.50 Let *R* be a relation on the set of ordered pairs of positive integers such that $((p,q),(r,s)) \in R$ if and only if $p - s = q - r$. Which one of the following is true about *R*?

(A) Both reflexive and symmetric
(B) Reflexive but not symmetric
(C) Not reflexive but symmetric
(D) Neither reflexive nor symmetric

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Q.51 Suppose X_i for $i = 1,2,3$ are independent and identically distributed random variables whose probability mass functions are $\Pr[X_i = 0] = \Pr[X_i = 1] = 1/2$ for $i = 1, 2, 3$. Define another random variable $Y = X_1 X_2 \oplus X_3$, where $\oplus$ denotes XOR. Then

$\Pr[Y = 0 | X_3 = 0] =$_____.

Q.52 The total number of prime implicants of the function $f(w, x, y, z) = \sum(0, 2, 4, 5, 6, 10)$ is _____.

Q.53 Suppose $c = \langle c[0], \ldots, c[k-1] \rangle$ is an array of length k, where all the entries are from the set $\{0, 1\}$. For any positive integers a and n, consider the following pseudocode.

```
DOSOMETHING(c, a, n)
z ← 1
for i ← 0 to k − 1
    do z ← z^2 mod n
     if c[i] = 1
         then z ← (z × a) mod n
return z
```

If $k = 4$, $c = \langle 1, 0, 1, 1 \rangle$, $a = 2$ and $n = 8$, then the output of DOSOMETHING(c, a, n) is _____.

Q.54 Let $f(n) = n$ and $g(n) = n^{(1+\sin n)}$, where n is a positive integer. Which of the following statements is/are correct?

I. $f(n) = O(g(n))$
II. $f(n) = \Omega(g(n))$

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

Q.55 Consider the following grammar G

$$S \rightarrow F \mid H$$
$$F \rightarrow p \mid c$$
$$H \rightarrow d \mid c$$

where S, F, and H are non-terminal symbols, p, d, and c are terminal symbols. Which of the following statement(s) is/are correct?

S1. LL(1) can parse all strings that are generated using grammar G
S2. LR(1) can parse all strings that are generated using grammar G

(A) Only S1 (B) Only S2 (C) Both S1 and S2 (D) Neither S1 nor S2

END OF THE QUESTION PAPER