

Question. 1

Two alternative package A and B are available for processing a database having 10^k records. Package A requires $0.0001 n^2$ time units and package B requires $10n \log_{10} n$ time units to process n records. What is the smallest value of k for which package B will be preferred over A ?

- (A) 12 (B) 10
(C) 6 (D) 5

Question. 2

The weight of a sequence a_0, a_1, \dots, a_{n-1} of real numbers is defined as $a_0 + a_1/2 + \dots + a_{n-1}/2^{n-1}$. A subsequence of a sequence is obtained by deleting some elements from the sequence, keeping the order of the remaining elements the same. Let X denote the maximum possible weight of a subsequence of a_0, a_1, \dots, a_{n-1} and Y the maximum possible weight of a subsequence of a_1, a_2, \dots, a_{n-1} . Then X is equal to

- (A) $\max(Y, a_0 + Y)$ (B) $\max(Y, a_0 + Y/2)$
(C) $\max(Y, a_0 + 2Y)$ (D) $a_0 + Y/2$

Common Data for Questions 3 & 4

Consider a complete undirected graph with vertex set $\{0, 1, 2, 3, 4\}$. Entry W_{ij} in the matrix W below is the weight of the edge $\{i, j\}$.

$$W = \begin{pmatrix} 0 & 1 & 8 & 1 & 4 \\ 1 & 0 & 12 & 4 & 9 \\ 8 & 12 & 0 & 7 & 3 \\ 1 & 4 & 7 & 0 & 2 \\ 4 & 9 & 3 & 2 & 0 \end{pmatrix}$$

Question. 3

What is the minimum possible weight of a spanning tree T in this graph such that vertex 0 is a leaf node in the tree T ?

- (A) 7 (B) 8

(C) 9

(D) 10

Question. 4

What is the minimum possible weight of a path P from vertex 1 to vertex 2 in this graph such that P contains at most 3 edges ?

(A) 7

(B) 8

(C) 9

(D) 10

Question. 5

What data structure in a compiler is used for managing information about variables and their attributes?

(A) Abstract syntax tree

(B) Symbol table

(C) Semantic stack

(D) Parse table

Question. 6

Which languages necessarily need heap allocation in the runtime environment ?

(A) Those that support recursion

(B) Those that use dynamic scoping

(C) Those that allow dynamic data structure

(D) Those that use global variables

Question. 7

The grammar $S \rightarrow aSA|bS|c$ is

(A) LL (1) but not LR (1)

(B) LR (1) but not LL(1)

(C) Both LL (1) and LR (1)

(D) Neither LL (1) nor LR (1)

Question. 8

One of the header fields in an IP datagram is the Time-to-Live (TTL) field. Which of the following statements best explains the need for this field ?

- (A) It can be used to prioritize packets
- (B) It can be used to reduce delays
- (C) It can be used to optimize throughput
- (D) It can be used to prevent packet looping

Question. 9

Which one of the following is not a client-server application ?

- (A) Internet chat
- (B) Web browsing
- (C) E-mail
- (D) Ping

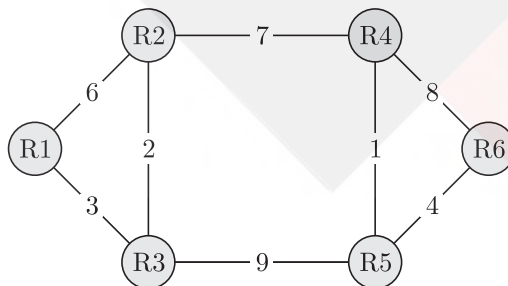
Question. 10

Suppose computers A and B have IP addresses 10.105.1.113 and 10.105.1.91 respectively and they both use the same netmask N. Which of the values of N given below should not be used if A and B should belong to the same network ?

- (A) 225.255.255.0
- (B) 255.255.255.128
- (C) 255.255.255.192
- (D) 255.255.255.224

Statement for Linked Answer Questions 11 & 12

Consider a network with 6 routers R1 and R6 connected with links having weights as shown in the following diagram.

**Question. 11**

All the routers use the distance vector based routing algorithm to update their routing

tables. Each starts with its routing table initialized to contain an entry for each neighbour with the weight of the respective connecting link. After all the routing tables stabilize, how many links in the network will never be used for carrying any data ?

- (A) 4
(B) 3
(C) 2
(D) 1

Question. 12

Suppose the weights of all unused links in the previous question are changed to 2 and the distance vector algorithm is used again until all routing tables stabilize. How many links will now remain unused ?

- (A) 0
(B) 1
(C) 2
(D) 3

Question. 13

A main memory unit with a capacity of 4 megabytes is build using $1M \times 1 - \text{bit}$ DRAM chips. Each DRAM chip has 1K rows of cells with 1 K cells in each row. The time taken for a single refresh operation is 100 nanoseconds. The time required to perform one refresh operation on all the cells in the memory unit is

- (A) 100 nanoseconds
(B) $100 * 2^{10}$ nanoseconds
(C) $100 * 2^{20}$ nanoseconds
(D) $3200 * 2^{20}$ nanoseconds

Question. 14

A-5 stage pipelined processor has Instruction Fetch. (IF), Instruction Decode (ID), Operand Fetch (OF), Perform Operation (PO) and Write Operand (WO) stages. The IF, ID, OF and WO stages take 1 clock cycle each for any instruction. The PO stage takes 1 clock cycle for ADD and SUB instruction. The PO stage takes 1 stake clock cycle for ADD and SUB instructions 3 clock cycles for MUL instruction, and 6 clock cycles for DIV instruction respectively. Operand forwarding is used in the pipeline. What is the number of clock cycles needed to execute the following sequence of instructions ?

Instruction Meaning of instruction

I_0 : MUL R_2, R_0, R_1

$R_2 \leftarrow R_0 * R_1$

$I_1: \text{DIV } R_5, R_3, R_4$
 $R_5 \leftarrow R_3 / R_4$
 $I_2: \text{ADD } R_2, R_5, R_2$
 $R_2 \leftarrow R_5 + R_2$
 $I_3: \text{SUB } R_5, R_2, R_6$
 $R_5 \leftarrow R_2 - R_6$

(A) 13

(B) 15

(C) 17

(D) 19

Question. 15

The program below uses six temporary variables a, b, c, d, e, f

 $a = 1$
 $b = 10$
 $c = 20$
 $d = a + b$
 $e = c + d$
 $f = c + e$
 $b = c + e$
 $e = b + f$
 $d = 5 + e$

Assuming that all operations take their operands from register, what is the minimum number of registers needed to execute this program without spilling ?

(A) 2

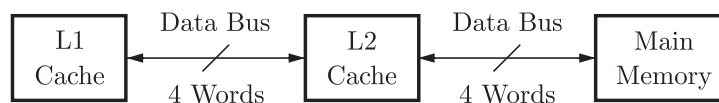
(B) 3

(C) 4

(D) 6

Common Data for Questions 16 & 17

A computer system has an L1 and L2 cache, an L2 cache, and a main memory unit connected as shown below. The block size in L1 cache is 4 words. The block size in L2 cache is 16 words. The memory access times are 2 nanoseconds, 20 nanoseconds and 200 nanoseconds for L1 cache, L2 cache and main memory unit respectively.



Question. 16

When there is a miss in L1 cache and a hit in L2 cache, a block is transferred from L2 cache to L1 cache. What is the time taken for this transfer ?

- (A) 2 nanoseconds (B) 20 nanoseconds
(C) 22 nanoseconds (D) 88 nanoseconds

Question. 17

When there is a miss in both L1 cache and L2 cache, first a block is transferred from memory to L2 cache, and then a block is transferred from L2 cache to L1 cache. What is the total time taken for these transfers ?

- (A) 222 nanoseconds (B) 888 nanoseconds
(C) 902 nanoseconds (D) 968 nanoseconds

Question. 18

Consider a B^+ -tree in which the maximum number of keys in a node is 5. What is the minimum number of keys in any non-root node?

- (A) 1 (B) 2
(C) 3 (D) 4

Question. 19

A relational schema for a train reservation database is given below.

Passenger (pid, pname, age)

Reservation (pid, class, tid)

Table : passenger

pid	pname	Age
0	'Sachin'	65

1	'Rahul'	66
2	Sourav'	67
3	'Anil'	69

Table : Reservation

pid	class	tid
0	'AC'	8200
1	'AC'	8201
2	'SC'	8201
3	'AC'	8203
4	'SC'	8204
5	'AC'	8202

What pids are returned by the following SQL query for the above instance of the tables ?

```
SELECT pid
FROM Reservation
WHERE class= 'AC' AND
EXISTS (SELECT*
FROM Passenger
WHERE age>65 AND
Passenger.pid = Reservation.pid)
```

- (A) 1,0 (B) 1, 2
(C) 1, 3 (D) 1, 5

Question. 20

Which of the following concurrency control protocols ensure both conflict serializability and freedom from deadlock?

- I. 2-phase locking
II Time-stamp ordering
- (A) I only (B) II only
(C) Both I and II (D) Neither I nor II

Question. 21

Consider the following schedule for transactions T1, T2, and T3 :

T1	T2	T3
Read (X)		
	Read (Y)	
		Read (Y)
Write (X)		Write (X)
	Read (X)	
	Write (X)	

Which one of the schedules below is the correct serialization of the above ?

- (A) $T1 \rightarrow T3 \rightarrow T2$ (B) $T2 \rightarrow T1 \rightarrow T3$
 (C) $T2 \rightarrow T3 \rightarrow T1$ (D) $T3 \rightarrow T1 \rightarrow T2$

Question. 22

The following functional dependencies hold for relations R(A,B,C) and S(B,D,E):

$B \rightarrow A$

$A \rightarrow C$

The relation R contains 200 tuples and the relation S contains 100 tuples. What is the maximum number of tuples possible in the natural join $R \bowtie S$?

- (A) 100 (B) 200
 (C) 300 (D) 2000

Question. 23

The minterm expansion of $f(P, Q, R) = PQ + Q\bar{R} + P\bar{R}$ is

- (A) $m_2 + m_4 + m_6 + m_1$ (B) $m_0 + m_1 + m_3 + m_5$
 (C) $m_0 + m_1 + m_6 + m_1$ (D) $m_2 + m_3 + m_4 + m_5$

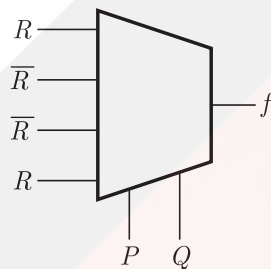
Question. 24

P is a 16-bit signed integer. The 2's complement representation of P is $(F87B)_{16}$. The 2's complement representation of 8^*P is

- (A) $(C3D8)_{16}$
- (B) $(187B)_{16}$
- (C) $(F878)_{16}$
- (D) $(987B)_{16}$

Question. 25

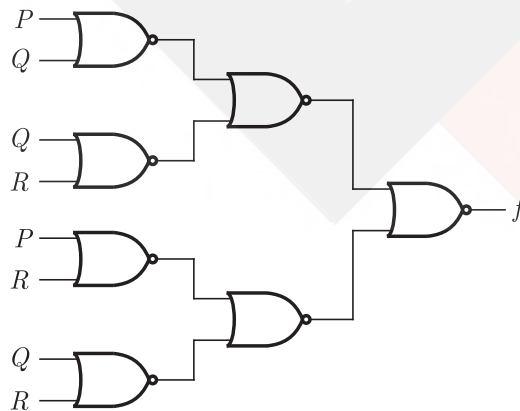
The Boolean expression for the output f of the multiplexer shown below is



- (A) $\overline{P \oplus Q \oplus R}$
- (B) $P \oplus Q \oplus R$
- (C) $P + Q + R$
- (D) $\overline{P + Q + R}$

Question. 26

What is the boolean expression for the output f of the combinational logic circuit of NOR gates given below ?



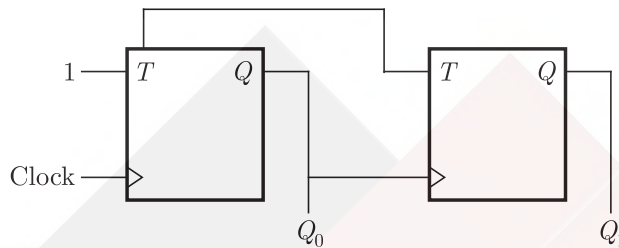
- (A) $\overline{Q + R}$
- (B) $\overline{P + Q}$

(C) $\overline{P+R}$

(D) $\overline{P+Q+R}$

Question. 27

In the sequential circuit shown below, if the initial value of the output $Q_1 Q_0$ is 00, what are the next four values of $Q_1 Q_0$?



(A) 11, 10, 01, 00

(B) 10, 11, 01, 00

(C) 10, 00, 01, 11

(D) 11, 10, 00, 01

Question. 28

Let $G = (V, E)$ be a graph. Define $\xi(G) = \sum_d i_d \times d$, where i_d is the

number of vertices of degree d in G . If S and T are two different trees with $\xi(S) = \xi(T)$, then

(A) $|S| = 2|T|$

(B) $|S| = |T| - 1$

(C) $|S| = |T|$

(D) $|S| = |T| + 1$

Question. 29

Newton-Raphson method is used to compare a root of the equation $x^2 - 13 = 0$ with 3.5 as the initial value. The approximation after one iteration is

(A) 3.575

(B) 3.677

(C) 3.667

(D) 3.607

Question. 30

What is the possible number of reflexive relations on a set of 5 elements ?

- (A) 2^{10} (B) 2^{15}
(C) 2^{20} (D) 2^{25}

Question. 31

Consider the set $S = \{1, \omega, \omega^2\}$, where ω and ω^2 are cube roots of unity. If $*$ denotes the multiplication operation, the structure $\{S, *\}$ forms

- (A) a group (B) a ring
(C) an integral domain (D) a field

Question. 32

What is the value of $\lim_{n \rightarrow \infty} \left(1 - \frac{1}{n}\right)^{2n}$?

- (A) 0 (B) e^{-2}
(C) $(n-1)/2$ (D) 1

Question. 33

In a binary tree with n nodes, every node has an odd number of descendants. Every node is considered to be its own descendant. What is the number of nodes in the tree that have exactly one child ?

- (A) 0 (B) 1
(C) $(n-1)/2$ (D) $n-1$

Question. 34

Consider a company that assembles computers. The probability of a faulty assembly of any computer is p . The company therefore subjects each computer to a testing process. This testing process gives the correct result for any computer with a probability of q . What is the probability of a computer being declared faulty ?

- (A) $pq + (1-p)(1-q)$ (B) $(1-q)p$
(C) $(1-p)q$ (D) pq

Question. 35

What is the probability that a divisor of 10^{99} is a multiple of 10^{96} ?

- (A) $1/625$ (B) $4/625$
(C) $12/625$ (D) $16/625$

Question. 36

The degrees sequence of a simple graph is the sequence of the degrees of the nodes in the graph in decreasing order. Which of the following sequence can not be the degree sequence of any graph ?

- I 7, 6, 5, 4, 4, 3, 2, 1
II 6, 6, 6, 6, 3, 3, 2, 2
III 7, 6, 6, 4, 4, 3, 2, 2
IV 8, 7, 7, 6, 4, 2, 1, 1

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

Question. 37

Consider the following matrix.

$$A = \begin{bmatrix} 2 & 3 \\ X & Y \end{bmatrix}$$

If the eigenvalues of A are 4 and 8, then

- (A) $x = 4, y = 10$ (B) $x = 5, y = 8$
(C) $x = -3, y = 9$ (D) $x = -4, y = 10$

Question. 38

Suppose the predicate $F(x, y, t)$ is used to represent the statement that person x can fool person y at time t . Which one of the statements below expresses best the meaning of the formula $\forall x \exists y \exists t (\neg F(x, y, t))$?

- (A) Everyone can fool some person at some time
- (B) No one can fool everyone all the time
- (C) Everyone cannot fool some person all the time
- (D) No one can fool some person at some time.

Question. 39

Consider the methods used by processes P1 and P2 for accessing their critical sections whenever needed, as given below. The initial values of shared boolean variables S1 and S2 are randomly assigned.

Method used by P1	Method used by P2
While (S1==S2); Critical Section S1=S2;	While (S1!=S2); Critical Section S2=not (S1)

While one of the following statements describes properties achieved ?

- (A) Mutual exclusion but not progress
- (B) Progress but not mutual exclusion
- (C) Neither mutual exclusion nor progress
- (D) Both mutual exclusion and progress

Question. 40

A system uses FIFO policy for page replacement. It has 4 page frames with no pages loaded to begin with. The system first accesses 100 distinct pages in some order and then accesses the same 100 pages but now in the reverse order. How many page faults will occur ?

- (A) 196
- (B) 192
- (C) 197
- (D) 195

Question. 41

Which of the following statements are true ?

- I Shortest remaining time first scheduling may cause starvation
- II Preemptive scheduling may cause starvation

II Round robin is better than FCFS in terms of response time

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

Question. 42

The following program consists of 3 concurrent processes and 3 binary semaphores. The semaphores are initialized as $S_0 = 1, S_1 = 0, S_2 = 0$

Process P_0	Process P_1	Process P_2
<pre>While (true){ wait (S₀); print '0' release (S₁); release (S₂); }</pre>	<pre>wait (S₁); release (S₀);</pre>	<pre>wait (S₂) release (S₀);</pre>

How many times will process P_0 print '0' ?

- (A) At least twice (B) Exactly twice
(C) Exactly thrice (D) Exactly once

Question. 43

A system has n resources $R_0 \dots R_{n-1}$, and k processes $P_0 \dots P_{k-1}$. The implementation of the resource request logic of each process P_i , is as follows:

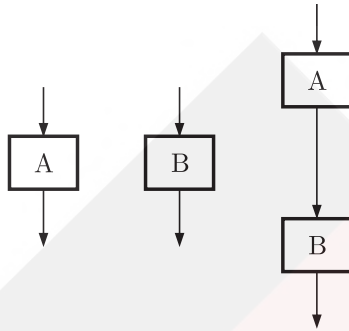
```
if (i%2==0){
    if(i<n)requestRi;
    if(i+2<n)request Ti+2;
}
else {
    if (i<n)request Rn-1;
    if (i+2<n)requestRn-i-2;
}
```

In which one of the following situations is a deadlock possible ?

- (A) $n = 40, k = 26$ (B) $n = 21, k = 12$

(C) $n = 20, k = 10$ (D) $n = 41, k = 19$ **Question. 44**

The cyclomatic complexity of each of the modules A and B shown below is 10. What is the cyclomatic complexity of the sequential integration shown on the right hand side ?



(A) 19

(B) 21

(C) 20

(D) 10

Question. 45

What does the following program print ?

```

#include<stdio.h>
void f(int *p, int *q){
    p = q;
    *p = 2;
}
int i=0, j=1;
int main(){
    f(&i, &j);
    printf("%d%d\n", i, j);
    return 0;
}
  
```

(A) 22

(B) 21

(C) 01

(D) 02

Question. 46

What is the appropriate pairing of items in the two columns listing various activities encountered in a software life cycle ?

- | | |
|------------------------|---------------------------------------|
| P. Requirement Capture | 1. Module Development and Integration |
| Q. Design | 2. Domain Analysis |
| R. Implementation | 3. Structural and Behavioral Modeling |
| S. Maintenance | 4. Performance Tuning |

(A) P-3 Q-2, R-4 S-1

(B) P-2 Q-3 R-1 S-4

(C) P-3 Q-2 R-1 S-4

(D) P-2 Q-3 R-4 S-1

Question. 47

What is the value printed by the following C program ?

```
#include<stdio.h>
int f(int *a, int n)
{
    if (n<=0) return 0;
    else if (*a%2==0) return *a+f(a+1,n-1);
    else return *a-f(a+1,n-1);
}
int main()
{
    int a[]={12, 7, 13, 4, 11, 6};
    printf("%d",f(a,6));
    return 0;
}
```

(A) -9

(B) 5

(C) 15

(D) 19

Question. 48

The following C function takes a singly-linked list as input argument. It modified the list by moving the last element to the front of the list and returns the modified list. Some part of the code is left blank.

```
typedef struct node {
    int value;
    struct node *next
} Node;
Node *mode_to_front(Node *head){
```



```

Node *p, *q;
if ((head==NULL) || (head->next==NULL)) return head;
q=NULL; p=head;
while (p->next != NULL) {
    q=p;
    p=q->next;
}
_____
return head;
}

```

Choose the correct alternative to replace the blank line.

- (A) `q=NULL; p->next=head; head=p;`
- (B) `q->next=NULL; head=p; p->next=head;`
- (C) `head=p; p->next=q; q->next=NULL;`
- (D) `q->next=NULL; p->next=head; head=p;`

Question. 49

The following program is to be tested for statement coverage :

```

begin
    if (a==b) {S1; exit}
    else if (c==d) {S2;}
    else {S3; exit;}
S4;
end

```

The test cases T1, T2, T3, and T4 given below are expressed in terms of the properties satisfied by the values of variables a, b, c and d. The exact values are not given.

T1 : a, b, c and d are all equal

T2 : a, b, c and d are all distinct

T3 : a = b and c ≠ d

T4 : a ≠ b and c = d

Which of the test suites given below ensures coverage of statements S1, S2, S3 and S4 ?

- (A) T1, T2, T3 (B) T2, T4
(C) T3, T4 (D) T1, T2, T4

Statement for Linked Answer Questions 50 & 51

A has table of length 10 uses open addressing with hash function $h(k)=k \bmod 10$, and linear probing. After inserting 6 values into an empty has table, the table is as shown below.

0	
1	
2	42
3	23
4	34
5	52
6	46
7	33
8	
9	

Question. 50

Which one oft he following choices gives a possible order in which the key values could have been inserted in the table ?

- (A) 46, 42, 34, 52, 23, 33 (B) 34, 42, 23, 52, 33, 46
(C) 46, 34, 42, 23, 52, 33 (D) 42, 46, 33, 23, 34, 52

Question. 51

How many different insertion sequences of the key values using hte same hash function and linear probing will result in the hash table shown above ?

- (A) 10 (B) 20
(C) 30 (D) 40

Question. 52

Let $L1$ be a recursive language. Let $L2$ and $L3$ be language that are recursively enumerable but not recursive. What of the following statements is not necessarily true ?

- (A) $L1 - L1$ is recursively enumerable
- (B) $L1 - L3$ is recursively enumerable
- (C) $L2 \cap L3$ is recursively enumerable
- (D) $L2 \cap L3$ is recursively enumerable

Question. 53

Let $L = \{\omega \in (0+1)^* \mid \omega \text{ has even number of 1s}\}$, i.e., L is the set of all bit strings with even number of 1s. Which one of the regular expressions below represents L ?

- (A) $(0^*10^*1)^*$
- (B) $0^*(10^*10^*)^*$
- (C) $0^*(10^*1)^*0^*$
- (D) $0^*1(10^*1)^*10^*$

Question. 54

Consider the language $L1 = \{0^i1^j \mid i \neq j\}$, $L2 = \{0^i1^j \mid i = j\}$, $L3 = \{0^i1^j \mid i = 2j + 1\}$
 $L4 = \{0^i1^j \mid i \neq 2j\}$. Which one of the following statements is true ?

- (A) Only $L2$ is context free
- (B) Only $L2$ and $L3$ are context free
- (C) Only $L1$ and $L2$ are context free
- (D) All are context free

Question. 55

Let ω be any string of length n in $\{0,1\}^*$. Let L be the set of all substrings of ω . What is the minimum number of states in a non-deterministic finite automaton that accepts L ?

- (A) $n - 1$
- (B) n
- (C) $n + 1$
- (D) 2^{n+1}
