GATE Previous Year Solved Paper

Computer Science/IT

(Fully Solved)

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Q. No. 1 – 25 Carry One Mark Each

1. Consider an undirected random graph of eight vertices. The probability that there is an edge between a pair of vertices is ½. What is the expected number of unordered cycles of length three?

(A) 1/8 (B) 1 (C) 7 (D) 8

Ans. (C)

Exp: $P(\text{edge}) = \frac{1}{2}$

Number of ways we can choose the vertices out of 8 is 8_{C_3}

(Three edges in each cycle)

Expected number of unordered cycles of length $3 = 8_{C_3} \times \left(\frac{1}{2}\right)^3 = 7$

2. Which of the following statements is/are **TRUE** for undirected graphs?

P: Number of odd degree vertices is even.

Q: Sum of degrees of all vertices is even.

(A) P only (B) Q only

(C) Both P and Q (D) Neither P nor Q

Ans: (C)

Exp: Q: Sum of degrees of all vertices $= 2 \times (\text{number of edges})$

3. Function f is known at the following points:

x	0	0.3	0.6	0.9	1.2	1.5	1.8	2.1	2.4	2.7	3.0
f(x)	0	0.09	0.36	0.81	1.44	2.25	3.24	4.41	5.76	7.29	9.00

The value of $\int_0^3 f(x)\,dx$ computed using the trapezoidal rule is

(A) 8.983 (B) 9.003 (C) 9.017 (D) 9.045

Ans: (D)

Exp: $\int_0^3 f(x)\,dx = \frac{h}{2}\left[f(x_0) + f(x_{10}) + 2\left(f(x_1) + f(x_2) + \ldots + f(x_9)\right)\right]$

$= \frac{0.3}{2}\left[9.00 + 2(25.65)\right] = 9.045$

4. Which one of the following functions is continuous at x = 3 ?

(A) $f(x)=\begin{cases}2, & \text{if } x=3\\ x-1, & \text{if } x>3\\ \dfrac{x+3}{3}, & \text{if } x<3\end{cases}$

(B) $f(x)=\begin{cases}4, & \text{if } x=3\\ 8-x & \text{if } x\neq 3\end{cases}$

(C) $f(x)=\begin{cases}x+3, & \text{if } x\le 3\\ x-4 & \text{if } x>3\end{cases}$

(D) $f(x)=\dfrac{1}{x^3-27}, \quad \text{if } x\neq 3$

Ans: (A)

Exp: $\lim\limits_{x\to 3+} f(x)=\lim\limits_{x\to 3+}(x-1)=2=f(3)$

$\lim\limits_{x\to 3-} f(x)=\lim\limits_{x\to 3-}\left(\dfrac{x+3}{3}\right)=2=f(3)$

$\therefore f(x)$ is continuous at $x=3$

5. Which one of the following expressions does **NOT** represent exclusive NOR of x and y?

(A) $xy+x'y'$ (B) $x\oplus y'$ (C) $x'\oplus y$ (D) $x'\oplus y'$

Ans: (D)

Exp: (A) $x\odot y=xy+\bar{x}\,\bar{y}$

(B) $x\oplus y=\overline{xy}+\bar{x}\,\bar{y}=xy+\bar{x}\,\bar{y}=x\odot y$

(C) $\bar{x}\oplus y=(\bar{x})\bar{y}+\overline{x\,\bar{y}}=\bar{x}\,\bar{y}+xy=x\odot y$

(D) $\bar{x}\oplus\bar{y}=(\bar{x})y+x\bar{y}=x\oplus y$

6. In a k-way set associative cache, the cache is divided into v sets, each of which consists of k lines. The lines of a set are placed in sequence one after another. The lines in set s are sequenced before the lines in set (s+1). The main memory blocks are numbered 0 onwards. The main memory block numbered j must be mapped to any one of the cache lines from

(A) $(j \bmod v)*k$ to $(j \bmod v)*k+(k-1)$

(B) $(j \bmod v)$ to $(j \bmod v)+(k-1)$

(C) $(j \bmod k)$ to $(j \bmod k)+(v-1)$

(D) $(j \bmod k)*v$ to $(j \bmod k)*v+(v-1)$

Ans: (B)

Exp: Set number in the cache = (main memory block number) MOD number of sets in the cache.

As the lines in the set are placed in sequence, we can have the lines from 0 to K – 1 in the set.

Number of sets = v

Main memory block number = j

First line = (j mod v); last line = (j Mod v) + (k – 1)

7. What is the time complexity of Bellman-Ford single-source shortest path algorithm on a complete graph of n vertices?

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

Ans: (C)

Exp: Bellman-ford time complexity: $\Theta(|V| \times |E|)$

For complete graph: $|E| = \frac{n(n-1)}{2}$

$|V| = n$

$\therefore \Theta\left(n \times \frac{n(n-1)}{2}\right) = \Theta(n^3)$

8. Which of the following statements are **TRUE**?

(1) The problem of determining whether there exists a cycle in an undirected graph is in P.

(2) The problem of determining whether there exists a cycle in an undirected graph is in NP.

(3) If a problem A is NP-Complete, there exists a non-deterministic polynomial time algorithm to solve A.

(A) 1,2 and 3 (B) 1 and 2 only (C) 2 and 3 only (D) 1 and 3 only

Ans: (A)

Exp: 1. Cycle detection using DFS: $O(V+E) = O(V^2)$ and it is polynomial problem

2. Every P-problem is NP $(\text{since } P \subset NP)$

3. NP – complete $\in$ NP

Hence, NP-complete can be solved in non-deterministic polynomial time

9. Which of the following statements is/are **FALSE**?

(1) For every non-deterministic Turing machine, there exists an equivalent deterministic Turing machine.

(2) Turing recognizable languages are closed under union and complementation.

(3) Turing decidable languages are closed under intersection and complementation

(4) Turing recognizable languages are closed under union and intersection.

(A) 1 and 4 only (B) 1 and 3 only (C) 2 only (D) 3 only

Ans: (C)

Exp: (1) NTM $\cong$ DTM

(2) RELs are closed under union & but not complementation

(3) Turing decidable languages are recursive and recursive languages are closed under intersection and complementation

(4) RELs are closed under union & intersection but not under complementation

10. Three concurrent processes X, Y, and Z execute three different code segments that access and update certain shared variables. Process X executes the P operation (i.e., wait) on semaphores a, b and c; process Y executes the P operation on semaphores b, c and d; process Z executes the P operation on semaphores c, d, and a before entering the respective code segments. After completing the execution of its code segment, each process invokes the V operation (i.e., signal) on its three semaphores. All semaphores are binary semaphores initialized to one. Which one of the following represents a deadlock-free order of invoking the P operations by the processes?

(A) $X:P(a)P(b)P(c)$ $Y:P(b)P(c)P(d)$ $Z:P(c)P(d)P(a)$

(B) $X:P(b)P(a)P(c)$ $Y:P(b)P(c)P(d)$ $Z:P(a)P(c)P(d)$

(C) $X:P(b)P(a)P(c)$ $Y:P(c)P(b)P(d)$ $Z:P(a)P(c)P(d)$

(D) $X:P(a)P(b)P(c)$ $Y:P(c)P(b)P(d)$ $Z:P(c)P(d)P(a)$

Ans: (B)

Exp: Suppose X performs P(b) and preempts, Y gets chance, but cannot do its first wait i.e., P(b), so waits for X, now Z gets the chance and performs P(a) and preempts, next X gets chance. X cannot continue as wait on 'a' is done by Z already, so X waits for Z. At this time Z can continue its operations as down on c and d. Once Z finishes, X can do its operations and so Y. In any of execution order of X, Y, Z one process can continue and finish, such that waiting is not circular. In options (A),(C) and (D) we can easily find circular wait, thus deadlock

11. An index is clustered, if

(A) it is on a set of fields that form a candidate key.

(B) it is on a set of fields that include the primary key.

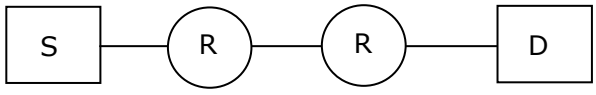
(C) the data records of the file are organized in the same order as the data entries of the index.

(D) the data records of the file are organized not in the same order as the data entries of the index.

Ans: (C)

Exp: Clustered index is built on ordering non key field and hence if the index is clustered then the data records of the file are organized in the same order as the data entries of the index.

12. Assume that source S and destination D are connected through two intermediate routers labeled R. Determine how many times each packet has to visit the network layer and the data link layer during a transmission from S to D.



(A) Network layer – 4 times and Data link layer-4 times

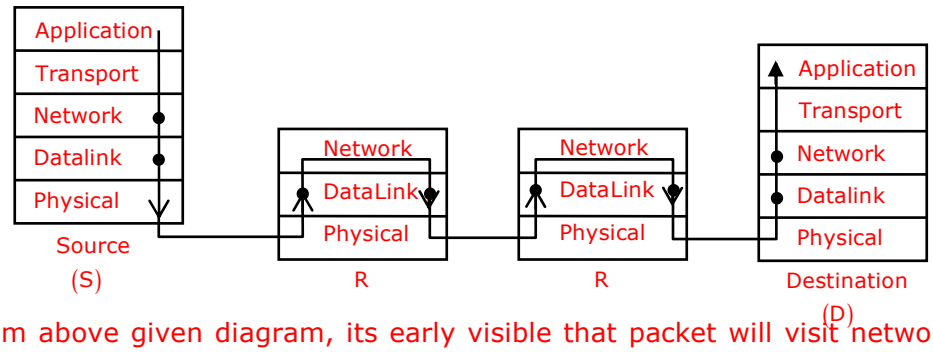
(B) Network layer – 4 times and Data link layer-3 times

(C) Network layer – 4 times and Data link layer-6 times

(D) Network layer – 2 times and Data link layer-6 times

Ans: (C)

Exp:



From above given diagram, its early visible that packet will visit network layer 4 times, once at each node [S, R, R, D] and packet will visit Data Link layer 6 times. One time at S and one time at D, then two times for each intermediate router R as data link layer is used for link to link communication.

Once at packet reaches R and goes up from physical –DL-Network and second time when packet coming out of router in order Network – DL- Physical

13. The transport layer protocols used for real time multimedia, file transfer, DNS and email, respectively are

(A) TCP, UDP, UDP and TCP (B) UDP, TCP, TCP and UDP

(C) UDP, TCP, UDP and TCP (D) TCP, UDP, TCP and UDP

Ans: (C)

Exp: Real time multimedia needs connectionless service, so under lying transport layer protocol used is UDP

File transfer rums over TCP protocol with port no-21

DNS runs over UDP protocol within port no-53

Email needs SMTP protocol which runs over TCP protocol within port no – 25

14. Using public key cryptography, X adds a digital signature σ to message M, encrypts <M, σ>, and sends it to Y, where it is decrypted. Which one of the following sequences of keys is used for the operations?

(A) Encryption: X's private key followed by Y's private key; Decryption: X's public key followed by Y's public key

(B) Encryption: X's private key followed by Y's public key; Decryption: X's public key followed by Y's private key

(C) Encryption: X's public key followed by Y's private key; Decryption: Y's public key followed by X's private key

(D) Encryption: X's private key followed by Y's public key; Decryption: Y's private key followed by X's public key

Ans: (D)

Exp:

Encryption { Source has to encrypt with its private key for forming Digital signature for Authentication. source has to encrypt the $\langle M, \sigma \rangle$ with Y's public key to send it confidentially

Decryption { Destination Y has to decrypt first with its private key, then decrypt using source public key

15. Match the problem domains in **Group I** with the solution technologies in **Group II**.

Group I	Group II
(p) Services oriented computing	(1) Interoperability
(q) Heterogeneous communicating systems	(2) BPMN
(R) Information representation	(3) Publish-find bind
(S) Process description	(4) XML

(A) P – 1, Q – 2, R – 3, S – 4 (B) P – 3, Q – 4, R – 2, S – 1
(C) P – 3, Q – 1, R – 4, S – 2 (D) P – 4, Q – 3, R – 2, S – 1

Ans: (C)

16. A scheduling algorithm assigns priority proportional to the waiting time of a process. Every process starts with priority zero(the lowest priority). The scheduler re-evaluates the process priorities every T time units and decides the next process to schedule. Which one of the following is TRUE if the processes have no I/O operations and all arrive at time zero?

(A) This algorithm is equivalent to the first-come-first-serve algorithm.
(B) This algorithm is equivalent to the round-robin algorithm.
(C) This algorithm is equivalent to the shortest-job-first algorithm.
(D) This algorithm is equivalent to the shortest-remaining-time-first algorithm.

Ans: (B)

Exp: The given scheduling definition takes two parameters, one is dynamically assigned process priority and the other is 'T' time unit to re-evaluate the process priorities.

This dynamically assigned priority will be deciding processes order in ready queue of round robin algorithm whose time quantum is same as 'T' time units. As all the processes are arriving at the same time, they will be given same priority but soon after first 'T' time burst remaining processes will get higher priorities

17. What is the maximum number of reduce moves that can be taken by a bottom-up parser for a grammar with no epsilon- and unit-production (i.e., of type $A \rightarrow \in$ and $A \rightarrow a$) to parse a string with n tokens?

(A) n/2 (B) n-1 (C) 2n-1 (D) 2^n

Ans: (C)

Exp: string = abcd

S
⇑ (7)
YD
⇑ $(6: Y \rightarrow XC)$
XCD
⇑ $(5: X \rightarrow AB)$
ABCD
⇑ $(4: D \rightarrow d)$
ABCd
⇑ $(3: C \rightarrow c)$
ABcd
⇑ $(2: B \rightarrow b)$
Abcd
⇑ $(1: A \rightarrow a)$
abcd

$2 \times (4) - 1 = 7$ reductions

$\Rightarrow 2n - 1$ reductions required

[Note : Unit productions is given as $A \rightarrow a$, it was typo]

Above reductions are not in reverse of RMD but when they are reduced in bottom up parsing we will get same number of reductions.

18. Consider the languages $L_1 = \Phi$ and $L_2 = \{a\}$. Which one of the following represents $L_1 L_2^* \cup L_1^*$?

(A) $\{\in\}$ (B) Φ (C) a* (D) $\{\varepsilon, a\}$

Ans: (A)

EXP: Concatenation of empty language with any language will give the empty language and $L_1^* = \Phi^* = \in$. Hence $L_1 L_2^* \cup L_1^* = \{\in\}$

19. Which one of the following is the tightest upper bound that represents the time complexity of inserting an object into a binary search tree of n nodes?

(A) O(1) (B) O(log n) (C) O(n) (D) O(n log n)

Ans: (C)

Exp: For skewed binary search tree on n nodes, the tightest upper bound to insert a node is O(n)

20. Which one of the following is the tightest upper bound that represents the number of swaps required to sort n numbers using selection sort?

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

Ans: (B)

Exp: The maximum number of swaps that takes place in selection sort on n numbers is n

21. In the following truth table, V = 1 if and only if the input is valid.

Inputs			Outputs			
D_0	D_1	D_2	D_3	X_0	X_1	V
0	0	0	0	X	X	0
1	0	0	0	0	0	1
0	1	0	0		1	1
1	X	1	0		0	1
X	X	X	1	1	1	1

What function does the truth table represent?

(A) Priority encoder (B) Decoder

(C) Multiplexer (D) Demultiplexer

Ans: (A)

Exp: 4 to 2 priority encoder.

22. The smallest integer than can be represented by an 8-bit number in 2's complement form is

(A) -256 (B) -128 (C) -127 (D) 0

Ans: (B)

Exp: $-2^{8-1} = -128$. Range is $-2^{(n-1)}$ to $+2^{(n-1)}-1$

23. Which one of the following does **NOT** equal $\begin{vmatrix} 1 & x & x^2 \\ 1 & y & y^2 \\ 1 & z & z^2 \end{vmatrix}$?

(A) $\begin{vmatrix} 1 & x(x+1) & x+1 \\ 1 & y(y+1) & y+1 \\ 1 & z(z+1) & z+1 \end{vmatrix}$ (B) $\begin{vmatrix} 1 & x+1 & x^2+1 \\ 1 & y+1 & y^2+1 \\ 1 & z+1 & z^2+1 \end{vmatrix}$

(C) $\begin{vmatrix} 0 & x-y & x^2-x^2 \\ 0 & y-z & y^2-z^2 \\ 1 & z & z^2 \end{vmatrix}$ (D) $\begin{vmatrix} 2 & x+y & x^2+y^2 \\ 2 & y+z & y^2+z^2 \\ 1 & z & z^2 \end{vmatrix}$

Ans: (A)

If matrix B is obtained from matrix A by replacing the l^{th} row by itself plus k times the m^{th} row, for $l \neq m$ then det(B)=det(A). With this property given matrix is equal to the matrices given in options (B),(C) and (D).

24. Suppose p is number of cars per minute passing through a certain road junction between 5 PM and 6PM, and p has a Poisson distribution with mean 3. What is the probability of observing fewer than 3 cars during any given minute in this interval?

(A) $8/\left(2e^3\right)$ (B) $9/\left(2e^3\right)$ (C) $17/\left(2e^3\right)$ (D) $26/\left(2e^3\right)$

Ans: (C)

Exp:

$$P(p<3)=P(p=0)+P(p=1)+P(p=2)$$

$$=\frac{e^{-\mu}\mu^0}{0!}+\frac{e^{-\mu}\mu^1}{1!}+\frac{e^{-\mu}\mu^2}{2!}\ (\text{where } \mu=3)$$

$$=e^{-3}+e^{-3}\times 3+\frac{e^{-3}\times 9}{2}$$

$$=e^{-3}\left(1+3+\frac{9}{2}\right)=\frac{17}{2e^3}$$

25. A binary operation $\oplus$ on a set of integers is defined as $x\oplus y=x^2+y^2$. Which one of the following statements is **TRUE** about $\oplus$?

(A) Commutative but not associative (B) Both commutative and associative

(C) Associative but not commutative (D) Neither commutative nor associative

Ans: (A)

Exp: $x\oplus y=x^2+y^2=y^2+x^2=y\oplus x$

$\therefore$ commutative

Not associative, since, for example

$(1\oplus 2)\oplus 3\neq 1\oplus(2\oplus 3)$

Q. No. 26 – 55 Carry Two Marks Each

26. Which one of the following is **NOT** logically equivalent to $\neg\exists x\left(\forall y(\alpha)\wedge\forall z(\beta)\right)$?

(A) $\forall x\left(\exists z(\neg\beta)\rightarrow\forall y(\alpha)\right)$ (B) $\forall x\left(\forall z(\beta)\rightarrow\exists y(\neg\alpha)\right)$

(C) $\forall x\left(\forall y(\alpha)\rightarrow\exists z(\neg\beta)\right)$ (D) $\forall x\left(\exists y(\neg\alpha)\rightarrow\exists z(\neg\beta)\right)$

Ans: (A)

Exp: $\neg\exists x\left(\forall y(\alpha)\wedge\forall z(\beta)\right)\equiv\forall\times\left[\forall y(\alpha)\rightarrow\exists z(\neg\beta)\right]$ option "C"

$\left[\because\neg(P\wedge q)\equiv\ p\Rightarrow\neg q\right]$

$\equiv\forall x\left[\forall z(\beta)\rightarrow\exists y(\neg\alpha)\right]$ option "B"

$\left[\because p\Rightarrow q\equiv\neg q\Rightarrow\neg p\right]$

$\equiv\forall x\left[\forall y(\alpha)\rightarrow\exists z(\neg\beta)\right]$ option "D"

$\left[\because\neg(p\wedge q)\equiv p\Rightarrow(\neg q)\right]$

27. A RAM chip has a capacity of 1024 words of 8 bits each $(1K \times 8)$. The number of 2×4 decoders with enable line needed to construct a $16K \times 16$ RAM from $1K \times 8$ RAM is

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

Ans: (B)

Exp. RAM chip size = $1k \times 8$[1024 words of 8 bits each]

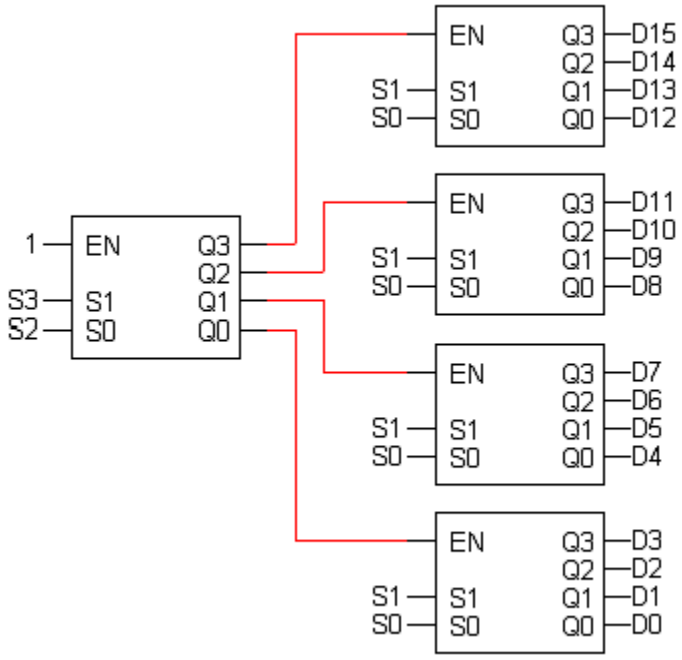
RAM to construct $= 16k \times 16$

Number of chips required = $\frac{16k \times 16}{1k \times 8} = 16 \times 2$ [16 chips vertically with each having 2 chips horizontally]

So to select one chip out of 16 vertical chips, we need 4 x 16 decoder.

Available decoder is – 2 x 4 decoder

To be constructed is 4 x 16 decoder



So we need 5, 2 x 4 decoder in total to construct 4 x 16 decoder.

28. Consider an instruction pipeline with five stages without any branch prediction: Fetch Instruction (FI), Decode Instruction (DI), Fetch Operand (FO), Execute Instruction (EI) and Write Operand (WO). The stage delays for FI, DI, FO, EI and WO are 5 ns, 7 ns, 10 ns, 8 ns and 6 ns, respectively. There are intermediate storage buffers after each stage and the delay of each buffer is 1 ns. A program consisting of 12 instructions $I_1, I_2, I_3, ...I_{12}$ is executed in this pipelined processor. Instruction I_4 is the only branch instruction and its branch target is I_9. If the branch is taken during the execution of this program, the time (in ns) needed to complete the program is

(A) 132 (B) 165 (C) 176 (D) 328

Ans: (C)

Exp: Total clock slots taken are 16. Each slot will take maximum of {5, 7, 10, 8 ,7} =10.

Hence total slots for all the instructions = $16\times10+16\left(pipeline\ delay\right)=176$

29. Consider the following operation along with Enqueue and Dequeue operations on queues, where k is a global parameter

```
MultiDequeue(Q) {
    m = k
    while (Q is not empty) and (m > 0) {
        Dequeue (Q)
        m = m – 1
    }
}
```

What is the worst case time complexity of a sequence of n queue operations on an initially empty queue?

(A) $\Theta(n)$ (B) $\Theta(n+k)$ (C) $\Theta(nk)$ (D) $\Theta(n^2)$

Ans: (C)

30. The preorder traversal sequence of a binary search tree is 30, 20, 10, 15, 25, 23, 39, 35, 42. Which one of the following is the postorder traversal sequence of the same tree?

(A) 10,20,15,23,25,35,42,39,30 (B) 15,10,25,23,20,42,35,39,30

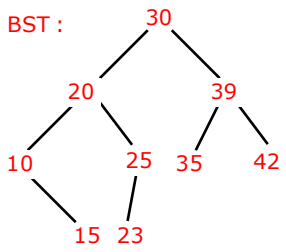
(C) 15,20,10,23,25,42,35,39,30 (D) 15,10,23,25,20,35,42,39,30

Ans: (D)

Exp:

Preorder : 30,20,10,15,25,23,39,35,42

Inorder : 10,15,20,23,25,30,35,39,42



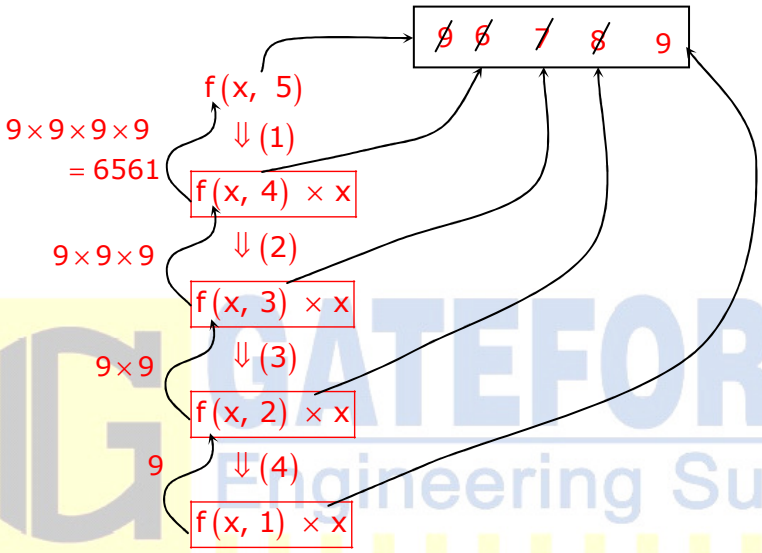
31. What is the return value of $f(p,p)$ if the value of p is initialized to 5 before the call? Note that the first parameter is passed by reference, whereas the second parameter is passed by value.

```
int f (int & x, int c) {
    c = c - 1;
    if (c == 0) return 1;
    x = x + 1;
    return f(x, c) * x;
}
```

(A) 3024 (B) 6561 (C) 55440 (D) 161051

Ans: (B)

Exp:



32. Which of the following is/are undecidable?

1. G is a CFG. Is $L(G) = \Phi$?
2. G is a CFG. IS $L(G) = \Sigma^*$?
3. M is a Turning machine. Is L(M) regular?
4. A is a DFA and N is a NFA. Is $L(A) = L(N)$?

(A) 3 only (B) 3 and 4 only (C) 1, 2 and 3 only (D) 2 and 3 only

Ans: (D)

Exp: There is an algorithm to check whether the given CFG is empty, finite or infinite and also to convert NFA to DFA hence 1 and 4 are decidable.

33. Consider the following two sets of LR(1) items of an LR(1) grammar

$X \rightarrow c.X, c / d$	$X \rightarrow c.X, \$$
$X \rightarrow .cX, c / d$	$X \rightarrow .cX, \$$
$X \rightarrow .d, c / d$	$X \rightarrow .d, \$$

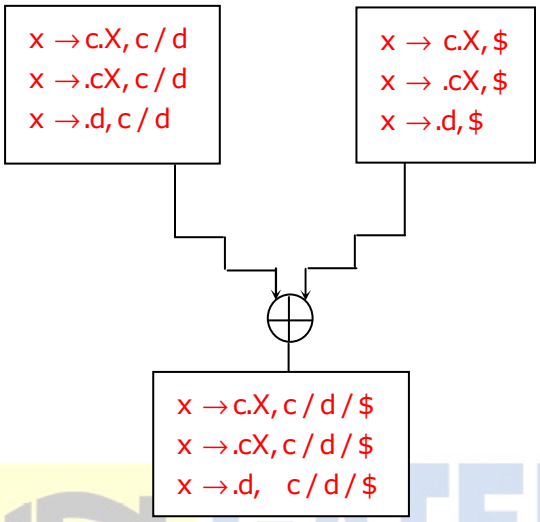
Which of the following statements related to merging of the two sets in the corresponding LALR parser is/are **FALSE**?

1. Cannot be merged since look aheads are different
2. Can be merged but will result in S–R conflict
3. Can be merged but will result in R–R conflict
4. Cannot be merged since goto on c will lead to two different sets

(A) 1 only (B) 2 only (C) 1 and 4 only (D) 1, 2, 3 and 4

Ans: (D)

Exp:



1. Merging of two states depends on core part (production rule with dot operator), not on look aheads.
2. The two states are not containing Reduce item ,So after merging, the merged state can not contain any S-R conflict
3. As there is no Reduce item in any of the state, so can't have R-R conflict.
4. Merging of stats does not depend on further goto on any terminal.

So all statements are false.

34. A certain computation generates two arrays a and b such that $a[i] = f(i)$ for $0 \le i < n$ and $b[i] = g(a[i])$ for $0 \le i < n$. Suppose this computation is decomposed into two concurrent processes X and Y such that X computes the array a and Y computes the array b. The processes employ two binary semaphores R and S, both initialized to zero. The array a is shared by the two processes. The structures of the processes are shown below.

```
Process X;                          Process Y;
private i;                          private i;
for (i = 0; i < n; i++) {           for (i = 0; i < n; i++) {
    a[i] = f(i);                        EntryY(R, S);
    ExitX(R, S);                        b[i] = g(a[i]);
}                                   }
```

Which one of the following represents the **CORRECT** implementations of ExitX and EntryY?

(A)
```
ExitX(R, S) {
    P(R);
    V(S);
}
EntryY(R, S) {
    P(S);
    V(R);
}
```

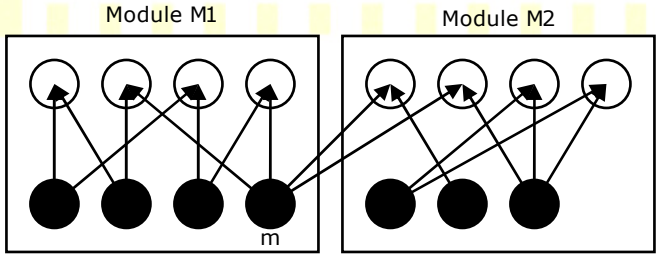
(B)
```
ExitX(R, S) {
    V(R);
    V(S);
}
EntryY(R, S) {
    P(R);
    P(S);
}
```

(C)
```
ExitX(R, S) {
    P(S);
    V(R);
}
EntryY(R, S) {
    V(S);
    P(R);
}
```

(D)
```
ExitX(R, S) {
    V(R);
    P(S);
}
EntryY(R, S) {
    V(S);
    P(R);
}
```

Ans: (B)

35. The following figure represents access graphs of two modules M1 and M2. The filled circles represent methods and the unfilled circles represent attributes. IF method m is moved to module M2 keeping the attributes where they are, what can we say about the average cohesion and coupling between modules in the system of two modules?



(A) There is no change.

(B) Average cohesion goes up but coupling is reduced

(C) Average cohesion goes down and coupling also reduces

(D) Average cohesion and coupling increase

Ans: (B)

36. In an IPv4 datagram, the M bit is 0, the value of HLEN is 10, the value of total length is 400 and the fragment offset value is 300. The position of the datagram, the sequence numbers of the first and the last bytes of the payload, respectively are

(A) Last fragment, 2400 and 2789

(B) First fragment, 2400 and 2759

(C) Last fragment, 2400 and 2759

(D) Middle fragment, 300 and 689

Ans: (C)

Exp: M= 0 – Means there is no fragment after this, i.e. Last fragment

HLEN=10 - So header length is 4×10=40, as 4 is constant scale factor

Total Length = 400(40 Byte Header + 360 Byte Payload)

Fragment Offset = 300, that means 300×8 Byte = 2400 bytes are before this last fragment

So the position of datagram is last fragment

Sequence number of First Byte of Payload = 2400 (as 0 to 2399 Sequence no are used)

Sequence number of Last Byte of Payload = 2400+360-1=2759

37. Determine the maximum length of cable (in km) for transmitting data at a rate of 500 Mbps in an Ethernet LAN with frames of size 10,000 bits. Assume the signal speed in the cable to be 2,00,000 km/s

(A) 1 (B) 2 (C) 2.5 (D) 5

Ans: (B)

Exp:

500×10^6 bits $-----$ 1 sec

$\therefore 10^4$ bits $----- \frac{5\times10^8}{10^4} = \frac{10^4}{5\times10^8}\text{sec} = \frac{1}{5\times10^4}\text{sec}$

1 sec $----- 2\times10^5$ km

$\therefore \frac{1}{5\times10^4}\text{sec} ----- \frac{2\times10^5}{5\times10^4} = 4\,\text{km}$

$\therefore$ Maximum length of cable $= \frac{4}{2} = 2$ km

38. Consider the following relational schema.

Students(rollno: integer, sname: string)

Courses(courseno: integer, cname: string)

Registration(rollno: integer, courseno; integer, percent: real)

Which of the following queries are equivalent to this query in English?

"Find the distinct names of all students who score more than 90% in the course numbered 107"

(I) SELECT DISTINCT S.sname
FROM Students as S, Registration as R
WHERE R.rollno=S.rollno AND R.Courseno=107 AND R.percent>90

(II) $\Pi_{\text{sname}}\left(\sigma_{\text{courseno}=107} \wedge \text{percent} > 90\left(\text{Registration} \quad \text{Students}\right)\right)$

(III) $\{T \mid \exists S \in \text{Students}, \exists R \in \text{Registration}\ (S.\text{rollno} = R.\text{rollno} \wedge$
$R.\text{courseno} = 107 \wedge R.\text{percent} > 90 \wedge T.\text{sname} = S.\text{name})\}$

(IV) $\left\{< S_N > \mid \exists S_R \exists R_P\ (< S_R, S_N > \in \text{Students} \wedge < S_R, 107, R_P > \in \text{Registration} \wedge R_P > 90)\right\}$

(A) I, II, III and IV (B) I, II and III only

(C) I, II and IV only (D) II, III and IV only

Ans: (A)

Exp: Four queries given in SQL, RA, TRC and DRC in four statements respectively retrieve the required information.

39. A shared variable x, initialized to zero, is operated on by four concurrent processes W, X, Y, Z as follows. Each of the processes W and X reads x from memory, increments by one, stores it to memory, and then terminates. Each of the processes Y and Z reads x from memory, decrements by two, stores it to memory, and then terminates. Each process before reading x invokes the P operation (i.e., wait) on a counting semaphore S and invokes the V operation (i.e., signal) on the semaphore S after storing x to memory. Semaphore S is initialized to two. What is the maximum possible value of x after all processes complete execution?

(A) –2 (B) –1 (C) 1 (D) 2

Ans: (D)

Exp:

	W	X	Y	Z
1	R (x)	R (x)	R (x)	R (x)
2	x++	x++	x=x-2;	x=x-2;
3	w(x)	w(x)	w(x)	w(x)

R(x) is to read x from memory, w(x) is to store x in memory

(I) w_1 (x 0) [W is Preempted]

(II) Y_1, Y_2, Y_3 (x –2) [Y is completed]

(III) Z_1, Z_2, Z_3 (x –4) [Z is completed]

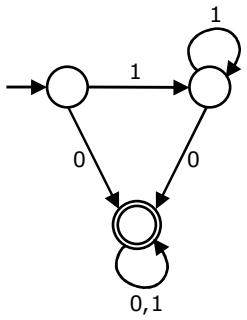
(IV)

W_2, W_3 (x 1) [It increments local copy of x and stores & W is completed]

(V) X_1, X_2, X_3 (x 2) [X is completed]

Maximum value of x = 2

40. Consider the DFA given below.



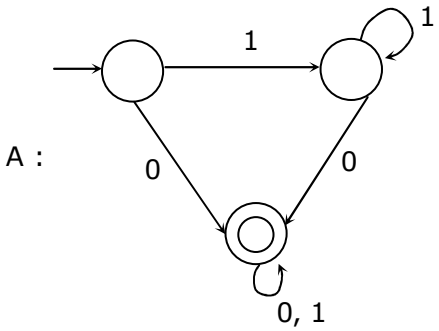
Which of the following are FALSE?

1. Complement of L(A) is context–free
2. $L(A) = L\left((11*0+0)(0+1)*0*1*\right)$
3. For the language accepted by A, A is the minimal DFA
4. A accepts all strings over {0, 1} of length at least 2

(A) 1 and 3 only (B) 2 and 4 only (C) 2 and 3 only (D) 3 and 4 only

Ans: (D)

Exp:



(1) L(A) is regular, its complement is also regular and if it is regular it is also context free.

(2) $L(A) = (11*0+0)(0+1)*0*1* = 1*0(0+1)*$

Language has all strings where each string contains '0'.

(3) A is not minimal, it can be constructed with 2 states

(4) Language has all strings, where each string contains '0'. (atleast length one)

41. Consider the following languages

$L_1 = \{0^p1^q0^r \mid p,q,r \geq 0\}$

$L_2 = \{0^p1^q0^r \mid p,q,r \geq 0,\ p \neq r\}$

Which one of the following statements is FALSE?

(A) L_2 is context–free

(B) $L_1 \cap L_2$ is context–free

(C) Complement of L_2 is recursive

(D) Complement of L_1 is context–free but not regular

Ans: (D)

Exp: $L_1 = \{0^P\ 1^q\ 0^r \mid p,q,r \geq 0\}$ is regular

$L_2 = \{0^P\ 1^q\ 0^r \mid p,q,r \geq 0,\ p \neq r\}$ is CFL

(A) L_2 is CFL (True)

(B) $L_1 \cap L_2$ = CFL (True)

(C) L_2 complement is recursive (True)

(D) L_1 complement is CFL but not regular (False) as L_1 is regular $\bar{L}_1$ is regular

42. Consider the following function

```
int unknown(int n){
        int i, j, k = 0;
        for (i = n / 2; i <= n; i++)
            for (j = 2; j <= n; j = j * 2)
            k = k + n / 2;
        return (k);
}
```

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

Ans: (B)

Exp: $i = \left(\frac{n}{2}, \frac{n}{2}+1, \frac{n}{2}+2, ----n\right)$

Repeats $\frac{n}{2}$ to $n = \left(\frac{n}{2}+1\right)$ times $\left\{\begin{matrix} J = (2, 2^2, 2^3, 2^4, ----n) \\ k = k + \frac{n}{2} \end{matrix}\right\} k = \Theta(n \log n)$

$$k = \frac{n}{2} + \frac{n}{2} + ----\log n \text{ times} = \frac{n}{2}\log n$$

$$= \frac{n}{2}\log n + \frac{n}{2}\log n + \frac{n}{2}\log n ---- \left(\frac{n}{2}+1\right) \text{times}$$

$$= \left(\frac{n}{2}+1\right) \cdot \frac{n}{2} \log n$$

$$= \Theta(n^2 \log n)$$

43. The number of elements that can be sorted in $\Theta(\log n)$ time using heap sort is

(A) $\Theta(1)$ (B) $\Theta(\sqrt{\log}\ n)$ (C) $\Theta\left(\frac{\log n}{\log \log n}\right)$ (D) $\Theta(\log n)$

Ans: (A)

Exp: After constructing a max-heap in the heap sort , the time to extract maximum element and then heapifying the heap takes $\Theta(\log n)$ time by which we could say that $\Theta(\log n)$ time is required to correctly place an element in sorted array. If $\Theta(\log n)$ time is taken to sort using heap sort, then number of elements that can be sorted is constant which is $\Theta(1)$

44. Consider a hard disk with 16 recording surfaces $(0-15)$ having 16384 cylinders $(0-16383)$ and each cylinder contains 64 sectors $(0-63)$. Data storage capacity in each sector is 512 bytes. Data are organized cylinder–wise and the addressing format is <cylinder no., sector no.>. A file of size 42797 KB is stored in the disk and the starting disk location of the file is <1200, 9, 40>. What is the cylinder number of the last sector of the file, if it is stored in a contiguous manner?

(A) 1281 (B) 1282 (C) 1283 (D) 1284

Ans: (D)

$42797\ KB \equiv \frac{42797 \times 1024}{512} = 85594$ sectors

Starting is $\langle 1200, 9, 40 \rangle$ contains total $24 + (6 \times 64) = 408$ sectors

Next, 1201, --------, 1283 cylinders contains total $1024 \times 83 = 84992$ sectors

$(\because$ each cylinder contains $16 \times 64 = 1024$ sectors$)$

$\therefore$ Total $= 408 + 84992 = 85400$ sectors

$\therefore$ The required cylinder number is $\langle 1284 \rangle$ which will contain the last sector of the file

45. Consider the following sequence of micro–operations

MBR ← PC

MAR ← X

PC ← Y

Memory ← MBR

Which one of the following is a possible operation performed by this sequence?

(A) Instruction fetch (B) Operand fetch

(C) Conditional branch (D) Initiation of interrupt service

Ans: (D)

Exp: PC content is stored in memory via MBR and PC gets new address from Y. It represents a function call (routine), which is matching with interrupt service initiation

46. The line graph L(G) of a simple graph G is defined as follows:

- There is exactly one vertex v(e) in L(G) for each edge e in G.
- For any two edges e and e' in G, L(G) has an edge between v(e) and v(e'), if and only if e and e' are incident with the same vertex in G.

Which of the following statements is/are **TRUE**?

(P) The line graph of a cycle is a cycle.

(Q) The line graph of a clique is a clique.

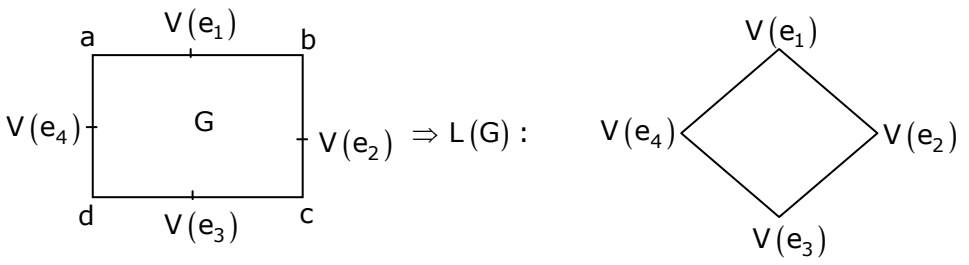
(R) The line graph of a planar graph is planar.

(S) The line graph of a tree is a tree.

(A) P only (B) P and R only (C) R only (D) P, Q and S only

Ans: (B)

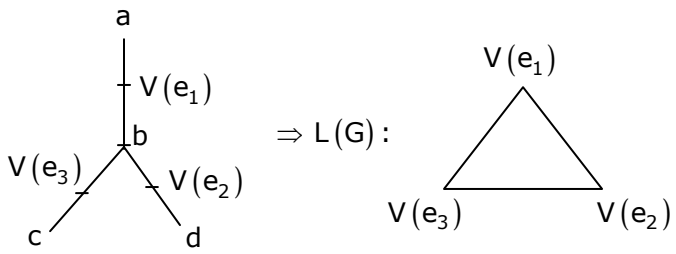
Exp: P) The line graph of a cycle is a cycle



is also cycle graph

R) Line graph of planar graph is planar

S)



The line graph of a tree need not be tree.

47. What is the logical translation of the following statement?

"None of my friends are perfect."

(A) $\exists x\left(F(x)\wedge\neg P(x)\right)$ (B) $\exists x\left(\neg F(x)\wedge P(x)\right)$

(C) $\exists x\left(\neg F(x)\wedge\neg P(x)\right)$ (D) $\neg\exists x\left(F(x)\wedge P(x)\right)$

Ans: (D)

Exp: "None of my friends are perfect"

$= \forall x\left(F(x)\rightarrow\neg P(x)\right)$

$= \forall x\left(\neg F(x)\vee\neg P(x)\right)$

$= \neg\exists x\left(F(x)\wedge P(x)\right)$

Common Data Questions: 48 & 49

The procedure given below is required to find and replace certain characters inside an input character string supplied in array A. The characters to be replaced are supplied in array oldc, while their respective replacement characters are supplied in array newc. Array A has a fixed length of five characters, while arrays oldc and newc contain three characters each. However, the procedure is flawed

```
void find_and_replace (char *A, char *oldc, char *newc) {
        for (int i = 0; i < 5; i++)
            for (int j = 0; j < 3; j++)
                if (A[i] == oldc[j])    A[i] = newc[j];
}
```

The procedure is tested with the following four test cases

(1) oldc = "abc", newc = "dab" (2) oldc = "cde", newc = "bcd"

(3) oldc = "bca", newc = "cda" (4) oldc = "abc", newc = "bac"

48. The tester now tests the program on all input strings of length five consisting of characters 'a', 'b', 'c', 'd' and 'e' with duplicates allowed. If the tester carries out this testing with the four test cases given above, how many test cases will be able to capture the flaw?

(A) Only one (B) Only two (C) Only three (D) All four

Ans: (B)

Exp: Flaw in this given procedure is that one character of Array 'A' can be replaced by more than one character of newc array, which should not be so.Test case (3) and (4) identifies this flaw as they are containing 'oldc' and 'newc' array characters arranged in specific manner. Following string can reflect flaw, if tested by test case (3).

initially i = j = 0

A = "bcda" oldc = "bca" newc = "cda"

i = 0 j = 0 j = 0

b = b so replaced by c

Next i = 0 & j = 1

A = "ccda" oldc = "bca" newc = "cda"

i = 0 j = 1 j = 1

c = c so replaced by d

Likewise single character 'b' in A is replaced by 'c' and then by 'd'.

Same way test case (4) can also catch the flaw.

49. If array A is made to hold the string "abcde", which of the above four test cases will be successful in exposing the flaw in this procedure?

(A) None (B) 2 only (C) 3 and 4 only (D) 4 only

Ans: (C)

Exp: Now for string "abcde" in array A, both test case (3) and (4) will be successful in finding the flaw, as explained in above question.

Common Data Questions: 50 & 51

The following code segment is executed on a processor which allows only register operands in its instructions. Each instruction can have almost two source operands and one destination operand. Assume that all variables are dead after this code segment

```
c = a + b;
d = c * a;
e = c + a;
x = c * c;
if (x > a) {
   y = a * a;
}
else {
   d = d * d;
   e = e * e;
}
```

50. Suppose the instruction set architecture of the processor has only two registers. The only allowed compiler optimization is code motion, which moves statements from one place to another while preserving correctness. What is the minimum number of spills to memory in the compiled code?

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

Ans: (C)

Exp:

$c = a + b;$	$R_2 \leftarrow R_1 + R_2$
$d = c * a;$	$[spill] \leftarrow R_2 * R_1$
$e = c + a;$	$[spill_2] \leftarrow R_2 + R_1$
$x = c * c;$	$R_2 \leftarrow R_2 * R_2$
if $(x > a)$	CMP R_2 R_1 JNG xxx (Jump if not greater)
$\{y = a * a;\}$	$R_1 \leftarrow R_1 * R_1$ goto yyy

else
{
$d = d * d;$
$e = e * e;$
}
	xxx : $R_1 \leftarrow [spill_1]$
	$R_2 \leftarrow [spill_2]$
	$R_1 \leftarrow R_1 * R_1$
	$R_2 \leftarrow R_2 * R_2$
	yyy : Exit

In the above code total number of spills to memory is 2

51. What is the minimum number of registers needed in the instruction set architecture of the processor to compile this code segment without any spill to memory? Do not apply any optimization other than optimizing register allocation

(A) 3 (B) 4 (C) 5 (D) 6

Ans: (B)

Exp:

$c = a + b;$	$R_2 \leftarrow R_1 + R_2$
$d = c * a;$	$R_3 \leftarrow R_2 * R_1$
$e = c + a;$	$R_4 \leftarrow R_2 + R_1$
$x = c * c;$	$R_2 \leftarrow R_2 * R_2$

if (x > a)	CMP R_2 R_1 JNG xxx (Jump if not greater)
{y = a * a;}	$R_1 \leftarrow R_1 * R_1$ goto yyy

else
{
d = d * d;
e = e * e;
}
	xxx : $R_3 \leftarrow R_3 * R_3$
	$R_4 \leftarrow R_4 * R_4$
	yyy : Exit

In the above code minimum number of registers are used = 4

Linked Answer Questions: Q.52 to Q.55 Carry Two Marks Each

Statement for Linked Answer Questions: 52 & 53

Relation R has eight attributes ABCDEFGH. Fields of R contain only atomic values.

$F = \{CH \rightarrow G,\ A \rightarrow BC,\ B \rightarrow CFH,\ E \rightarrow A,\ F \rightarrow EG\}$ is a set of functional dependencies (FDs) so that F^+ is exactly the set of FDs that hold for R

52. How many candidate keys does the relation R have?

(A) 3 (B) 4 (C) 5 (D) 6

Ans: (B)

Exp: Candidate keys are AD, BD, ED and FD

53. The relation R is

(A) in INF, but not in 2NF (B) in 2NF, but not in 3NF

(C) in 3NF, but not in BCNF (D) in BCNF

Ans: (A)

Exp: $A \rightarrow BC, B \rightarrow CFH$ *and* $F \rightarrow EG$ are partial dependencies. Hence it is in 1NF but not in 2NF

Statement for Linked Answer Questions: 54 & 55

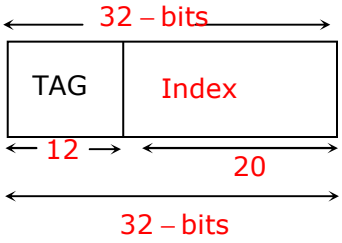
A computer uses 46–bit virtual address, 32–bit physical address, and a three–level paged page table organization. The page table base register stores the base address of the first–level table (T_1) ,which occupies exactly one page. Each entry of T_1 stores the base address of a page of the second–level table (T_2). Each entry of T_2 stores the base address of a page of the third–level table (T_3) Each entry of T_3 stores a page table entry (PTE). The PTE is 32 bits in size. The processor used in the computer has a 1 MB 16 way set associative virtually indexed physically tagged cache. The cache block size is 64 bytes.

54. What is the size of a page in KB in this computer?

(A) 2 (B) 4 (C) 8 (D) 16

Ans: (B)

Exp: As it is virtually indexed



$1MB = 2^{20}$ byte

Set size = 16×64 Bytes $= 2^{10}$

number of sets $= \frac{2^{20}}{2^{10}} = 2^{10}$

Index of cache bits will be used as frame bits.

Frame size = 2^{12}=4K bytes

55. What is the minimum number of page colours needed to guarantee that no two synonyms map to different sets in the processor cache of this computer?

(A) 2 (B) 4 (C) 8 (D) 16

Ans:

Q. No. 56 – 60 Carry One Mark Each

56. Complete the sentence:

Universalism is to particularism as diffuseness is to _____

(A) specificity (B) neutrality (C) generality (D) adaptation

Ans: (A)

The relation is that of antonyms

57. Were you a bird, you _____ in the sky.

(A) would fly (B) shall fly

(C) should fly (D) shall have flown

Ans: (A)

58. Which one of the following options is the closest in meaning to the word given below?

Nadir

(A) Highest (B) Lowest (C) Medium (D) Integration

Ans: (B)
Nadir in the lowest point on a curve

59. Choose the grammatically INCORRECT sentence:
(A) He is of Asian origin
(B) They belonged to Africa
(C) She is an European
(D) They migrated from India to Australia

Ans: (C)

60. What will be the maximum sum of 44, 42, 40, ... ?
(A) 502 (B) 504 (C) 506 (D) 500

Ans: (C)
The maximum sum is the sum of 44, 42,- - - - -2.
The sum of 'n' terms of an AP

$= \frac{n}{2}\left[2a + (n-1)d\right]$

In this case, n = 22, a = 2 and d = 2

$\therefore \text{Sum} = 11\left[4 + 21 \times 2\right] = 11 \times 46 = 506$

Q. No. 61 – 65 Carry Two Marks Each

61. Out of all the 2-digit integers between 1 and 100, a 2-digit number has to be selected at random. What is the probability that the selected number is not divisible by 7?
(A) 13/90 (B) 12/90 (C) 78/90 (D) 77/90

Ans: (D)
The number of 2 digit multiples of 7 = 13
$\therefore$ Probability of choosing a number

Not divisible by $7 = \frac{90-13}{90} = \frac{77}{90}$

62. A tourist covers half of his journey by train at 60 km/h, half of the remainder by bus at 30 km/h and the rest by cycle at 10 km/h. The average of the tourist in km/h during his entire journey is
(A) 36 (B) 30 (C) 24 (D) 18

Ans: (C)
Let the total distance covered be 'D'

Now, average speed = $\frac{D}{\text{Total time taken}}$

$= \frac{D}{\left(\frac{\frac{D}{2}}{60} + \frac{\frac{D}{4}}{30} + \frac{\frac{D}{4}}{10}\right)} = \frac{1}{\frac{1}{120} + \frac{1}{120} + \frac{1}{40}} = \frac{120}{5} = 24\,\text{km/hr}$

63. Find the sum of the expression

$$\frac{1}{\sqrt{1}+\sqrt{2}}+\frac{1}{\sqrt{2}+\sqrt{3}}+\frac{1}{\sqrt{3}+\sqrt{4}}+\ldots..+\frac{1}{\sqrt{80}+\sqrt{81}}$$

(A) 7 (B) 8 (C) 9 (D) 10

Ans: (B)

The expression can be written as

$$\frac{\left(\sqrt{2}\right)^2-\left(\sqrt{1}\right)^2}{\sqrt{1}+\sqrt{2}}+\frac{\left(\sqrt{3}\right)^2-\left(\sqrt{2}\right)^2}{\sqrt{2}+\sqrt{3}}+------\frac{\left(\sqrt{81}\right)^2-\left(\sqrt{80}\right)^2}{\sqrt{80}+\sqrt{81}}$$

$$=\frac{\left(\sqrt{2}-\sqrt{1}\right)\left(\sqrt{1}+\sqrt{2}\right)}{\left(\sqrt{1}+\sqrt{2}\right)}+-------+\frac{\left(\sqrt{81}-\sqrt{80}\right)\left(\sqrt{81}+\sqrt{80}\right)}{\sqrt{80}+\sqrt{81}}$$

64. The current erection cost of a structure is Rs. 13,200. If the labour wages per day increase by 1/5 of the current wages and the working hours decrease by 1/24 of the current period, then the new cost of erection in Rs. is

(A) 16,500 (B) 15,180 (C) 11,000 (D) 10,120

Ans: (B)

Let 'W' be the labour wages, and 'T' be the working hours.

Now, total cost is a function of $W \times T$

Increase in wages = 20%

$\therefore$ Revised wages = 1.2 W

Decrease in labour time = $\left(\frac{100}{24}\right)\%$

$$\therefore \text{ Revised time} = \left(1-\frac{1}{24}\right)T = \frac{23}{24}\,T$$

$$\therefore \text{ Revised Total cost} = 1.2\times\frac{23}{24}\,WT = 1.15\,WT$$

$$= 1.15\times 13200 = 15180$$

65. After several defeats in wars, Robert Bruce went in exile and wanted to commit suicide. Just before committing suicide, he came across a spider attempting tirelessly to have its net. Time and again, the spider failed but that did not deter it to refrain from making attempts. Such attempts by the spider made Bruce curious. Thus, Bruce started observing the near-impossible goal of the spider to have the net. Ultimately, the spider succeeded in having its net despite several failures. Such act of the spider encouraged Bruce not to commit suicide. And then, Bruce went back again and won many a battle, and the rest is history.

Which one of the following assertions is best supported by the above information?

(A) Failure is the pillar of success

(B) Honesty is the best policy

(C) Life begins and ends with adventures

(D) No adversity justifies giving up hope

Ans: (D)

GATE 2015 – A Brief Analysis
(Based on student test experiences in the stream of CS on 8th February, 2015 – (Morning Session)

Section wise analysis of the paper

Section Classification	1 Mark	2 Marks	Total Number of Questions
Engineering Mathematics	2	3	5
Discrete Mathematics	3	2	5
Digital Logic	1	2	3
Computer Organization	2	2	4
Theory of Computation	1	3	4
Data Structures & Algorithms	9	5	14
Compiler Design	1	3	4
Operating Systems	2	2	4
DBMS	1	3	4
Computer Networks	2	2	4
SEWT	1	3	4
Verbal Ability	2	3	5
Numerical Ability	3	2	5
	30	**35**	**65**

Questions from the Paper

GATE 2015
8th February 9:00 to 12:00

1. Let f(x) be a linear function such that $f(-2)=29$ and $f(3)=39$. Find the value of f(5).

2. What is the value of the postfix operation?

3. Consider a program code which was fed with 100 artificial errors. On analyzing the errors, 159 errors were reported of which 75 were the artificial errors that were initially seeded. What is the closest approximation of the number of errors in the program?

4. Question on <base href=" " >

5. Consider a power set U of a set $S=\{1,2,3,4,5,6\}$. Let $T \in U$ such that T' denotes the compliment of the set and |T| denote the number of elements in T. Let T/R denote the set of elements which are T but not in R. Which of the following is true?

   (A) $\forall X \in U(|X|=|X'|)$

   (B) $\exists X \exists Y \in U(|X|=5,|Y|=5,X \cap Y=\phi)$

   (C) $\forall X \forall Y \in U(|X|=2,|Y|=3,X/Y=\phi)$

   (D) $\forall X \forall Y \in U(X/Y=Y'/X')$

6. The maximum number of processes that can be in READY state on a processor with n CPUs is?

   (A) n (B) n – 1 (C) 2 ^ n (D) Independent of n

Key: (D)

Exp: Number of processes which are in running proceses will be atmost n as there are n processors. Maximum no. of processes that will be in ready state in independent of no. of processors.

7. Consider the following statements. Which of them is true?

   S1: TCP allows full duplex communication

   S2: TCP has no option for selective acknowledgments

   S3: TCP work as a message stream.

   (A) Only S1

   (B) Only S2

   (C) S1, S2, S3

   (D) S1 and S3, but not S2

8. Consider a hash table with 25 slots and 200 entries. What is the load factor α of the hash table?

9. Consider the following relation table:

table(theatre, address capacity)

What should be written at the end of this query

Select P1.address

From table P1

Such that it returns the theatre with maximum capacity?

(A) Where capacity > = ALL(select P2.capacity from table p2)

(B) Where capacity > = ANY(select P2.capacity from table p2)

(C) Where capacity > ALL(select P2.capacity from table p2)

(D) Where capacity > ANY(select P2.capacity from table p2)

Key: (A)

Exp: Inner query collects capacities of all the theatres and in outer query we are filterin the tuples with the condition "capaicty>=All". So the theatres which are having maximum capacity will be satisfy the conductivity and they will.

10. How many 4-digit numbers can be formed such that the digits are in non-decreasing order (from left to right) using only digits {1, 2, 3}?

11. Question on critical section where two processes P_1 and P_2. It asks about mutual exclusion and deadlock.

12. Consider the equation $\Sigma i^3 = X$. Also consider the following:

i. $\theta(n^4)$

ii. $\theta(n^3)$

iii. $O(n \wedge 5)$

iv. $\Omega(n \wedge 5)$

Which of the above can correctly replace X?

(A) Only I (B) I and II (C) I, III and IV (D)

Key: (C)

Exp: X= sum of the cabes of n natural numbers $= \frac{n^2(n+1)^2}{4}$ which is $\theta(n^4), 0(n^5)$ & $\Omega(n^3)$.

13. Consider the following C code:

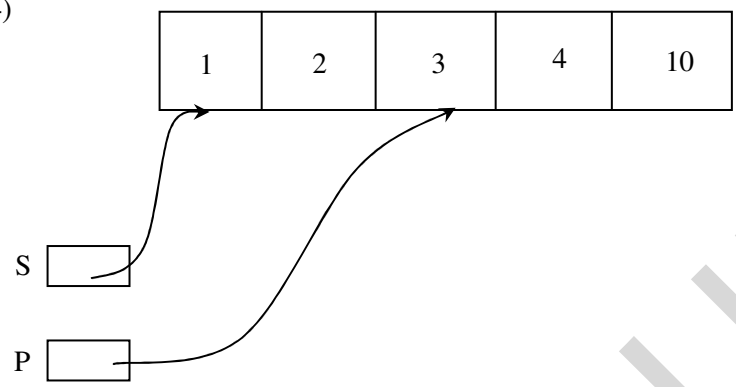
```
#include<stdio.h>
main(){
char s1[7] = "1234", *p;
```

```
p = s1+2;
*p = '0';
Printf("%s", s1);
}
```

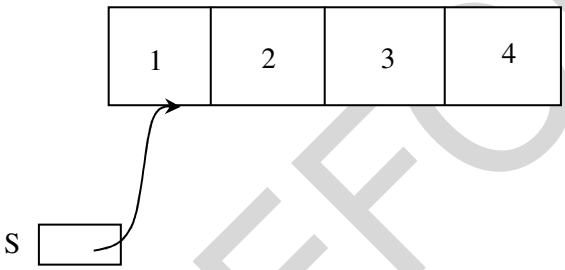
(A) 12 (B) 120400 (C) 1204 (D)

Key: (1204)

Exp:



After *P = '0'.



and we are pointing strife s which is 1204.

14. Let # be a binary operator such that:

$X\# = X' + Y'$

Consider the following two statements:

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

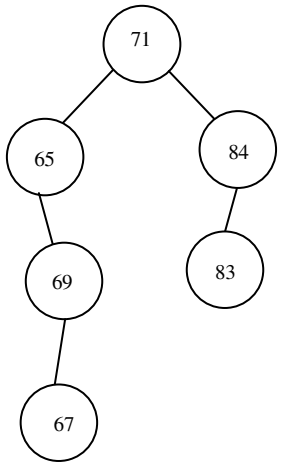
$S2: Q\#R = R\#Q$

Which of them is correct?

15. Consider the language $L = \Sigma^* 0011 \Sigma^*$ where $\Sigma = \{0,1\}$. What is the minimum number of states in the DFA of compliment of L i.e. L'?

16. The elements 71, 65, 84, 69, 67, 83 are inserted in a binary search tree. The element in the lowest level is?

Exp:



17. Consider the following elements:

$< 85,19,50,17,11,12,15,8,9,6,5,2,100 >$

The minimum number of interchanges required to convert this into a max-heap is?

Exp: 1st snap is between 100 & 12

2nd snap is between 100 & 50

3rd snap is between 100 & 85.

18. The limit evaluates to:

$\lim_{x \to \infty} \left(1 + x^2\right) e^{-x}$

(A) 1 (B) $1/2$ (C) -1 (D) ∞

19. Given a relation (PQRTUV) and the following two functional dependencies:

PQ -> RS.

Which of the following is a trivial FD which can be implied from F+ over F?

20. CSMA/CD question to find speed of signal:

Ans: $\frac{1250 * 8}{10^8} \geq 2 * \frac{1}{x}$

Exp: Given L=1250 Bytes

B= 100 mbps

d= 1km

V=?

In CSMA/CD, $L = 2 \times \frac{d}{v} \times B$

$$\Rightarrow V = \frac{2dB}{L} = \frac{2\times10^{3}\times10^{84}}{10^{4}}$$

$$\Rightarrow V = 20,000\,KM/sec$$

(or)

$$V = 0.2\times\omega^{8}\ m/s$$

21. Consider a binary tree with 200 leaf nodes. What is the number of nodes having exactly two children?

Key: 399

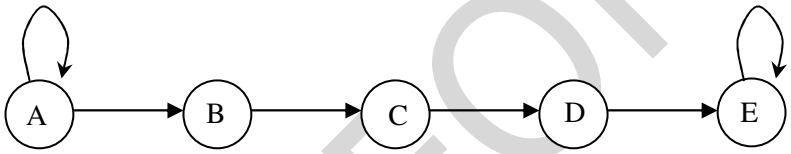
Exp: $p = \frac{n+1}{2}$

$p = 200$

$200 = \frac{n+1}{2}$

$2(200) = n+1$

$n = 400-1 = 399$



A	AB	A
B	C	–
C	–	D
D	–	E
E	E	E
AB	ABC	A
ABC	ABC	AD
AD	AB	AE
AE	ABE	AE
ABE	ABCE	AE
ABCE	ABCE	ADE
ADE	ABE	AE

22. Consider a 2^20 byte addressable main memory and block size of 16 bytes with a direct mapped cache of 2^12 cache lines. Two bytes are consecutively stored in the memory addresses $(E201F)_{16}$ and $(E2020)_{16}$. What is the tag and cache line address of address $(E201F)_{16}$?

(A) E, 201 (B) E, E201 (C) F, 201 (D) ..

23. There are types of people. Type 1 always tells the truth and Type 2 always tell the lie. A coin is tossed by one person whose type is unknown. He does not tell the result of coin toss till asked. Upon asking, he replies:

"The coin toss has resulted in heads if and only if I tell the truth"

Which is the following is true?

(A) Result is head

(B) Result is tail

(C) If person is Type 1, then result is tail

(D) If person is Type 2, then result is tail

24. Consider the following C code:

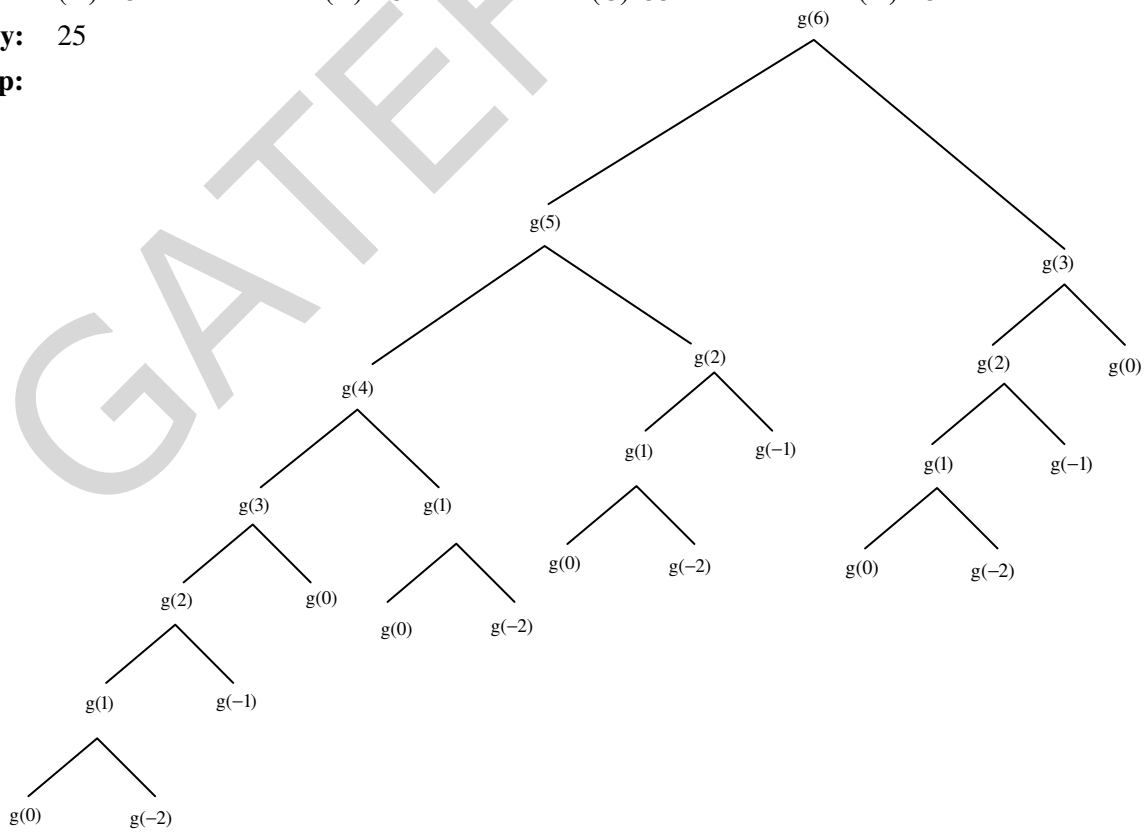
```
get int(n)
{
    if (n < 1) return;
    get(n − 1);
    get(n − 3)
    print f(%d", n);
}
```

If the above function is called from main() with get(6), then the number of times the get() recursive call is made?

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

Key: 25

Exp:



25. Question about GoBackN and minimum number of bits in sequence number. W>= 1+2a

26. A language L1 is polynomial time reducible to L2. A language L3 is also polynomial time reducible to L2, which in turn is polynomial time reducible to L4. Which of the following statement are true?

i. If $L4 \in P$, then $L2 \in P$

ii.

iii.

iv. If $L4 \in P$, then $L1 \in P$ and $L3 \in P$

Key: (C)

Exp: $L_2 \leq pL_4$

$L_1 \leq pL_2$

If $L_4 \in P$ then $L_2 \in P$ hence $L_1 \in P$ hence option C.

27. Mergesort algorithm takes about 30 seconds on an input of 64 elements. What is the correct approximation for the number of elements that can be sorted in 6 minutes using mergesort?

Key: 256

Exp: Time complexity $= 0(n \log n)$

$0(n \log n) = 30s.$

$n = 64$

$\theta(64 \times \log 64) = 30$

hence will set factor of 12.8.

for 3 min.

$= 3 \times 60$

$0(256109256) \Rightarrow 180$

will get factory of 11.37

for 512 will get 25.6.

for 1024 will get 56.8

for 2048 will get 125.155

hence 256 is near to answer.

28. Consider a network 200.10.11.144/27. What is the value of the last octet (in decimal) of the last host in this network?

Key:

Exp: Given IP address 200.10.11.144/27

To find out the loss address in a block, we have to set (32-4) no. of right most bits to 1.

n=27

$32 - n = 32 - 27 = 5$

200.10.11.10011111

200.10.11.159

$\therefore$ CDR Address range is 200.10.11.128/27-200.10.11.159/27

But w.r.t the question, the volume of the last octet of last host in this n/w is 200.10.11.158.

29. Consider two functions:

$f(n) = n$

$g(n) = n^{(1+\sin n)}$

Then which is correct

$f(n) = O(g(n))$

$g(n) = O(f(n))$

Exp: As $-1 \leq \sin x \leq 1$, neither of them is true

30. Consider a relation R on ordered pair of integers such that $((p,q),(r,s)) \in R$ If $p - s = q - r$.

Which of the following is true about the relation R?

(A) Reflexive and Symmetric

(B) Not reflexive but symmetric

(C) Reflexive but not symmetric

(D) Not reflexive nor symmetric

Key: (B)

Exp: R is reflexive if (p,q) R (p,q) $\forall$ p,q $\in$ z

(p,q) R (p,q) if p-q = q-p which is false

$\therefore$ R is not reflexive

R is symmetric is (p,q) R (r,s) then (r,s) R (p,q)

If (p,q) R (r,s) then p-s = q-r

If (r,s) R (p,q) then r-q = s-p which is true when p-s = q-r

$\therefore$ R is symmetric

31. A graph consists of 100 vertices and 300 edges. The minimum spanning tree of the graph has a weight of 500. The weight of each edge is then increased by 5. The weight of the new MST is___.

Key: 995

Exp: 100 vertices and weight 500

So there 99 edges with weight 500.

Consider one instances

where 98 edges have weight 5

and one edge having weight 10

no we have to increase weight by 5.

Hence, $98\times10+15=995$

32. Mccabe cyclomatic complexity of two modules A and B, and their combined cyclomatic complexity: Answer: 4,4,7

33. Two hosts communicate using packet switched. The hosts are connected via a switch over 10^7 bit per second links. The propagation delay on both links is 20 microseconds. The hosts send a total of 10000 bits in two packets of 5000 bits each. The switch waits for 35 microseconds between sending a frame and receiving a frame. What is the total delay (in microseconds) between sending the last bit and receiving the first bit?

34. The function $af(x)+bf\left(\frac{1}{x}\right)=\frac{1}{x}-25$. What is the value of $\int_1^2 f(x)dx$?

(A) $\frac{1}{a^z-b^z}\left\{a(\ln 2-25)+\frac{47b}{2}\right\}$

35. The maximum number of possible solutions to the equation $(43)_x=(y3)_8$ are:

Key: (5)

Exp: $(43)_x = (y3)_8$

$\Rightarrow 3+4x = 3+8y \Rightarrow 4x = 8y$

$\Rightarrow x = 2y$

$\Rightarrow x\geq5$ and $y\leq7$

$\therefore$ 5 solutions are possible which are (14,7), (12,6), (10,5), (8,4) and (6,3)

36. Consider the following code fragment:

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

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

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

What is the output?

(A) i only (B) ii only (C) I & iii (D) I & ii

Key:

Exp: $a^m b^n a^n b^m \Rightarrow$ This one is CFL

$a^m b^n a^m b^n \Rightarrow$ by pumping lemma this one is not CFL.

$\{a^m b^n | m = 2n+1\}$ This is CFL.

37. An array $C =< c_0, c_1 .. c_{k-1} >$ has elements from either 0 or 1. Consider the following code:

```
DoSomething(c,a,n)
{
    z < −1
    For i = 0 to k − 1
    do
                z < −z^2 mod n
                if c[i] = 1
                z < −a * z mod n
    end
    return z;
}
```

If $k-4, c =< 1,0,1,1 >, a = 2,$ and $n = 8$, what is the value returned?

Key: (0)

Exp:

C	i	0	1	1

$2 = 0$

20 something

$\{z=1$ for $i=0+0.3$ do	$k=0$ $z=1$			
$z<-2^2 \bmod$ if $c[i]=1$ $z<-2\times 2 \bmod 8$ end return 2$\}$	$z=1$ $c[0]=1$ $z=2$	$z=4$ $c[1]=0$	$z=0$ $c[1]=1$ $z=0$	$z=0$ $c[1]=1$ $z=0$

Ans: z=0

38. Which of the following is a context free language?

i. $\{a^m b^n a^n b^m\}$

ii. $\{a^m b^n a^m b^n\}$

iii. $\{a^m b^n \mid 2m=n+1\}$

39. Consider a binary function $F=P'+QR$ such that $P'=!P$. Which of the following is correct for F?

i. $F=\Sigma(4,5,6)$

ii. $F=\Sigma(0,1,2,3,7)$

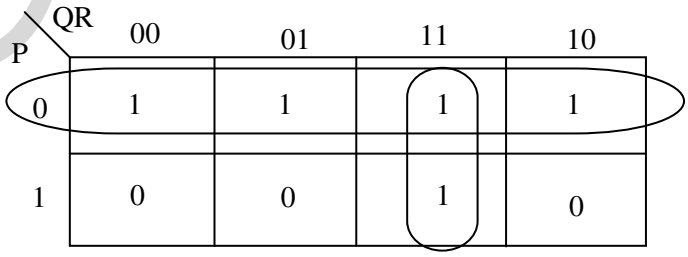
iii. $F=\Pi(4,5,6)$

iv. $F=\pi(0,1,2,3,7)$

(A) only A (B) only B (C) Both B & C (D) Both A & C

Key:

Exp: $F=P'+QR$



hence $\sum(0,1,2,3,7)$

$\pi(4,5,6)$

41. A B+ tree has a search value field of 12 Bytes, a record pointer of ..bytes, and a block pointer of 8 bytes with block size 1024. What is the maximum number of keys that can be accommodated in a non-leaf node?

Key: 50

Exp: Suppose that 'k' is order of the non-leaf node

$k(8)+(k-1)12 \le 1024$

$20k \le 1036$

$$k \le \left\lfloor \frac{1036}{20} \right\rfloor \Rightarrow k \le 51$$

As the order is 51, maximum we can store 50 keys

42. Consider the following C Code:

```
#inlcude < stdio.h >
void main( )
{
int a{10,20,30,40,50};
int* p[ ]={a,a+3,a+4,a+1,a+2}
int**ptr;
ptr = &p;

ptr++;
printf("%d%d", ptr-p, **ptr);
}
```

What is the output?

43. CO question about data dependence in pipeline:

OP OP r_1, r_2, r_3 implies $r_1 < -r_2$ OP r_3

There are five instructions to be executed. ……..

44. X is a two dimensional matrix such that X is initialized as $X[I, j] = i + j,$ and Y is a one dimensional matrix with all zero's. Two code fragments are given.

In one: $y[i] += x[0][i]$ and in another $y[i] += x[i][0]$

45. Question about Simpson's 1/3rd rule

46. Question about computing Function point after providing all the parameter values

47. Question about smallest turnaround time in OS after providing four processes:

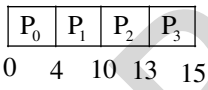
Process	Arrival Time	Duration
P_0	0	4
P_2	1	6
P_3	5	4
P_4	6	2

(Values may be inaccurate)

Exp: Given snapshot

Process	AT	BT
P_0	0	4
P_1	1	6
P_2	4	3
P_3	6	2

(A) Gautt chart:



	AT	BT	LT	TAT
P_0	0	4	4	4
P_1	1	6	10	9
P_2	4	3	13	9
P_3	6	2	15	9
				31

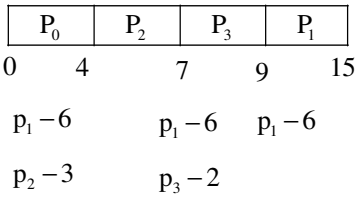
$$\frac{31}{4} = 7.75$$

(B) SJF(Non-preemption)

	AT	BT	LT	TAT
P_0	0	4	4	4
P_1	1	6	15	14
P_2	4	3	7	3
P_3	6	2	9	3
				24

$$\frac{24}{4} = 6$$

Gautt Chart



(C) SRTF

	AT	BT	LT	TAT
P_0	0	4	4	4
P_1	1	6	15	14
P_2	4	3	7	3
P_3	6	2	9	3
				24

$$\frac{24}{4} = 6$$

Gautt Chart

P_0	P_2	P_3	P_1

0 4 7 9 15

P_0	P_0	P_2	P_2	P_3	P_1

0 1 4 6 7 9 15

$p_0 - 3$ $p_1 - 6$ $p_1 - 6$ $p_1 - 6$ $p_1 - 6$

$p_1 - 6$ $p_2 - 3$ $p_2 - 1$ $p_3 - 2$

$p_3 - 2$

(D) R.R (T.Q=2)

	AT	BT	LT	TAT
P_0	0	4	6	6
P_1	1	6	15	14
P_2	4	3	13	9
P_3	6	2	12	6
				35

$$\frac{35}{4} = 8.7 \Rightarrow \text{R.Q}: P_0 P_1 P_0 P_2 P_1 P_3 P_2 P_1$$

Gautt Chart

P_0	P_1	P_0	P_2	P_1	P_3	P_2	P_1

0 2 4 6 8 10 12 13 15

49. Consider the following system of equation with a non-trivial solution

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

50. Consider two transactions:

T1	T2
Read(A)	
Write(A)	
	Read(C)
	Write(C)
	Read(B)
	Write(B)
	Read(A)
	Commit
Read(B)	

If the transaction T1 fails after the execution of Read(B), then which is true?

(A) Recoverable

(B) Non-recoverable

Key: (B)

Exp: T_2 is reading the value written by T_1 and getting committed before T_1 commits. So it is non-recoverable schedule

51. Consider three random variables X_i with $i=\{1,2,3\}$. X_i is either 0 or 1 for $i=\{1,2,3\}$ Consider another variable $Y = X_1.X_2 \oplus X_3$. What is the probability of $P\left[Y=0 \middle| X_3=0\right]$?

52. A graph was given and asked about correct equation:

Exp: $x = -\left(y - |y|\right)$

53. A code fragment was provided with case statement and asked how many times printf statement will be printed.

General Aptitude

Q. 1 – Q. 5 carry one mark each

1. Out of the following four sentences, select the most suitable sentence with respect to grammar and usage.

   (A) I will not leave the place until the minister does not meet me.

   (B) I will not leave the place until the minister doesn't meet me.

   (C) I will not leave the place until the minister meet me.

   (D) I will not leave the place until the minister meets me.

Key: (D)

2. A rewording of something written or spoken is a _____.

   (A) paraphrase (B) paradox (C) paradigm (D) paraffin

Key: (A)

3. Archimseedes said, "Give me a lever long enough and a fulcrum on which to place it, and I will move the world."

   The sentence above is an example of a _____ statement.

   (A) figurative (B) collateral (C) literal (D) figurine

Key: (A)

4. If 'relftaga' means carefree, 'otaga' means careful and 'fertaga' means careless, which of the following could mean 'aftercare'?

   (A) zentaga (B) tagafer (C) tagazen (D) relffer

Key: (C)

5. A cube is built using 64 cubic blocks of side one unit. After it is built, one cubic block is removed from every corner of the cube. The resulting surface area of the body (in square units) after the removal is.

   (A) 56 (B) 64 (C) 72 (D) 96

Key: (D)

Exp: Four blocks are needed for each direction(totally 3 directions) to build a bigger cube containing 64 blocks. So area of one side of the bigger cube= $4\times4=16$units

There are 6 faces so total area= $6\times16=96$units

When cubes at the corners are removed they introduce new surfaces equal to exposes surfaces so the area of the bigger cube does not change from 96

Q. No. 6 – 10 Carry Two Marks Each

6. A shaving set company sells 4 different types of razors, Elegance, Smooth, Soft and Executive.

Elegance sells at Rs. 48, Smooth at Rs. 63, Soft at Rs. 78 and Executive at Rs. 173 per piece. The table below shows the numbers of each razor sold in each quarter of a year.

Quarter/Product	Elegance	Smooth	Soft	Executive
Q1	27300	20009	17602	9999
Q2	25222	19392	18445	8942
Q3	28976	22429	19544	10234
Q4	21012	18229	16595	10109

Which product contributes the greatest fraction to the revenue of the company in that year?

(A) Elegance (B) Executive (C) Smooth (D) Soft

Key: (B)

Exp: Total income from Elegance=48(27300+25222+28976+21012) = 4920480

Total income from Smooth=63(20009+19392+22429+18229 = 5043717

Total income from Soft=78(17602+18445+19544+16595) =5630508

Total income from Executive=173(9999+8942+10234+10109) =6796132

7. Indian currency notes show the denomination indicated in at least seventeen languages. If this is not an indication of the nation's diversity, nothing else is.

Which of the following can be logically inferred from the above sentences?

(A) India is a country of exactly seventeen languages.

(B) Linguistic pluralism is the only indicator of a nation's diversity.

(C) Indian currency notes have sufficient space for all the Indian languages.

(D) Linguistic pluralism is strong evidence of India's diversity.

Key: (D)

8. Consider the following statements relating to the level of poker play of four players P, Q, R and S.

I. P always beats Q

II. R always beats S

III. S loses to P only sometimes

IV. R always loses to Q

Which of the following can be logically inferred from the above statements?

(i) P is likely to beat all the three other players

(ii) S is the absolute worst player in the set

(A) (i) only (B) (ii) only (C) (i) and (ii) (D) neither (i) nor (ii)

Key: (D)

9. If $f(x) = 2x^7 + 3x - 5$, which of the following is a factor of f(x)?

(A) (x^3+8) (B) (x-1) (C) (2x-5) (D) (x+1)

Key: (B)

Exp: from the option (b0 substitute x=1 in

$2x^7 + 3x - 5 = 0$

$2(1)^7 + 3(1) - 5 = 0$

$5 - 5 = 0$

So $(x-1)$ is a factor of $f(x)$

10. In a process, the number of cycles to failure decreases exponentially with an increase in load. At a load of 80 units, it takes 100 cycles for failure. When the load is halved, it takes 10000 cycles for failure. The load for which the failure will happen in 5000 cycles is .

(A) 40.00 (B) 46.02 (C) 60.01 (D) 92.02

Key: (B)

Exp: From the data given we assume

$$\text{load} = \frac{\text{exponent}}{\log(\text{cycles})}$$

$$80 = \frac{x}{\log(10000)} \Rightarrow x = 160$$

$$40 = \frac{x}{\log(10000)} \Rightarrow x = 160$$

$$\text{load} = \frac{160}{\log 5000} = 43.25$$

Computer Science Engineering

Q. No. 1 – 25 Carry One Mark Each

1. Let p, q, r, s represent the following propositions.

p: $x \in \{8, 9, 10, 11, 12\}$

q: x is a composite number

r: x is a perfect square

s: x is a prime number

The integer $x \geq 2$ which satisfies $\neg((p \Rightarrow q) \wedge (\neg r \vee \neg s))$ is.

Key: (11)

Exp: $\sim((p \Rightarrow q) \wedge (\sim r \vee v \sim s)) = \sim(P \Rightarrow q) \vee \sim(\sim r \wedge \sim s)$

$= \sim(p \Rightarrow q) \vee \sim(r \wedge s)$

$= \sim(p \Rightarrow q) \vee (r \wedge s)$

$= \sim(\sim p \vee q) \wedge (r \wedge s)$

$= (p \wedge \sim q) \vee (r \wedge s)$

For x=11 only the above compound preposition is true.

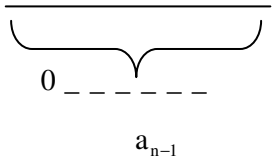
2. Let a_n be the number of n-bit strings that do NOT contain two consecutive 1s. Which one of the following is the recurrence relation for a_n?

(A) $a_n = a_{n-1} + 2a_{n-2}$ (B) $a_n = a_{n-1} + 2a_{n-2}$

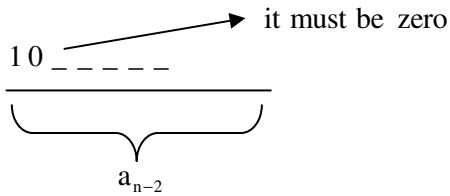
(C) $a_n = a_{n-1} + 2a_{n-2}$ (D) $a_n = a_{n-1} + 2a_{n-2}$

Key: (B)

Exp: Case I First bit is '0'



Case II First bit is '1'



$\therefore a_n = a_{n-1} + a_{n-2}$

3. $\lim_{x\to 4}\frac{\sin(x-4)}{x-4}=$ _____.

Key: (1)

Exp:

$$\lim_{x\to 4}\frac{\sin(x-4)}{x-4}$$
$$=\lim_{x-4\to 0}\frac{\sin(x-4)}{x-4}$$
$$=\lim_{y\to 0}\frac{\sin y}{y} \qquad \text{(By taking } y=x-4\text{)}$$
$$=1$$

4. A probability density function on the interval [a, 1] is given by $1/x^2$ and outside this interval the value of the function is zero. The value of a is____.

Key: (0.5)

Exp: Given $f(x)=\frac{1}{x^2}\ x\in[a,1]$
$=0$ other wise

We know that $\int_a^1 f(x)dx=1$

$$\Rightarrow\int_a^1\frac{1}{x^2}dx=1\Rightarrow\left(\frac{-1}{x}\right)_a^1=1$$
$$\Rightarrow\frac{1}{a}-1=1$$
$$\Rightarrow a=0.5$$

5. Two eigen values of a 3 × 3 real matrix P are $(2+\sqrt{-1})$ and 3. The determinant of P is _____.

Key: (15)

Exp: Given that $2+\sqrt{-1}$ and 3 are two Eigen values of 3×3 real matrix is, $2+i$ and 3 are Eigen values.

But 2-i also Eigen values $(\because$ complex roots occurs in pair only$)$

det = Product of Eigen values

$$=(2+i)\times(2-i)\times 3=5\times 3=15$$

6. Consider the Boolean operator # with the following properties:

$x \# 0 = x$, $x \# 1 = \bar{x}$, $x \# x = 0$ and $x \# \bar{x} = 1$. Then $x \# y$ is equivalent to

(A) $x\bar{y} + \bar{x}y$ (B) $x\bar{y} + \bar{x}\,\bar{y}$ (C) $\bar{x}y + xy$ (D) $xy + \bar{x}\,\bar{y}$

Key: (A)

7. The 16-bit 2's complement representation of an integer is 1111 1111 1111 0101; its decimal representation is _____.

Key: (-11)

Exp:

1111 1111 1111 0101

2's complement 0000 0000 0000 1011

11 and 1st bit is 1.

So result is -11

8. We want to design a synchronous counter that counts the sequence 0-1-0-2-0-3 and then repeats. The minimum number of J-K flip-flops required to implement this counter is _____.

Key: (4)

9. A processor can support a maximum memory of 4 GB, where the memory is word-addressable (a word consists of two bytes). The size of the address bus of the processor is at least _____ bits.

Key: (31)

Exp: Memory size=4GB=2^{32}bytes

Word size=2 bytes

$$\therefore \text{No.of Address bits} = \frac{\text{Memorysize}}{\text{Word size}} = \frac{2^{32}\text{ bytes}}{2\text{ bytes}} = 2^{31} \Rightarrow 31\text{bits}$$

10. A queue is implemented using an array such that ENQUEUE and DEQUEUE operations are performed efficiently. Which one of the following statements is **CORRECT** (n refers to the number of items in the queue)?

(A) Both operations can be performed in O(1) time

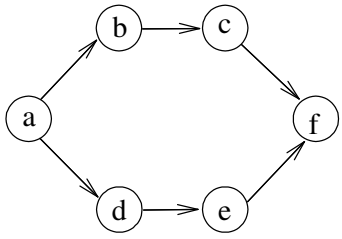
(B) At most one operation can be performed in O(1) time but the worst case time for the other operation will be $\Omega(n)$

(C) The worst case time complexity for both operations will be $\Omega(n)$

(D) Worst case time complexity for both operations will be $\Omega(\log n)$

Key: (A)

11. Consider the following directed graph:



The number of different topological orderings of the vertices of the graph is _____.

Key: (6)

Exp:

a b c d e f
a d e b c f
a b d c e f
a d b c e f
a b d e c f
a d b e c f

12. Consider the following C program.

```
void f(int, short);

void main()

{

    int i = 100;

    short s = 12;

    short *p  = &s;

    _____;    // call to f()

}
```

Which one of the following expressions, when placed in the blank above, will NOT result in a type checking error?

(A) f(s,*s) (B) i = f(i,s) (C) f(i,*s) (D) f(i,*p)

Key: (D)

Exp: Here function f takes two arguments one is int and the other is short and its return type is void. So, in main function 'P' is a pointer to short and when we call f (i,*p) there won't be any type checking error.

13. The worst case running times of Insertion sort, Merge sort and Quick sort, respectively, are:
(A) $\Theta(n \log n)$, $\Theta(n \log n)$, and $\Theta(n^2)$

(B) $\Theta(n^2)$, $\Theta(n^2)$, and $\Theta(n \log n)$

(C) $\Theta(n^2)$, $\Theta(n \log n)$, and $\Theta(n \log n)$

(D) $\Theta(n^2)$, $\Theta(n \log n)$, and $\Theta(n^2)$

Key: (D)

Exp: Merge sort $\theta(n \log n)$ in all the cases

Quick sort $\theta(n \log n)$ best case and $\theta(n^2)$ worst cases

Insertion sort $\theta(n)$best case R $\theta(n^2)$ worst case

14. Let G be a weighted connected undirected graph with distinct positive edge weights. If every edge weight is increased by the same value, then which of the following statements is/are TRUE?

P: Minimum spanning tree of G does not change

Q: Shortest path between any pair of vertices does not change

(A) P only (B) Q only (C) Neither P nor Q (D) Both P and Q

Key: (A)

15. Consider the following C program.

```
#include<stdio.h>
void mystery(int *ptra, int *ptrb) {
    int *temp;
    temp = ptrb;
    ptrb = ptra;
    ptra = temp;
}
```

```
int main() {
    int a=2016, b=0, c=4, d=42;
    mystery(&a, &b);
    if (a < c)
        mystery(&c, &a);
    mystery(&a, &d);
    printf("%d\n", a);
}
```

The output of the program is _____.

Key: (2016)

Exp: Output is not affected by the function mystery () as it is just taking the address of a&b into ptra & ptrb and contents of ptra & ptrb are swapped leaving a&b as it is.

16. Which of the following languages is generated by the given grammar?

$S \rightarrow aS|bS|\varepsilon$

(A) $\{a^n b^m \mid n,m \geq 0\}$

(B) $\{w \in \{a,b\}^* \mid w \text{ has equal number of } a\text{'s and } b\text{'s}\}$

(C) $\{a^n \mid n \geq 0\} \cup \{b^n \mid n \geq 0\} \cup \{a^n b^n \mid n \geq 0\}$

(D) $\{a, b\}*$

Key: (D)

Exp: Given grammar generates all strings of a's and b's including null string

$\therefore L = (a+b)*$

17. Which of the following decision problems are undecidable?

I. Given NFAs N_1 and N_2, is $L(N_1) \cap L(N_2) = \Phi$?

II. Given a CFG G = (N, Σ, P, S) and a string $x \in \Sigma*$, does $x \in L(G)$?

III. Given CFGs G1 and G2, is L(G1) = L(G2)?

IV. Given a TM M, is $L(M) = \Phi$?

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

(C) III and IV only (D) II and IV only

Key: (C)

Exp: There is no known algorithm to check whether the language accepted by TM is empty. Similarly there is no algorithm to check whether language CFG's are equivalent.

18. Which one of the following regular expressions represents the language: the set of all binary strings having two consecutive 0s and two consecutive 1s?

(A) $(0 + 1)*0011(0 + 1)* + (0 + 1)*1100(0 + 1)*$

(B) $(0 + 1)*(00(0 + 1)*11 + 11(0 + 1)*00)(0 + 1)*$

(C) $(0 + 1)*00(0 + 1)* + (0 + 1)*11(0 + 1)*$

(D) $00(0 + 1)*11 + 11(0 + 1)*00$

Key: (B)

Exp: (a) contains 00 & 11 consecutively which is not the required condition.

(c) Doesn't guaranty that both 00 & 11 will be present in the string.

(d) Says string should start with 11 & ends with 00 or vice versa.

19. Consider the following code segment.

```
x = u - t;
y = x * v;
x = y + w;
y = t - z;
y = x  *  y;
```

The minimum number of total variables required to convert the above code segment to static single assignment form is _____.

Key: (7)

20. Consider an arbitrary set of CPU-bound processes with unequal CPU burst lengths submitted at the same time to a computer system. Which one of the following process scheduling algorithms would minimize the average waiting time in the ready queue?

(A) Shortest remaining time first

(B) Round-robin with time quantum less than the shortest CPU burst

(C) Uniform random

(D) Highest priority first with priority proportional to CPU burst length

Key: (A)

Exp: SRTF is pre emptive SJF which produces less average waiting time.

21. Which of the following is NOT a super key in a relational schema with attributes V , W , X , Y , Z and primary key V Y ?

(A) V XY Z (B) V W X Z (C) V W XY (D) V W XY Z

Key: (B)

Exp: Any superset of VY is a super key.

22. Which one of the following is NOT a part of the ACID properties of database transactions?

(A) Atomicity (B) Consistency (C) Isolation (D) Deadlock-freedom

Key: (D)

Exp: 'D' means durability not deadlock freedom.

23. A database of research articles in a journal uses the following schema. (VOLUME, NUMBER, STARTPAGE, ENDPAGE, TITLE, YEAR, PRICE)

The primary key is (VOLUME, NUMBER, STARTPAGE, ENDPAGE) and the following functional dependencies exist in the schema.

(VOLUME, NUMBER, STARTPAGE, ENDPAGE) → TITLE

(VOLUME, NUMBER → YEAR

(VOLUME, NUMBER, STARTPAGE, ENDPAGE) → PRICE

The database is redesigned to use the following schemas.

(VOLUME, NUMBER, STARTPAGE, ENDPAGE, TITLE, PRICE) (VOLUME, NUMBER, YEAR)

Which is the weakest normal form that the new database satisfies, but the old one does not?

(A) 1NF (B) 2NF (C) 3NF (D) BCNF

Key: (A)

Exp: candidate key is (volume, number, start page, end page)

(Volume number) → year is a partial dependency. So original table is in 1NF but not in 2NF

24. Which one of the following protocols is NOT used to resolve one form of address to another one?

(A) DNS (B) ARP (C) DHCP (D) RARP

Key: (C)

Exp: Except DHCP, remaining all the protocols are used to resolve one form of address to another one.

25. Which of the following is/are example(s) of stateful application layer protocols?

(i) HTTP (ii) FTP (iii) TCP (iv) POP3

(A) (i) and (ii) only

(B) (ii) and (iii) only

(C) (ii) and (iv) only

(D) (iv) only

Key: (C)

Exp: FTP and POP 3are stateful application layer protocols

Q. No. 26 – 55 Carry Two Marks Each

26. The coefficient of x^{12} in $\left(x^3+x^4+x^5+x^6+...\right)^3$ is _____.

Key: (10)

Exp: $\left(x^3+x^4+x^5+x^6+...\right)^3$

$=x^9\left(1+x+x^2+...\right)^3$

$=x^9\left((1-x)^{-1}\right)^3$

$=x^9(1-x)^{-3}$

$=x^9\sum_{n=0}^{\infty}\frac{(n+1)(n+2)}{2}x^n$

For coefficient of x^{12} put n=3 $=\frac{4\times5}{2}=10$

27. Consider the recurrence relation $a_1=8, a_n=6n^2+2n+a_{n-1}$. Let $a_{99}=K\times10^4$. The value of K is _____.

Key: (198)

Exp: The recurrence relation can be written as $a_n-a_{n-1}==6n^2+2n$ …(i)

Characteristic equation is m-1=0, m=1

Complementary solution $=a_n^{(1)}=C_1(1)^n=C_1$

Let the particular solution be $a_n^{(b)}=\left(An^2+Bn+c\right)n$ …(2)

$(\because$ RHS is second degree polynomial and 1 is root$)$

By substuting $a_n = (An^2 + Bn + C)n$ in (1) and solving A=2, B=4, C=2

General solution is $a_n = a_n^{(c)} + a_n^{(b)} = C_1 + (2n^2 + 4n + 2)n$

given $a_1 = B \Rightarrow B = c_1 + B \Rightarrow c_1 = 0$

Given $a_{99} = k \times 10^4$

$\Rightarrow [2(99)^2 + 4(99) + 2]99 = 2[(100-1)^2 + 2(100-1) + (100-1)] = 10^4(198) = K \times 10^4$

K=198

28. A function f : $N^+ \rightarrow N^+$, defined on the set of positive integers N^+, satisfies the following properties

f (n) = f (n/2) if n is even

f (n) = f (n + 5) if n is odd

Let R = {i | ∃ j: f (j) = i} be the set of distinct values that f takes. The maximum possible size of R is _____.

Key: (2)

Exp: Given $f(n) = f\left(\frac{n}{2}\right)$ if n is even

= f(n+5) if n is odd

We can observe that f(1) = f(2)=f(3)=f(4)=f(6)=f(7)…….

and f (5) = f (10) = f(15) =……

Clearly, the range of f(x) will contain two distinct elements only.

29. Consider the following experiment.

Step 1. Flip a fair coin twice.

Step 2. If the outcomes are (TAILS, HEADS) then output Y and stop.

Step 3. If the outcomes are either (HEADS, HEADS) or (HEADS, TAILS), then output N and stop.

Step 4. If the outcomes are (TAILS, TAILS), then go to Step 1.

The probability that the output of the experiment is Y is (up to two decimal places) _____.

Key: (0.33)

Exp: From the given steps we can observe that probabilities of y are

$$\frac{1}{4},\left(\frac{1}{4}\right)\left(\frac{1}{4}\right),\left(\frac{1}{4}\right)^2\frac{1}{4},.....$$

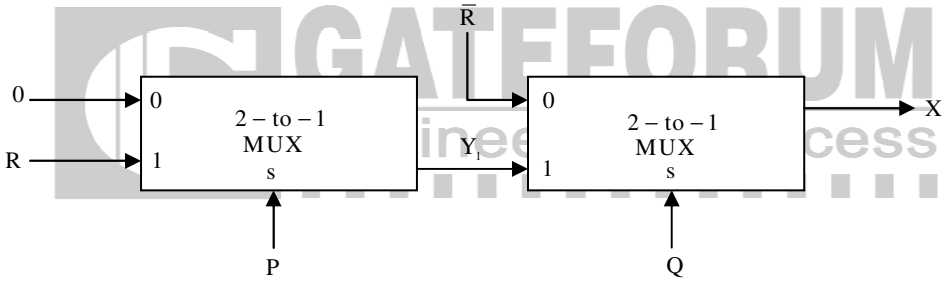
Required probability

$$=\frac{1}{4}+\left(\frac{1}{4}\times\frac{1}{4}\right)+\left(\left(\frac{1}{4}\right)^2\times\frac{1}{4}\right)+....$$

$$=\frac{1}{4}+\left(\frac{1}{4}\right)^2+\left(\frac{1}{4}\right)^3+...$$

$$=\frac{1}{4}\left(1+\frac{1}{4}+\left(\frac{1}{4}\right)^2+...\right)=\frac{1}{4}\left(\frac{1}{1-\frac{1}{4}}\right)=\frac{1}{4}\times\frac{4}{3}=\frac{1}{3}=0.33$$

30. Consider the two cascaded 2-to-1 multiplexers as shown in the figure.



The minimal sum of products form of the output X is

(A) $\bar{P}\bar{Q}+PQR$ (B) $\bar{P}Q+QR$ (C) $PQ+\bar{P}\bar{Q}R$ (D) $\bar{Q}\bar{R}+PQR$

Key: (D)

Exp: Output of first multiplexer is $Y_1=\bar{P}0+PR=PR$

Output of second multiplexer is $X=\bar{Q}\bar{R}+QY_1=\bar{Q}\bar{R}+QPR\Rightarrow\bar{Q}\bar{R}+PQR$

31. The size of the data count register of a DMA controller is 16 bits. The processor needs to transfer a file of 29,154 kilobytes from disk to main memory. The memory is byte addressable. The minimum number of times the DMA controller needs to get the control of the system bus from the processor to transfer the file from the disk to main memory is _____.

Key: (456)

Exp: DMA controller needs $\Rightarrow \frac{29154\text{kB}}{2^{16}\text{byte}} \Rightarrow 455.53125 = 456$

32. The stage delays in a 4-stage pipeline are 800, 500, 400 and 300 picoseconds. The first stage (with delay 800 picoseconds) is replaced with a functionally equivalent design involving two stages with respective delays 600 and 350 picoseconds. The throughput increase of the pipeline is _____ percent.

Key: (33.33)

Exp:

Old design $t_p = 800$

New design $t_p = 600$

Throughput $= \frac{800-600}{600} \times 100\% = 33.33\%$

33. Consider a carry look ahead adder for adding two n-bit integers, built using gates of fan-in at most two. The time to perform addition using this adder is

(A) $\Theta(1)$ (B) $\Theta(\log(n))$ (C) $\Theta(\sqrt{n})$ (D) $\Theta(n)$

Key: (B)

34. The following function computes the maximum value contained in an integer array p[ ] of size n (n >= 1).

```
int max(int *p, int n) {
    int a=0, b=n-1;
    while ( _____ )  {
    if (p[a] <= p[b]) {  a = a+1; }
    else             {  b  = b-1; }
    }
    return p[a];
}
```

The missing loop condition is

(A) a != n (B) b != 0 (C) b > (a + 1) (D) b != a

Key: (D)

Exp: When a=b then P[a] will have the maximum value of the array

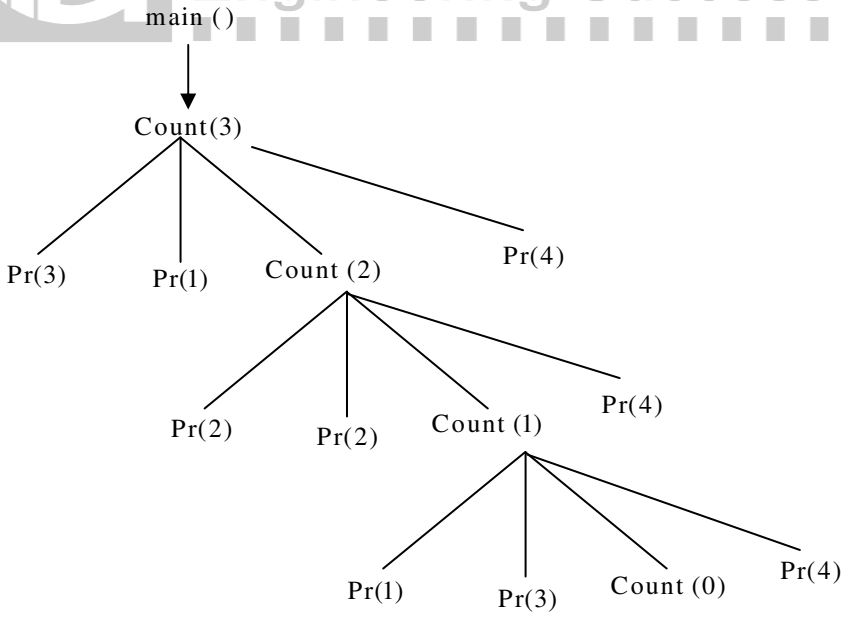
35. What will be the output of the following C program?

```
void count(int n){
    static int d=1;
    printf("%d  ", n); printf("%d  ", d); d++;
    if(n>1) count(n-1);
    printf("%d  ", d);
}
void main(){
count(3);
}
```

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

Key: (A)

Exp:



Output is 31 22 13 4 4 4

36. What will be the output of the following pseudo-code when parameters are passed by reference and dynamic scoping is assumed?

```
a=3;
```

```
void n(x) {x  = x  *  a; print(x);}

void m(y) {a = 1; a = y  - a; n(a); print(a);}

void main() {m(a);}
```

(A) 6, 2 (B) 6, 6 (C) 4, 2 (D) 4, 4

Key: (D)

Exp: Dynamic scoping looks for the definition of free variable in the reverse order of calling sequence.

37. An operator delete (i) for a binary heap data structure is to be designed to delete the item in the i-th node. Assume that the heap is implemented in an array and i refers to the i-th index of the array. If the heap tree has depth d (number of edges on the path from the root to the farthest leaf), then what is the time complexity to re-fix the heap efficiently after the removal of the element?

(A) O(1) (B) O(d) but not O(1)

(C) O(2d) but not O(d) (D) O(d 2d) but not O(2d)

Key: (B)

Exp: Time complexity of heapification is O (height) =O(d)

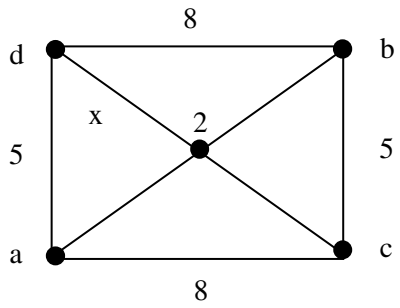
38. Consider the weighted undirected graph with 4 vertices, where the weight of edge {i, j} is given by the entry Wi j in the matrix W.

$$W = \begin{bmatrix} 0 & 2 & 8 & 5 \\ 2 & 0 & 5 & 8 \\ 8 & 5 & 0 & x \\ 5 & 8 & x & 0 \end{bmatrix}$$

The largest possible integer value of x, for which at least one shortest path between some pair of vertices will contain the edge with weight x is _____.

Key: (12)

Exp:

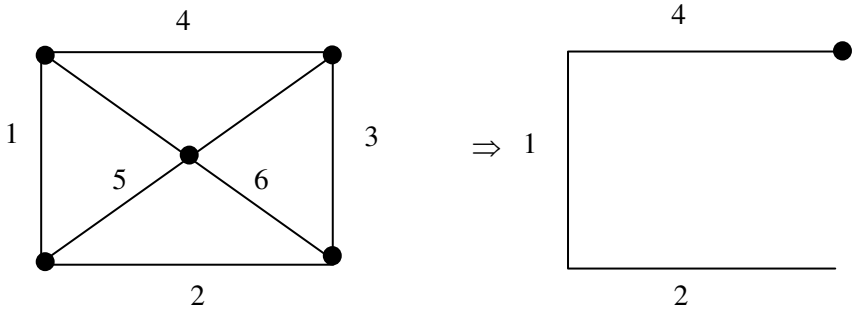


If x=12 then the shortest path between d & c will contain edge with lable ‘x’.

39. Let G be a complete undirected graph on 4 vertices, having 6 edges with weights being 1, 2, 3, 4, 5, and 6. The maximum possible weight that a minimum weight spanning tree of G can have is _____.

Key: (7)

Exp:



40. G = (V, E) is an undirected simple graph in which each edge has a distinct weight, and e is a particular edge of G. Which of the following statements about the minimum spanning trees (MSTs) of G is/are TRUE?

I. If e is the lightest edge of some cycle in G, then every MST of G includes e

II. If e is the heaviest edge of some cycle in G, then every MST of G excludes e

(A) I only (B) II only (C) both I and II (D) neither I nor II

Key: (B)

41. Let Q denote a queue containing sixteen numbers and S be an empty stack. Head(Q) returns the element at the head of the queue Q without removing it from Q. Similarly Top(S) returns the element at the top of S without removing it from S. Consider the algorithm given below.

```
while Q is not Empty do
    if S is Empty OR Top(S) ≤ Head(Q) then
        x := Dequeue(Q);
        Push(S, x);
    else
        x := Pop(S);
        Enqueue(Q, x);
    end
end
```

The maximum possible number of iterations of the while loop in the algorithm is _____.

Key: (256)

Exp. Maximum number of iterations will be $n^2 = 256 [\because n = 16]$

42. Consider the following context-free grammars:

G1: S → aS|B, B → b|bB

G2: S → aA|bB, A → aA|B|ε , B → bB|ε

Which one of the following pairs of languages is generated by G1 and G2, respectively?

(A) $\{a^m b^n | m > 0$ or $n > 0\}$ and $\{a^m b^n | m > 0$ and $n > 0\}$

(B) $\{a^m b^n | m > 0$ and $n > 0\}$ and $\{a^m b^n | m > 0$ or $n \leq 0\}$

(C) $\{a^m b^n | m \geq 0$ or $n > 0\}$ and $\{a^m b^n | m > 0$ and $n > 0\}$

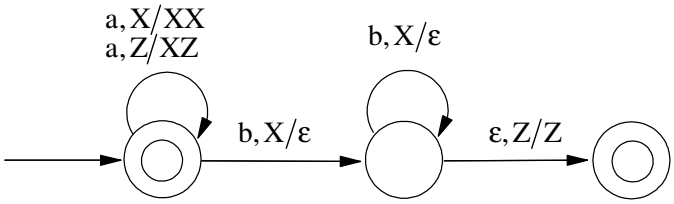
(D) $\{a^m b^n | m \geq 0$ or $n > 0\}$ and $\{a^m b^n | m > 0$ or $n > 0\}$

Key: (D)

Exp: Lagrange's generated by $G_1 = a^* b^+$

Lagrange's generated by $G_2 = a^+ b^* \setminus b^+$

43. Consider the transition diagram of a PDA given below with input alphabet Σ = {a, b} and stack alphabet Γ = {X , Z}. Z is the initial stack symbol. Let L denote the language accepted by the PDA.



Which one of the following is TRUE?

(A) $L = \{a^n b^n | n \geq 0\}$ and is not accepted by any finite automata

(B) $L = \{a^n | n \geq 0\} \cup \{a^n b^n | n \geq 0\}$ and is not accepted by any deterministic PDA

(C) L is not accepted by any Turing machine that halts on every input

(D) $L = \{a^n | n \geq 0\} \cup \{a^n b^n | n \geq 0\}$ and is deterministic context-free

Key: (D)

44. Let X be a recursive language and Y be a recursively enumerable but not recursive language.

Let W and Z be two languages such that Y reduces to W , and Z reduces to X (reduction means the standard many-one reduction). Which one of the following statements is TRUE?

(A) W can be recursively enumerable and Z is recursive.

(B) W can be recursive and Z is recursively enumerable.

(C) W is not recursively enumerable and Z is recursive.

(D) W is not recursively enumerable and Z is not recursive.

Key: (C)

45. The attributes of three arithmetic operators in some programming language are given below.

Operator	Precedence	Associativity	Arity
+	High	Left	Binary
−	Medium	Right	Binary
*	Low	Left	Binary

The value of the expression $2 - 5 + 1 - 7 * 3$ in this language is .

Key: (9)

Exp: $2-5+1-7*3$

$2-(5+1)-7*3$

$2-6-7*3$

$2-(6-7)*3$

$2-(-1)*3$

$(2+1)*3$

$3*3=9$

46. Consider the following Syntax Directed Translation Scheme (SDTS), with non-terminals {S, A} and terminals {a, b}.

$S \rightarrow aA$ {print 1}

$S \rightarrow a$ {print 2}

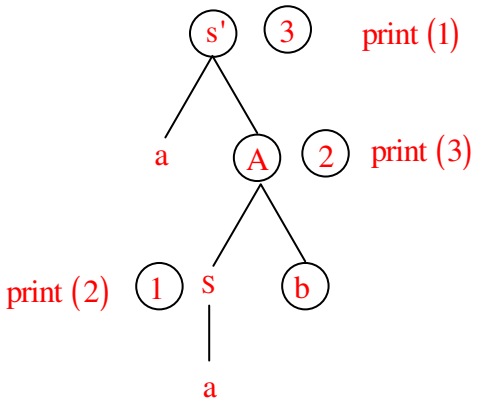
$A \rightarrow Sb$ {print 3}

Using the above SDTS, the output printed by a bottom-up parser, for the input aab is:

(A) 1 3 2 (B) 2 2 3 (C) 2 3 1 (D) syntax error

Key: (C)

Exp:



47. Consider a computer system with 40-bit virtual addressing and page size of sixteen kilobytes. If the computer system has a one-level page table per process and each page table entry requires 48 bits, then the size of the per-process page table is _____ megabytes.

Key: (384)

Exp: Given LA = 40 bit = LAS = 2^{40}

Page size = 16 KB

Page table Entry size (e) = 48 bits (or) 6 bytes

Page table size = ?

Size of the page table = n × e

$\therefore$ No. of pages $(n) = \frac{LAS}{PS} = \frac{2^{40}}{2^{14}} = 2^{26} = 64M$

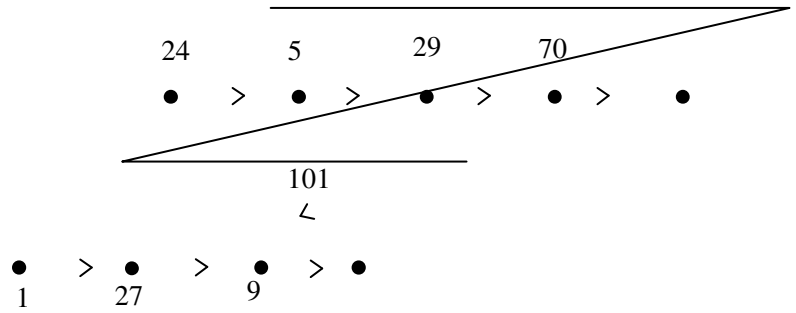
$\therefore$ Page table size = 64 × 6B = 384MB

48. Consider a disk queue with requests for I/O to blocks on cylinders 47, 38, 121, 191, 87, 11, 92, 10. The C-LOOK scheduling algorithm is used. The head is initially at cylinder number 63, moving towards larger cylinder numbers on its servicing pass. The cylinders are numbered from 0 to 199. The total head movement (in number of cylinders) incurred while servicing these requests is _____.

Key: (346)

Exp: C-Look disc Scheduling

0 10 11 38 47 63 87 92 121 191 199



$\therefore$ Total Head movements = 24 + 5 + 29 + 70 + 181 + 1 + 27 + 9 = 346

49. Consider a computer system with ten physical page frames. The system is provided with an access sequence (a_1, a_2, . . . , a_{20}, a_1, a_2, . . . , a_{20}), where each a_i is a distinct virtual page number. The difference in the number of page faults between the last-in-first-out page replacement policy and the optimal page replacement policy is _____.

Key: (1)

Exp: a_1 a_2 .....a_{20} a_1 a_2 .....a_{20}

LIFO

0	a_1
1	a_2
2	a_3
3	a_4
4	a_5
5	a_6
6	a_7
7	a_8
8	a_9
9	~~a_{10}~~ ~~a_{11}~~ ~~a_{12}~~ ~~a_{13}~~ ~~a_{14}~~ ~~a_{15}~~ ~~a_{16}~~ ~~a_{17}~~ ~~a_{18}~~ ~~a_{19}~~ a_{20}

For first a_1 to a_{20} 20 page fault

Now a_1 to a_9 Hit

again a_{10} to a_{20} replace only 9th position, so 11 page fault.

So total 31 page fault

Optimal

0	a_1
1	a_2
2	a_3
3	a_4
4	a_5
5	a_6
6	a_7
7	a_8
8	a_9
9	~~a_{10}~~ ~~a_{11}~~ ~~a_{12}~~ ~~a_{13}~~ ~~a_{14}~~ ~~a_{15}~~ ~~a_{16}~~ ~~a_{17}~~ ~~a_{18}~~ ~~a_{19}~~ a_{20}

For first a_1 to a_{20} 20 fault

Next a_1 to a_9 Hit

again a_{10} to a_{19} replace any location from 0 to 9 for a_{20} Hit.

So total 30 page fault

Difference $= 31 - 30 = 1$

50. Consider the following proposed solution for the critical section problem. There are n processes: $P_0 \ldots P_{n-1}$. In the code, function pmax returns an integer not smaller than any of its arguments. For all i, t[i] is initialized to zero.

Code for P_i:

```
do {
    c[i]=1; t[i] = pmax(t[0],. . .,t[n-1])+1;  c[i]=0;
    for every j = i in {0,. . .,n-1}  {
        while (c[j]);
        while (t[j] != 0  &&  t[j]<=t[i]);
    }
    Critical Section;
    t[i]=0;
    Remainder Section;
}   while (true);
```

Which one of the following is TRUE about the above solution?

(A) At most one process can be in the critical section at any time

(B) The bounded wait condition is satisfied

(C) The progress condition is satisfied

(D) It cannot cause a deadlock

Key: (A)

51. Consider the following two phase locking protocol. Suppose a transaction T accesses (for read or write operations), a certain set of objects $\{O_1, \ldots, O_k\}$. This is done in the following manner:

Step 1. T acquires exclusive locks to O1, . . . , Ok in increasing order of their addresses.

Step 2. The required operations are performed.

Step 3. All locks are released.

This protocol will

(A) guarantee serializability and deadlock-freedom

(B) guarantee neither serializability nor deadlock-freedom

(C) guarantee serializability but not deadlock-freedom

(D) guarantee deadlock-freedom but not serializability

Key: (A)

Exp: 2PL ensures serializability and here as we are following linear order in acquiring the locks there will not be any deadlock.

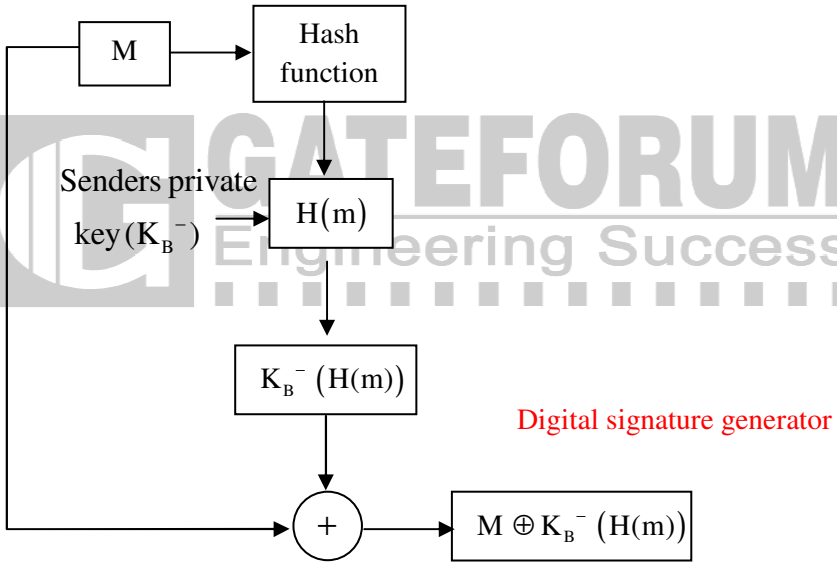
52. Consider that B wants to send a message m that is digitally signed to A. Let the pair of private and public keys for A and B be denoted by K_x^- and K_x^+ for x = A, B, respectively. Let $K_x(m)$ represent the operation of encrypting m with a key Kx and H (m) represent the message digest. Which one of the following indicates the CORRECT way of sending the message m along with the digital signature to A?

(A) $\{m, K_B^+(H(m))\}$ (B) $\{m, K_B^-(H(m))\}$

(C) $\{m, K_A^-(H(m))\}$ (D) $\{m, K_A^+(m)\}$

Key: (B)

Exp:

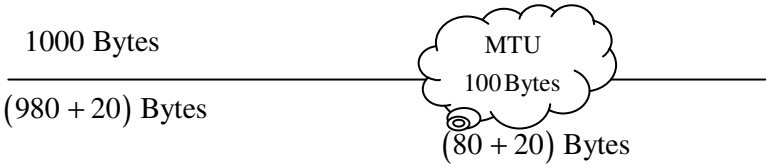


53. An IP datagram of size 1000 bytes arrives at a router. The router has to forward this packet on a link whose MTU (maximum transmission unit) is 100 bytes. Assume that the size of the IP header is 20 bytes.

The number of fragments that the IP datagram will be divided into for transmission is _____.

Key: (13)

Exp:



So, no. of fragments that are transferred in this scenario is 13.

54. For a host machine that uses the token bucket algorithm for congestion control, the token bucket has a capacity of 1 megabyte and the maximum output rate is 20 megabytes per second. Tokens arrive at a rate to sustain output at a rate of 10 megabytes per second. The token bucket is currently full and the machine needs to send 12 megabytes of data. The minimum time required to transmit the data is _____ seconds.

Key: (1.2)

Exp: Given

$C = 1\text{Mb}$

$\text{Max Output rate} = 20\,\text{Mbps}$

$\text{Arrival rate} \quad = 10\text{Mbps}$

$\therefore$ The minimum time required to transmit the data is $S = \frac{c}{m-\rho}$

$$S = \frac{1\text{ Mb}}{20 - 10\text{Mbps}} = \frac{1}{10} = 0.1\text{ sec}$$

For 12Mb of data, S value becomes 1.2seconds

55. A sender uses the Stop-and-Wait ARQ protocol for reliable transmission of frames. Frames are of size 1000 bytes and the transmission rate at the sender is 80 Kbps (1Kbps = 1000 bits/second). Size of an acknowledgement is 100 bytes and the transmission rate at the receiver is 8 Kbps. The one-way propagation delay is 100 milliseconds.

Assuming no frame is lost, the sender throughput is _____ bytes/second.

Key: (2500)

Exp: Frame size (L) =1000bytes

Sender side bandwidth (B_S) = 80kbps

Acknowledgement (L_A) =100bytes

Receiver side bandwidth (B_R) =8kbps

T_p=100ms

$$n = \frac{T_x}{T_x + T_{ack} + 2T_p}$$

$$(\text{msg})\,T_x = \frac{L}{B_S} = \frac{1000\,\text{Bytes}}{10 \times 10^3\ \text{BPS}} = 100\text{ms}$$

$$(\text{Ack})\ T_A = \frac{L_A}{B_R} = \frac{100\text{ Bytes}}{1 \times 10^3\ \text{BPS}} = 100\text{ms}$$

$$T_p = 100\text{ms}$$

$$\therefore \text{Channel Utilization} = \frac{T_n}{T_n + T_{ack} + 2T_p} = \frac{100\text{ms}}{100\,\text{ms} + 100\text{ms} + 200\text{ms}} = \frac{1}{4}$$

$$\therefore \text{Throughput} = \eta \times B = \frac{1}{4} \times 10 \times 10^3 = 2.5 \text{ Kbps } (\text{or } 2500 \text{ Bps})$$

General Aptitude

Q. No. 1 – 5 Carry One Mark Each

1. The man who is now Municipal Commissioner worked as _____.
   (A) the security guard at a university
   (B) a security guard at the university
   (C) a security guard at university
   (D) the security guard at the university

Key: (B)

2. Nobody knows how the Indian cricket team is going to cope with the difficult and seamer-friendly wickets in Australia.
   Choose the option which is closest in meaning to the underlined phase in the above sentence.
   (A) put up with (B) put in with (C) put down to (D) put up against

Key: (A)

3. Find the odd one in the following group of words.
   Mock, deride, praise, jeer
   (A) mock (B) deride (C) praise (D) jeer

Key: (C)

4. Pick the odd one from the following options.
   (A) CADBE (B) JHKIL (C) XVYWZ (D) ONPMQ

Key: (D)

5. In a quadratic function, the value of the product of the roots (α,β) is 4. Find the value of

$$\frac{\alpha^n+\beta^n}{\alpha^{-n}+\beta^{-n}}$$

   (A) n^4 (B) 4^n (C) 2^{2n-1} (D) 4^{n-1}

Key: (B)

Exp: Given $\alpha\beta = 4$

$$\frac{\alpha^n+\beta^n}{\alpha^{-n}+\beta^{-n}} = \frac{\alpha^n+\beta^n}{\frac{1}{\alpha^n}+\frac{1}{\beta^n}}$$

$$= \frac{\left(\alpha^n+\beta^n\right)\alpha^n\beta^n}{\left(\alpha^n+\beta^n\right)}$$

$$= (\alpha\beta)^n = 4^n$$

Q. No. 6 – 10 Carry Two Marks Each

6. Among 150 faculty members in an institute, 55 are connected with each other through Facebook and 85 are connected through WhatsApp. 30 faculty members do not have Facebook or WhatsApp accounts. The number of faculty members connected only through Facebook accounts is _____.

(A) 35 (B) 45 (C) 65 (D) 90

Key: (A)

Exp: $F \rightarrow$ Facebook, $W \rightarrow$ WhatsApp, $E \rightarrow$ Total faculties

given

$n(E) = 150, n\left(\overline{F \cup W}\right) = 30$

$n\left(F \cup W\right) = n(E) - N\left(\overline{F \cup W}\right) = 150 - 30$

$n\left(F \cup W\right) = 120$

$n\left(f \cup w\right) = n\left(f\right) + \left[n(w) - n(F \cap w\right]$

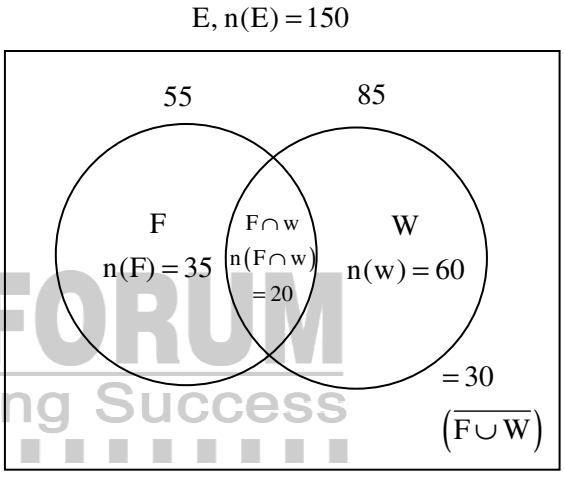
$120 = n(F) + 85$

$n(F) = 120 - 85 = 35$

$55 = n(F) + n\left(F \cap W\right)$

$n\left(F \cap w\right) = 55 - n(F) = 55 - 35 = 20$

$n(w) = 85 - 20 = 65$



7. Computers were invented for performing only high-end useful computations. However, it is no understatement that they have taken over our world today. The internet, for example, is ubiquitous. Many believe that the internet itself is an unintended consequence of the original invention with the advent of mobile computing on our phones, a whole new dimension is now enabled. One is left wondering if all these developments are good or more importantly, required.

Which of the statement(s) below is/are logically valid and can be inferred from the above paragraph?

(i) The author believes that computers are not good for us

(ii) Mobile computers and the internet are both intended inventions

(A) (i) (B) (ii) only

(C) both (i) and (ii) (D) neither (i) nor (ii)

Key: (D)

8. All hill-stations have a lake. Ooty has two lakes.

Which of the statement(s) below is/are logically valid and can be inferred from the above sentences?

(i) Ooty is not a hill-station

(ii) No hill-station can have more than one lake.

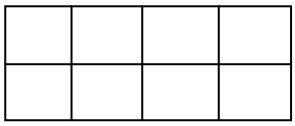
(A) (i) Only (B) (ii) Only (C) both (i) and (ii) (D) neither (i) nor (ii)

Key: (D)

9. In a 2×4 rectangle grid shown below, each cell is a rectangle. How many rectangles can be observed in the grid?

(A) 21 (B) 27

(C) 30 (D) 36



Key: (C)

Exp: 1: (AEOK)

2: (AEJF), (FJOK)

4: (ABLK), (BCML), (CDNM), (DEON)

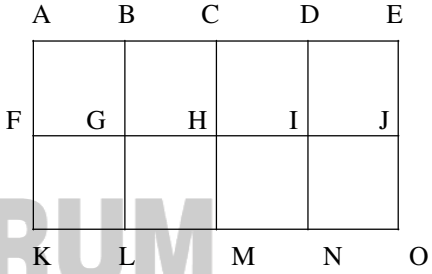
2: ACMK, ADNK | 2 : ECMD, EBLO | 2 : ACHF, ADIF

2: ECHJ, EBGJ | 2 : FHMK, FINK | 2 : JHMD, JGLO

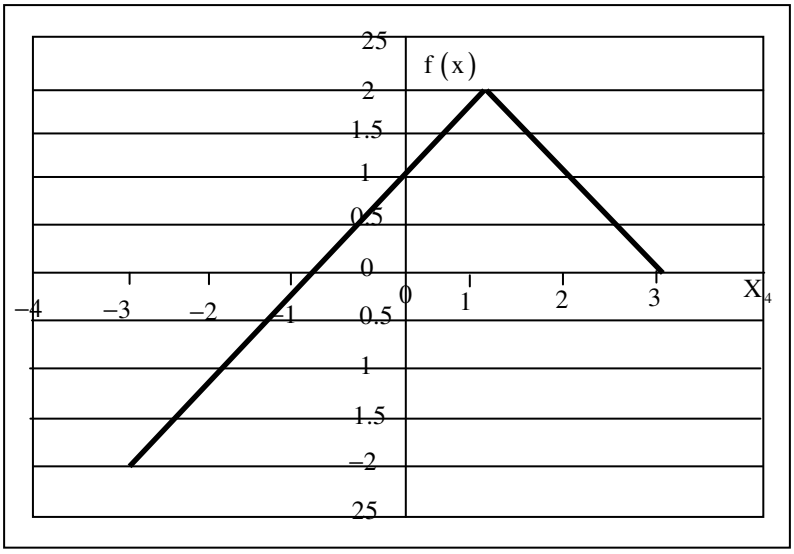
1: BDNL | 2 : BDIG, GINL

8: ABGF, BCHJ, CDIH, EDI, FGLK, GHML, HINM

Total = 1+2+4+2+2+2+2+2+2+1+2+8=30



10.



Chose the correct expression for f(x) given in the graph.

(A) $f(x)=1-|x-1|$ (B) $f(x)=1+|x-1|$

(C) $f(x)=2-|x-1|$ (D) $f(x)=2+|x-1|$

Key: (C)

Exp: Substituting the coordinates of the straight lines and checking all the four options given, we get the correct option as C which is f(x)= $2-|x-1|$

Computer Science Engineering

Q. No. 1 – 25 Carry One Mark Each

1. Consider the following expressions:

(i) false

(ii) Q

(iii) true

(iv) P ∨ Q

(v) ¬Q ∨ P

The number of expressions given above that are logically implied by P ∧ (P ⇒ Q) is_____.

Key: (4)

2. Let f (x) be a polynomial and g(x) = f '(x) be its derivative. If the degree of (f (x) + f (−x)) is 10, then the degree of (g(x) − g(−x)) is _____.

Key: (9)

Exp: If f(x) is polynomial of degree n,

then $g(x)=f'(x)$ is polynomial of degree n,

$\Rightarrow f(x)+f(-x)$ is polynomial of degree n,

But given $f(x)+f(-x)$ is polynomial of degree 10.

$\therefore n=10.$

$\Rightarrow g(x)$ is polynomial of 9.

$\therefore g(x)-g(-x)$ is polynomial of degree 9.

3. The minimum number of colours that is sufficient to vertex-colour any planar graph is _____.

Key: (4)

Exp: Any planar graph is four-colourable.

4. Consider the systems, each consisting of m linear equations in n variables.

I. If m < n, then all such systems have a solution

II. If m > n, then none of these systems has a solution

III. If m = n, then there exists a system which has a solution

Which one of the following is CORRECT?

(A) I, II and III are true
(B) Only II and III are true
(C) Only III is true
(D) None of them is true

Key: (C)

Exp: I is not correct

x+y+z=1

x+y+z=0

Has no solution, when no of equations is less than no of variables.

II is not correct

Eg:

$x-2y=2$

$2x+8y=16$

$x+y=5$

Has a solution (x=4, y=1).

III is correct

Eg:

x+y = 4,

x+2y=0

Has solutions (x=6, y=-2)

5. Suppose that a shop has an equal number of LED bulbs of two different types. The probability of an LED bulb lasting more than 100 hours given that it is of Type 1 is 0.7, and given that it is of Type 2 is 0.4. The probability that an LED bulb chosen uniformly at random lasts more than 100 hours is _____.

Key: (0.55)

Exp: E_1 –event of selecting type-I bulb

E_2-event of selecting type-II bulb

A- Event of selecting a bulb lasts more than 100 hours

Given $P(E_1)=0.5, P(E_2)=0.5$

$P(A/E_1)=0.7, P(A/E_2)=0.4$

Required probability,

$$P(A)=P(E_1)P(A/E_1)+P(E_2)P(A/E_2)$$
$$=0.5\times0.7+0.5\times0.4$$
$$=0.55$$

6. Suppose that the eigen values of matrix A are 1, 2, 4. The determinant of $(A^{-1})^T$ is _____.

Key: (0.125)

Exp: Given that 1,2,4 are eigen values of A>

$$\Rightarrow |A| = 8 \text{ and } |A^{-1}| = \frac{1}{|A|} = \frac{1}{8}$$

$$\text{Now, } \left|\left(A^{-1}\right)^{+}\right| = \left|A^{-1}\right|^{T} = \left|A^{-1}\right| = \frac{1}{8} = 0.125$$

7. Consider an eight-bit ripple-carry adder for computing the sum of A and B, where A and B are integers represented in 2's complement form. If the decimal value of A is one, the decimal value of B that leads to the longest latency for the sum to stabilize is _____.

Key: (-1)

8. Let, $x_1 \oplus x_2 \oplus x_3 \oplus x_4 = 0$ where x_1, x_2, x_3, x_4 are Boolean variables, and $\oplus$ is the XOR operator.

Which one of the following must always be TRUE?

(A) $x_1x_2x_3x_4 = 0$ (B) $x_1x_3 + x_2 = 0$

(C) $\overline{x}_1 \oplus \overline{x}_3 = \overline{x}_2 \oplus \overline{x}_4$ (D) $x_1 + x_2 + x_3 + x_4 = 0$

Key: (C)

9. Let X be the number of distinct 16-bit integers in 2's complement representation. Let Y be the number of distinct 16-bit integers in sign magnitude representation.

Then X – Y is _____.

Key: (1)

Exp:

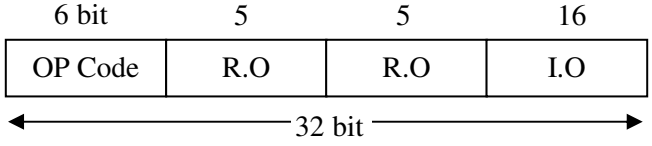
$$X = -2^{16-1} \text{ to } +2^{16-1} - 1$$

$$Y = -2^{16-1} - 1 \text{ to } +2^{16-1} - 1$$

$$\text{So } [X - Y = 1]$$

10. A processor has 40 distinct instructions and 24 general purpose registers. A 32-bit instruction word has an opcode, two register operands and an immediate operand. The number of bits available for the immediate operand field is _____.

Key: (16)

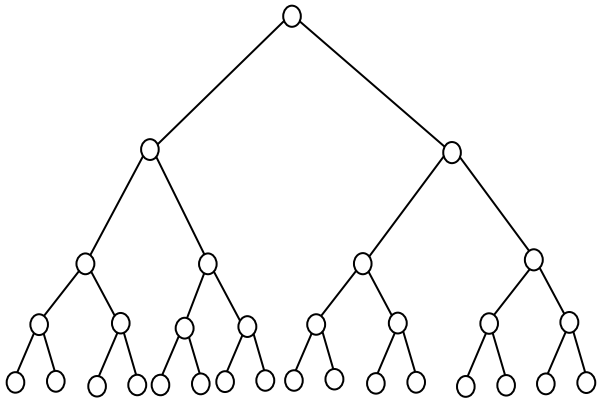


So 16 bit for immediate operand field

11. Breadth First Search (BFS) is started on a binary tree beginning from the root vertex. There is a vertex t at a distance four from the root. If t is the n-th vertex in this BFS traversal, then the maximum possible value of n is _____.

Key: (31)

Exp:



→ Required vertex is 31st vertex.

12. The value printed by the following program is _____.

```
void f(int* p, int m){
    m = m + 5;
    *p = *p + m;
    return;
}

void main(){
    int i=5, j=10;

    f(&i, j);
    printf("%d", i+j);
}
```

Key: (30)

Exp: i's address and j's value are passed to the function of f. f modifies i value to 20. j value remains same (as its value is passed not the reference).

$\therefore i + j = 30$ will be printed

13. Assume that the algorithms considered here sort the input sequences in ascending order. If the input is already in ascending order, which of the following are TRUE?

I. Quick sort runs in $\Theta(n^2)$ time

II. Bubble sort runs in $\Theta(n^2)$ time

III. Merge sort runs in Θ(n) time

IV. Insertion sort runs in Θ(n) time

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

Key: (D)

Exp: As input is already sorted quick sort runs in $\theta(n^2)$ & insertion sort runs in $\theta(n)$.

14. The Floyd-Warshall algorithm for all-pair shortest paths computation is based on

(A) Greedy paradigm

(B) Divide-and-Conquer paradigm.

(C) Dynamic Programming paradigm.

(D) Neither Greedy nor Divide-and-Conquer nor Dynamic Programming paradigm

Key: (C)

Exp: Floyd - warshall algorithm follows dynamic programming paradigm.

15. N items are stored in a sorted doubly linked list. For a delete operation, a pointer is provided to the record to be deleted. For a decrease-key operation, a pointer is provided to the record on which the operation is to be performed.

An algorithm performs the following operations on the list in this order: Θ(N) delete, O(log N) insert, O(log N) find, and Θ(N) decrease-key. What is the time complexity of all these operations put together?

(A) $O(\log^2 N)$ (B)O(N) (C)O(N2) (D) Θ(N2 log N)

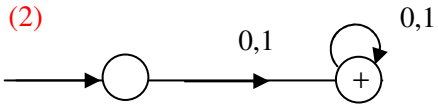
Key: (C)

16. The number of states in the minimum sized DFA that accepts the language defined by the regular expression is _____.

$$(0 + 1)*(0 + 1)(0 + 1)*$$

16. (2)

Exp:



17. Language L_1 is defined by the grammar: $S_1 \rightarrow aS_1b|\varepsilon$

Language L_2 is defined by the grammar: $S_2 \rightarrow abS_2|\varepsilon$

Consider the following statements:

P: L_1 is regular

Q: L_2 is regular

Which one of the following is TRUE?

(A) Both P and Q are true
(B) P is true and Q is false
(C) P is false and Q is true
(D) Both P and Q are false

Key: (C)

Exp: $L_1 = \{a^n b^n / n \geq 1\}$ CFL but not regular

$L_2 = (ab)^+$ regular

18. Consider the following types of languages: L_1: Regular, L_2: Context-free, L_3: Recursive, L_4: Recursively enumerable. Which of the following is/are TRUE?

I. $\overline{L}_3 \cup L_4$ is recursively enumerable

II. $\overline{L}_2 \cup L_3$ is recursive

III. $L_1^* \cap L_2$ is context-free

IV. $L_1 \cup \overline{L}_2$ is context-free

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

Key: (D)

Exp: $L_1 \cup \overline{L}_2$ is recursive but not CFL as CFL's are not closed under complementation.

19. Match the following:

(P) Lexical analysis	(i) Leftmost derivation
(Q) Top down parsing	(ii) Type checking
(R) Semantic analysis	(iii) Regular expressions
(S) Runtime environments	(iv) Activation records

(A) P ↔ i, Q ↔ ii, R ↔ iv, S ↔ iii
(B) P ↔ iii, Q ↔ i, R ↔ ii, S ↔ iv
(C) P ↔ ii, Q ↔ iii, R ↔ i, S ↔ iv
(D) P ↔ iv, Q ↔ i, R ↔ ii, S ↔ iii

Key: (B)

20. In which one of the following page replacement algorithms it is possible for the page fault rate to increase even when the number of allocated frames increases?

(A) LRU (Least Recently Used)
(B) OPT (Optimal Page Replacement)
(C) MRU (Most Recently Used)
(D) FIFO (First In First Out)

Key: (D)

Exp: If page fault rate increases even when the number of allocated frames increases, then that situation is called "Belady's Anamoly". It was happening with only FIFO among the given options.

21. B+ Trees are considered BALANCED because

(A) the lengths of the paths from the root to all leaf nodes are all equal.

(B) the lengths of the paths from the root to all leaf nodes differ from each other by at most 1.

(C) the number of children of any two non-leaf sibling nodes differ by at most 1.

(D) the number of records in any two leaf nodes differ by at most 1.

21. (A)

Exp: In both B& B+ trees all the leaf nodes will be at same level will be at same level.

22. Suppose a database schedule S involves transactions $T_1, \ldots, T_n$. Construct the precedence graph of S with vertices representing the transactions and edges representing the conflicts. If S is serializable, which one of the following orderings of the vertices of the precedence graph is guaranteed to yield a serial schedule?

(A) Topological order (B) Depth-first order

(C) Breadth-first order (D) Ascending order of transaction indices

Key: (A)

23. Anarkali digitally signs a message and sends it to Salim. Verification of the signature by Salim requires

(A) Anarkali's public key (B) Salim's public key

(C) Salim's private key (D) Anarkali's private key

Key: (A)

Exp: In digital signature generation process using senders private key we can encrypt the message and in verification process using senders public key we can decrypt the message.

24. In an Ethernet local area network, which one of the following statements is TRUE?

(A) A station stops to sense the channel once it starts transmitting a frame.

(B) The purpose of the jamming signal is to pad the frames that are smaller than the minimum frame size.

(C) A station continues to transmit the packet even after the collision is detected.

(D) The exponential backoff mechanism reduces the probability of collision on retransmissions.

Key: (D)

25. Identify the correct sequence in which the following packets are transmitted on the network by a host when a browser requests a webpage from a remote server, assuming that the host has just been restarted.

(A) HTTP GET request, DNS query, TCP SYN

(B) DNS query, HTTP GET request, TCP SYN

(C) DNS query, TCP SYN, HTTP GET request

(D) TCP SYN, DNS query, HTTP GET request

Key: (C)

Exp: When a browser requests a webpage from a remote server then that requests (URL address) will be mapped to IP address using DNS, then TCP synchronization takes place after that HTTP verify whether it is existed in the web server or not.

Q. No. 26 – 55 Carry Two Marks Each

26. A binary relation R on N × N is defined as follows: (a, b)R(c, d) if $a \leq c$ or $b \leq d$. Consider the following propositions:

P: R is reflexive

Q: R is transitive

Which one of the following statements is TRUE?

(A) Both P and Q are true (B) P is true and Q is false

(C) P is false and Q is true (D) Both P and Q are false

Key: (B)

Exp: 26. It is reflexive as every ordered pair is related to itself

(a,b) R (a,b) since $a \leq a$ or $b \leq b$

It is not transitive as (2,4)R(3,2) & (3,2) R(1,3) but (2,4) R (1,3)

27. Which one of the following well-formed formulae in predicate calculus is NOT valid?

(A) $(\forall x\ p(x) \Rightarrow \forall x\ q(x)) \Rightarrow (\exists x \neg p(x) \vee \forall x\ q(x))$

(B) $(\exists x\ p(x) \vee \exists x\ q(x)) \Rightarrow \exists x\ (p(x) \vee q(x))$

(C) $\exists x\ (p(x) \wedge q(x)) \Rightarrow (\exists x\ p(x) \wedge \exists x\ q(x))$

(D) $\forall x\ (p(x) \vee q(x)) \Rightarrow (\forall x\ p(x) \vee \forall x\ q(x))$

Key: (D)

28. Consider a set U of 23 different compounds in a Chemistry lab. There is a subset S of U of 9 compounds, each of which reacts with exactly 3 compounds of U. Consider the following statements:

I. Each compound in U \ S reacts with an odd number of compounds.

II. At least one compound in U \ S reacts with an odd number of compounds. III. Each compound in U \ S reacts with an even number of compounds.

Which one of the above statements is ALWAYS TRUE?

(A) Only I (B) Only II (C) Only III (D) None

Key: (B)

Exp: We can solve the given problems by taking an undirected graph with 23 vertices and 9 of these with degree 3.

Assume that if two compounds react with each other, then there exists an edge between the vertices.

Given that 9 vertices of degree 3 (odd)

By degree theorem atleast one of the remaining vertices must have odd degree ($\because$ No.of vertices of odd degree is always even).

29. The value of the expression $13^{99} \pmod{17}$, in the range 0 to 16, is _____.

Key: (4)

30. Suppose the functions F and G can be computed in 5 and 3 nanoseconds by functional units U_F and U_G, respectively. Given two instances of U_F and two instances of U_G, it is required to implement the computation F (G (X_i)) for $1 \le i \le 10$. Ignoring all other delays, the minimum time required to complete this computation is _____ nanoseconds.

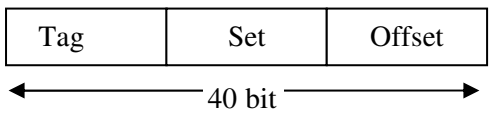
Key: (28)

31. Consider a processor with 64 registers and an instruction set of size twelve. Each instruction has five distinct fields, namely, opcode, two source register identifiers, one destination register identifier, and a twelve-bit immediate value. Each instruction must be stored in memory in a byte-aligned fashion. If a program has 100 instructions, the amount of memory (in bytes) consumed by the program text is _____.

Key: (500)

32. The width of the physical address on a machine is 40 bits. The width of the tag field in a 512 KB 8-way set associative cache is _____ bits.

Key: (24)



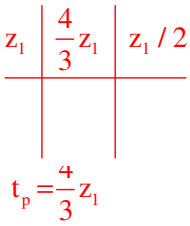
Tag bits = $40-(19-3)=24$ bits

33. Consider a 3 GHz (gigahertz) processor with a three-stage pipeline and stage latencies τ_1, τ_2, and τ_3 such that $\tau_1 = 3\tau_2/4 = 2\tau_3$. If the longest pipeline stage is split into two pipeline stages of equal latency, the new frequency is _____ GHz, ignoring delays in the pipeline registers.

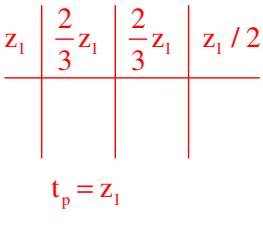
Key: (4)

Exp:

Pipeline



New Pipeline



34. A complete binary min-heap is made by including each integer in [1, 1023] exactly once. The depth of a node in the heap is the length of the path from the root of the heap to that node. Thus, the root is at depth 0. The maximum depth at which integer 9 can appear is _____.

Key: (8)

Exp: n^{th} smallest element will be present within 'n' levels of min heap

35. The following function computes XY for positive integers X and Y.

```
int exp(int X,  int Y)  {
    int res = 1, a = X,  b  = Y;
    while ( b  != 0  ){
        if ( b%2 == 0) {  a = a*a; b  = b/2; }
    else          {  res = res*a; b  = b-1; }
}
return res;
}
```

Which one of the following conditions is TRUE before every iteration of the loop?

(A) XY = ab

(B) (res * a)Y = (res * X)b

(C) XY = res * ab

(D) XY = (res * a)b

Key: (C)

36. Consider the following New-order strategy for traversing a binary tree:

- Visit the root;
- Visit the right subtree using New-order;
- Visit the left subtree using New-order;

The New-order traversal of the expression tree corresponding to the reverse polish expression 3 4 * 5 - 2 ^ 6 7 * 1 + - is given by:

(A) + - 1 6 7 * 2 ^ 5 - 3 4 *

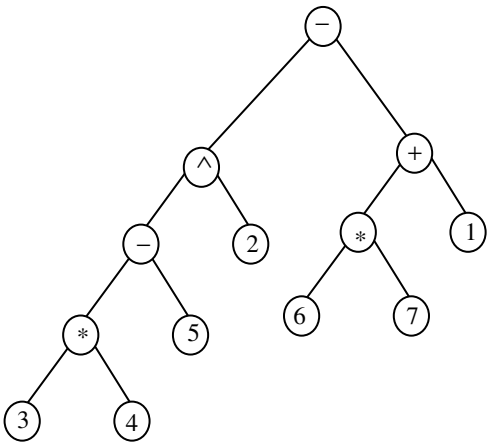
(B) - + 1 * 6 7 ^ 2 - 5 * 3 4

(C) - + 1 * 7 6 ^ 2 - 5 * 4 3

(D) 1 7 6 * + 2 5 4 3 * - ^ -

Key: (C)

Exp: Given is the post fix expression the expression tree given below.



New-order of above expression tree is

$-+1*76\wedge 2-5*43$

37. Consider the following program:

```
int f(int *p, int n)
{
    if (n <= 1) return 0;
    else return max(f(p+1,n-1),p[0]-p[1]);
}
int main()
{
    int a[ ] = {3,5,2,6,4};
    printf("%d", f(a,5));
}
```

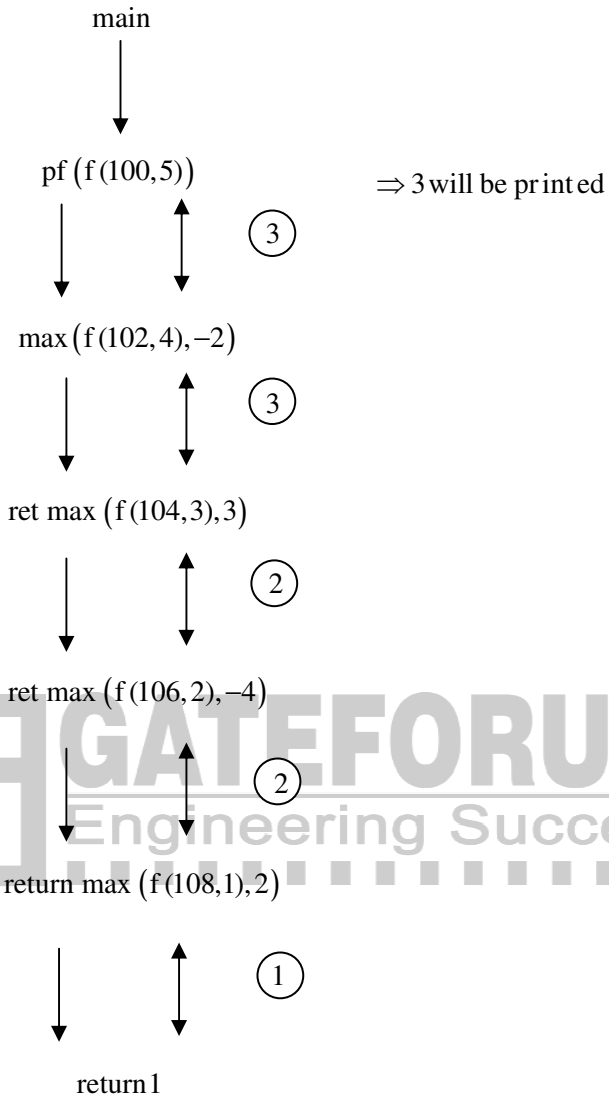
Note: max(x,y) returns the maximum of x and y.

The value printed by this program is _____.

Key: (3)

Exp: Assume base address of array a is 100.

3	5	2	6	4
100	102	104	106	108



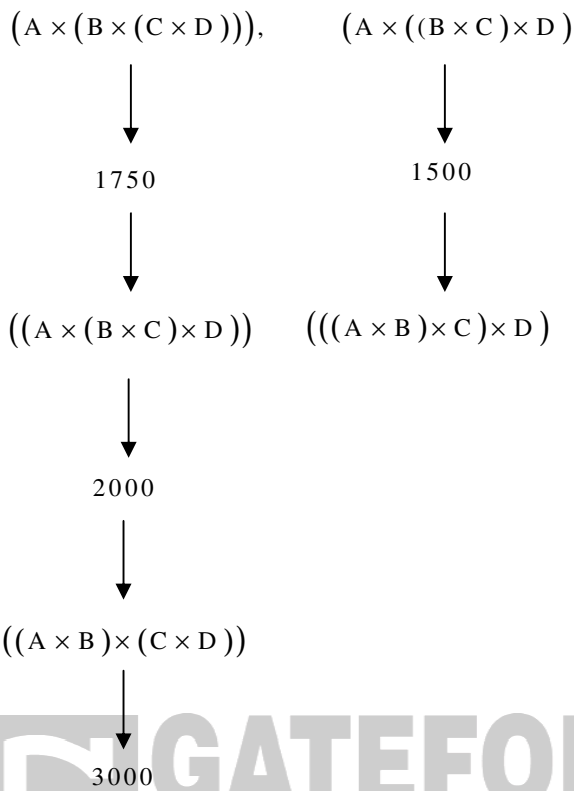
38. Let A_1, A_2, A_3, and A_4 be four matrices of dimensions 10×5, 5×20, 20×10, and 10×5, respectively. The minimum number of scalar multiplications required to find the product $A_1 A_2 A_3 A_4$ using the basic matrix multiplication method is _____.

Key: (1500)

Exp: No. of ways of multiplying the chain of matrices $= \frac{2^m C_m}{m+1}$

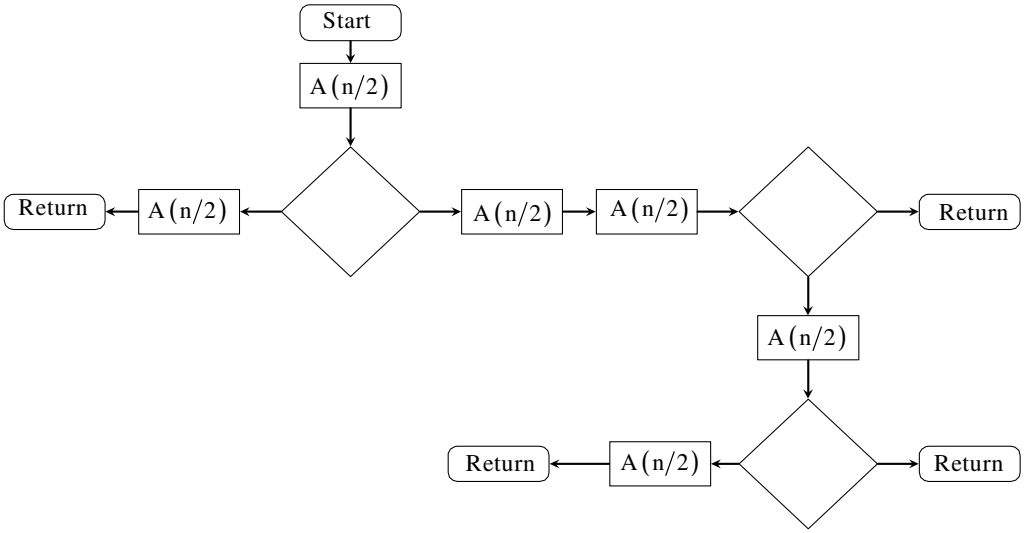
Where m= no. of multiplications (not matrices)

$\Rightarrow \frac{^6C_3}{3+1} = 5$



39. The given diagram shows the flowchart for a recursive function A(n). Assume that all statements, except for the recursive calls, have O(1) time complexity. If the worst case time complexity of this function is $O(n^{\alpha})$, then the least possible value (accurate up to two decimal positions) of α is _____.

Flowchart for Recursive Function A(n)



Key: (2.32)

40. The number of ways in which the numbers 1, 2, 3, 4, 5, 6, 7 can be inserted in an empty binary search tree, such that the resulting tree has height 6, is _____.

Note: The height of a tree with a single node is 0.

Key: (64)

Exp: 64, $2^6 = 64$

41. In an adjacency list representation of an undirected simple graph G = (V, E), each edge (u, v) has two adjacency list entries: [v] in the adjacency list of u, and [u] in the adjacency list of v. These are called twins of each other. A twin pointer is a pointer from an adjacency list entry to its twin. If |E | = m and |V | = n, and the memory size is not a constraint, what is the time complexity of the most efficient algorithm to set the twin pointer in each entry in each adjacency list?

(A) $\Theta(n^2)$ (B) $\Theta(n+m)$ (C) $\Theta(m^2)$ (D) $\Theta(n^4)$

Key: (B)

42. Consider the following two statements:

I. If all states of an NFA are accepting states then the language accepted by the NFA is Σ^*.

II. There exists a regular language A such that for all languages B, A ∩ B is regular.

Which one of the following is CORRECT?

(A) Only I is true (B) Only II is true

(C) Both I and II are true (D) Both I and II are false

Key: (B)

Exp: II is false, if all the states of DFA are accepting states then $L = \sum^*$

II is true because we can have regular language A= [ ] [Empty language] which satisfies the condition.

43. Consider the following languages:

$L_1 = \{a^n b^m c^{n+m}: m, n \geq 1\}$

$L_2 = \{a^n b^n c^{2n}: n \geq 1\}$

Which one of the following is TRUE?

(A) Both L_1 and L_2 are context-free.

(B) L_1 is context-free while L_2 is not context-free.

(C) L_2 is context-free while L_1 is not context-free.

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

Key: (B)

Exp: $L_1 \rightarrow$ we can rush a's & b's and for each c we can pop one item from stack, one c's are over stack should be empty.

$\therefore L_1$ = CFL

For L_2, we can't build PDA [a's & b's should be equal & C′ should be double of that count]

44. Consider the following languages.

$L_1 = \{\langle M\rangle \mid M \text{ takes at least 2016 steps on some input}\}$,

$L_2 = \{\langle M\rangle \mid M \text{ takes at least 2016 steps on all inputs}\}$ and

$L_3 = \{\langle M\rangle \mid M \text{ accepts } \varepsilon\}$,

where for each Turing machine M, $\langle M\rangle$ denotes a specific encoding of M. Which one of the following is TRUE?

(A) L_1 is recursive and L_2, L_3 are not recursive

(B) L_2 is recursive and L_1, L_3 are not recursive

(C) L_1, L_2 are recursive and L_3 is not recursive

(D) L_1, L_2, L_3 are recursive

Key: (C)

45. Which one of the following grammars is free from left recursion?

(A) $S \to AB$
$A \to Aa \mid b$
$B \to c$

(B) $S \to Ab \mid Bb \mid c$
$A \to Bd \mid \varepsilon$
$B \to e$

(C) $S \to Aa \mid B$
$A \to Bb \mid Sc \mid \varepsilon$

(D) $S \to Aa \mid Bb \mid c$
$A \to Bd \mid \varepsilon$
$B \to Ae \mid \varepsilon$

Key: (B)

Exp (C) & (D) are having indirect left recursion.

46. A student wrote two context-free grammars G1 and G2 for generating a single C-like array declaration. The dimension of the array is at least one. For example,

int a[10][3];

The grammars use D as the start symbol, and use six terminal symbols int ; id [ ] num.

Grammar G1	Grammar G2
D → int L;	D → int L;
L → id [E	L → id E
E → num]	E → E [num]
E → num] [E	E → [num]

Which of the grammars correctly generate the declaration mentioned above?

(A) Both G1 and G2 (B) Only G1

(C) Only G2 (D) Neither G1 nor G2

Key: (A)

47. Consider the following processes, with the arrival time and the length of the CPU burst given in milliseconds. The scheduling algorithm used is preemptive shortest remaining-time first.

Process	Arrival Time	Burst Time
P_1	0	10
P_2	3	6
P_3	7	1
P_4	8	3

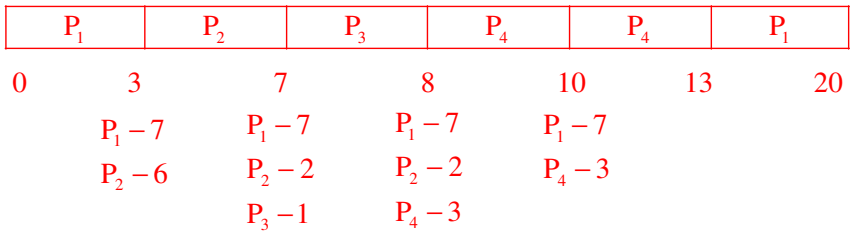
The average turnaround time of these processes is _____ milliseconds.

Key: (8.25)

Exp:

Process	Arrival Time	Burst Time	CT	TAT
P_1	0	10	20	20
P_2	3	6	10	7
P_3	7	1	8	1
P_4	8	3	13	5
			Total	8.25

Gant chart



48. Consider the following two-process synchronization solution

Process 0

Entry: loop while (turn == 1); (critical section)

Exit: turn = 1;

Process 1

Entry: loop while (turn == 0); (critical section)

Exit: turn = 0;

The shared variable turn is initialized to zero. Which one of the following is TRUE?

(A) This is a correct two-process synchronization solution.

(B) This solution violates mutual exclusion requirement.

(C) This solution violates progress requirement.

(D) This solution violates bounded wait requirement.

Key: (C)

Exp: The given solution for two process synchronization using "Turn" variable, satisfies the only mutual exclusion and bounded waiting but progess is violated.

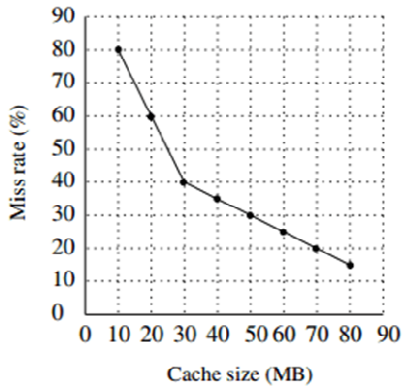
49. Consider a non-negative counting semaphore S. The operation P(S) decrements S, and V (S) increments S. During an execution, 20 P(S) operations and 12 V (S) operations are issued in some order. The largest initial value of S for which at least one P(S) operation will remain blocked is _____.

Key: (7)

Exp: S = -20 +12 = -8

∴ The largest initial value of S for which atleast one P(S) operation remains blocked is 7.

50. A file system uses an in-memory cache to cache disk blocks. The miss rate of the cache is shown in the figure. The latency to read a block from the cache is 1ms and to read a block from the disk is 10ms. Assume that the cost of checking whether a block exists in the cache is negligible. Available cache sizes are in multiples of 10 MB.



The smallest cache size required to ensure an average read latency of less than 6 ms is _____ MB.

Key: (30)

51. Consider the following database schedule with two transactions, T1 and T2.

$S = r_2(X); r_1(X); r_2(Y); w_1(X); r_1(Y); w_2(X); a_1; a_2$

where $r_i(Z)$ denotes a read operation by transaction T_i on a variable Z, $w_i(Z)$ denotes a write operation by T_i on a variable Z and a_i denotes an abort by transaction Ti.

Which one of the following statements about the above schedule is TRUE?

(A) S is non-recoverable

(B) S is recoverable, but has a cascading abort

(C) S does not have a cascading abort

(D) S is strict

Key: (C)

Exp: No transaction is reading the data item written by some other transaction. So the given schedule is cascadeless.

52. Consider the following database table named water_schemes:

Water_schemes		
Scheme_no	**District_name**	**Capacity**
1	Ajmeer	20
1	Bikaner	10
2	Bikaner	10
3	Bikaner	20
1	Churu	10
2	Churu	20
1	Dungargarh	10

The number of tuples returned by the following SQL query is _____.

```
with  total(name, capacity) as
      select  district_name, sum(capacity)
      from  water_schemes
      group by  district_name
with  total_avg(capacity) as select  avg(capacity)
      from  total
select  name
      from  total, total_avg
      where  total.capacity ≥  total_avg.capacity
```

Key: (2)

Exp: Two names Bikaner& churu will be selected.

53. A network has a data transmission bandwidth of 20×10^6 bits per second. It uses CSMA/CD in the MAC layer. The maximum signal propagation time from one node to another node is 40 microseconds. The minimum size of a frame in the network is _____ bytes.

Key: (200)

Exp: $B = 2\times 10^6$ bps

$T_p = 40\,\mu s$

L= ?

$$L = 2 \times T_p \times B \Rightarrow L = 2 \times 40 \times 10^{-6} \times 20 \times 10^{6}$$
$$= 1600 \text{ bits (or) } 200 \text{ bytes}$$
$$L = 200 \text{ bytes}$$

54. For the IEEE 802.11 MAC protocol for wireless communication, which of the following statements is/are TRUE?

I. At least three non-overlapping channels are available for transmissions.

II. The RTS-CTS mechanism is used for collision detection.

III. Unicast frames are ACKed.

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

Key: (B)

Exp: In collision avoidance, we use RTS-CTS mechanism but not in collision detection, only statement II is false.

55. Consider a 128×10^3 bits/second satellite communication link with one way propagation delay of 150 milliseconds. Selective retransmission (repeat) protocol is used on this link to send data with a frame size of 1 kilobyte. Neglect the transmission time of acknowledgement. The minimum number of bits required for the sequence number field to achieve 100% utilization is _____.

Key: (4)

Exp: B=128 kbps

$T_p = 150\text{ms}$

L = 1KB

$$\eta = 100\% \Rightarrow 1 = \frac{w}{1+2a}$$

$$T_x = \frac{L}{B} = \frac{8 \times 10^3}{128 \times 10^3} = 62.5\text{ms}$$

$$a = \frac{T_p}{T_x} = \frac{150\text{ms}}{62.5\text{ms}} = 2.4$$

$$\Rightarrow w = 1 + 2a \Rightarrow \frac{2^n}{2} = 1 + 2(2.4) \Rightarrow \frac{2^n}{2} = 5.8 \Rightarrow 2^n = 11.65$$

$$\Rightarrow 2^n = 11.6 \approx 12 \approx 2^4$$

$n = 4$

Computer Science Engineering

Q. No. 1 – 25 Carry One Mark Each

1. Let X be a Gaussian random variable mean 0 and variance σ^2 .Let Y=max(X, 0) where max (a,b) is the maximum of a and b. The median of Y is _____.

Key: (0)

Exp: 'X' is Gaussian random variable

$\Rightarrow X \sim N(0,\sigma^2)$ for $-\infty < x < \infty$

Given $y = \max(x,0)$

$$= \begin{cases} 0 \text{ if } -\infty < x \le 0 \\ x \text{ if } 0 < x < \infty, \text{is a random variable} \end{cases}$$

Since median is positional average

Therefore, median of Y is '0'.

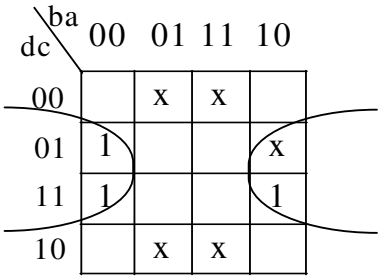
2. Consider the Karnaugh map given below, where x represents "don't care" and blank represents 0.

dc \ ba	00	01	11	10
00		x	x	
01	1			x
11	1			1
10		x	x	

Assume for all inputs (a, b, c, d) the respective complements $(\bar{a},\bar{b},\bar{c},\bar{d})$ are also available. The above logic is implemented 2-input NOR gates only. The minimum number of gates required is _____.

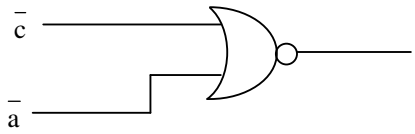
Key: (1)

Exp:



$F(a,b,c,d) = \bar{a}\bar{c} \Rightarrow \overline{\bar{a}.\bar{c}} = \overline{a + c}$ $\quad (\overline{x+y} = \bar{x}.\bar{y})$

$= \overline{a + \bar{c}}$



Only 1 NOR gate required

3. The statement $(\neg p) \Rightarrow (\neg q)$ is logically equivalent to which of the statements below?

I. $p \Rightarrow q$

II. $q \Rightarrow p$

III. $(\neg q) \vee p$

IV. $(\neg p) \vee q$

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

Key: (D)

Exp: By rule of contrapositive,

$\neg p \rightarrow \neg q \Leftrightarrow q \rightarrow p$

$q \rightarrow p \Leftrightarrow \sim q \vee p$

4. Consider the following table:

Algorithms		**Design Paradigms**	
P.	Kruskal	i.	Divide and Conquer
Q.	Quicksort	ii.	Greedy
R.	Floyd-Warshall	iii.	Dynamic Programming

Match the algorithms to the design paradigms they are based on.

(A) P-(ii), Q-(iii),R-(i) (B) P-(iii), Q-(i), R-(ii)

(C) P-(ii), Q-(i), R-(iii) (D) P-(i), Q-(ii), R-(iii)

Key: (C)

Exp: Kruskal's algorithm follows greedy approach in order to find MST of a connected graph. Quick sort follows divide and conquer strategy. Floyd Warshal algorithm is used to find the shortest path between every pair of vertices and it follows dynamic programming strategy.

5. A sender S sends a message m to receiver R, which is digitally signed by S with its private key. In this scenario, one or more of the following security violations can take place.

I. S can launch a birthday attack to replace m with a fraudulent message.

II. A third party attacker can launch a birthday attack to replace m with a fraudulent message.

III. R can launch a birthday attack to replace m with a fraudulent message.

Which of the following are possible security violations?

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

Key: (B)

Exp: Sender can launch a Birthday Attack to replace with fraudulent message, because he has the signature and he can decrypt the signature by his own public key and gets the hash value. With that same hash value, he can create another message and can be sent instead of original. Hence option(B) is correct.

6. Consider the following grammar.

$P \rightarrow xQRS$

$Q \rightarrow yz \mid z$

$R \rightarrow w \mid \in$

$S \rightarrow y$

What is FOLLOW (Q) ?

(A) {R} (B) {w} (C) {w, y} (D) {w, $}

Key: (C)

Exp: FOLLOW(*Q*) is FIRST(*R*) hence

FIRST(*R*) = {*w*, ϵ}

We add '*w*' in FOLLOW(*Q*) and for ϵ we calculate FIRST(*S*)

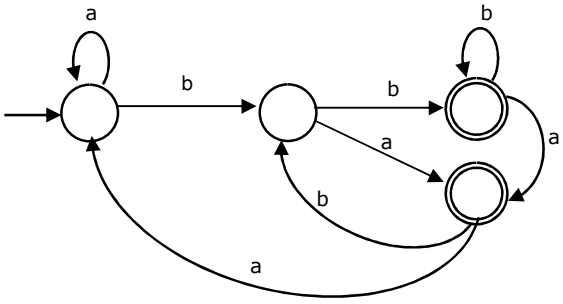
FIRST(*S*) ={*y*}

FOLLOW(*Q*) is {*w* ,*y*}

7. Consider the language L given by the regular expression $(a+b)^* b(a+b)$ over the alphabet {a, b}. The smallest number of states needed in a deterministic finite-state automation (DFA) accepting L is _____.

Key: (4)

Exp: The regular expression can be described as "All strings over {*a*, *b*} ending with "*ba*" or "*bb*". The minimal DFA accepting *L* is having 4 states:



8. Consider a two-level cache hierarchy with L1 and L2 caches. An application incurs 1.4 memory accesses per instruction on average. For this application, the miss rate of L1 cache

0.1, the L2 cache experiences, on average, 7 misses per 1000 instructions. The miss rate of L2 expressed correct to two decimal places is _____.

Key: (0.05)

Exp: $\left.\begin{matrix}\text{Number of memory access}\\ \text{in 1000 instructions}\end{matrix}\right\} = 1.4\times1000 = 1,400$

$$\therefore \text{Miss Rate} = \frac{7}{1400\times0.1} = 0.05$$

9. Consider the following CPU processes with arrival times (in milliseconds) and length of CPU burst (in milliseconds) as given below:

Process	Arrival time	Burst time
P1	0	7
P2	3	3
P3	5	5
P4	6	2

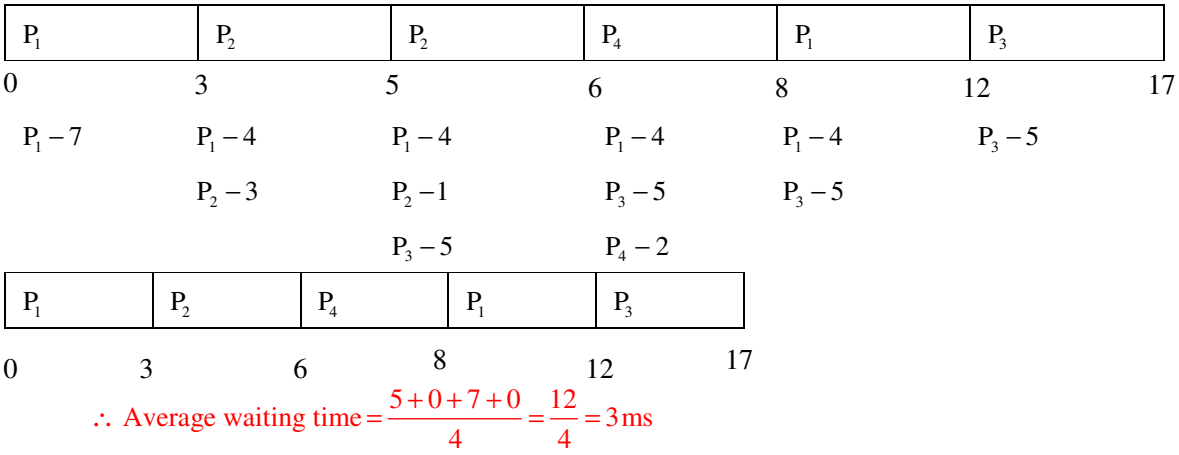
If the pre-emptive shortest remaining time first scheduling algorithm is used to schedule the processes., then the average waiting time across all processes is _____ milliseconds.

Key: (3)

Exp:

PID	AT	BT	CT	TAT	WT
P_1	0	7	12	12	5
P_2	3	3	6	3	0
P_3	5	5	17	12	7
P_4	6	2	8	2	0

Gantt chart:



$$\therefore \text{Average waiting time} = \frac{5+0+7+0}{4} = \frac{12}{4} = 3\,\text{ms}$$

10. Threads of a process share

(A) global variable but not heap.

(B) heap but not global variables.

(C) neither global variables nor heap.

(D) Both heap and global variables.

Key: (D)

Exp: Threads of a process can share all resources except stack and register set.

11. Let $c_1.....c_n$ be scalars, not all zero, such that $\sum_{i=1}^{n} c_i a_i = 0$ where a_i are column vectors in R^n. Consider the set of linear equations Ax = b

where $A=[a_1.....a_n]$ and $b=\sum_{i=1}^{n} a_i$ .The set of equations has

(A) a unique solution at $x = J_n$ where J_n denotes a n-dimensional vector of all 1

(B) no solution

(C) infinitely many solutions

(D) finitely many solutions

Key: (C)

Exp: Since the scalars are not all zero

$\therefore$ The column vectors a_i for $i = 1, 2..., n$ are linearly dependent

$\Rightarrow |A| = 0$ and $b = \sum_{i=1}^{n} a_i \Rightarrow Ax = b$ has infinitely many solutions.

12. Consider the C code fragment given below.

```
typedef struct node  {
    int data;
    node* next ;
} node;
void join (node* m, node* n)  {
node* p=n ;
while (p->next ! =NULL){
p = p –> next ;
}
p–> next = m;
}
```

Assuming that m and n point to valid NULL- terminated linked lists, invocation of join will

(A) append list m to the end of list n for all inputs.

(B) either cause a null pointer dereference or append list m to the end of list n.

(C) cause a null pointer dereference for all inputs.

(D) append list n to the end of list m for all inputs.

Key: **(B)**

Exp: While loop in Join Procedure moves the pointer 'p' to the last node of the list "n". And at the last statement, we are initializing the next of the last node of list n to start of list "m".

But in some cases it may dereference to null pointer.

13. The n-bit fixed-point representation of an unsigned real number real X uses f bits for the fraction part. Let i = n –f. The range of decimal values for X in this representation is

(A) 2^{-f} to 2^{i} (B) 2^{-f} to $\left(2^{i}-2^{-f}\right)$ (C) 0 to 2^{i} (D) 0 to $\left(2^{i}-2^{-f}\right)$

Key: **(D)**

Exp:

$i = n - f \;.\; f$

$\text{Max value} = 111.....1(\text{i times}).111.....1(\text{f times})$

$$= 2^{i} - 1 + \left(\frac{1}{2} + \frac{1}{2^{2}} + ... + \frac{1}{2^{f}}\right) = 2^{i} - 1 + \frac{2^{f}-1}{2^{f}} = 2^{i} - 2^{-f}$$

$\therefore 0 \text{ to } \left(2^{i} - 2^{-f}\right)$

14. Consider the following intermediate program in three address code

$p = a - b$

$q = p * c$

$p = u * v$

$q = p + q$

Which one of the following corresponds to *a static single assignment* form of the above code ?

(A)
$p_1 = a - b$
$q_1 = p_1 * c$
$p_1 = u * v$
$q_1 = p_1 + q_1$

(B)
$p_3 = a - b$
$q_4 = p_3 * c$
$p_4 = u * v$
$q_5 = p_4 + q_4$

(C)
$p_1 = a - b$
$q_1 = p_2 * c$
$p_3 = u * v$
$q_2 = p_4 + q_3$

(D)
$p_1 = a - b$
$q_1 = p * c$
$p_2 = u * v$
$q_2 = p + q$

Key: **(B)**

Exp: a-code violates condition for static single assignment since p_1 is initialized twice

c- $p_2, p_4, \& q_3$ are not initialized anywhere

d- $q_2 = p + q$ is incorrect code

15. Consider the C struct defined below:

```
struct data {
    int marks [100] ;
```

```
    char grade;
    int cnumber;
};
struct data student;
```

The base address of student is available in register R1. The field student.grade can be accessed efficiently using

(A) Post-increment addressing mode. (R1)+

(B) Pre-decrement addressing mode, -(R1)

(C) Register direct addressing mode, R1

(D) Index addressing mode, X(R1), where X is an offset represented in 2's complement 16-bit representation.

Key: (D)

Exp: Direct access is possible with only index addressing mode.

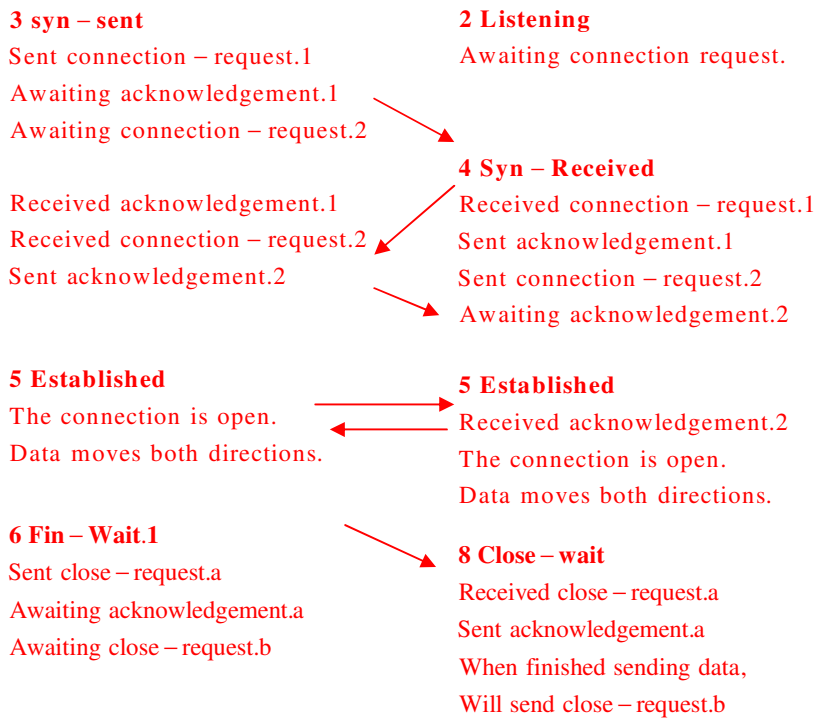
16. Consider a TCP client and a TCP server running on two different machines. After completing data transfer, the TCP client calls **close** to terminate the connectional and a FIN segment is sent to the TCP server. Server-side TCP responds by sending an ACK which is received by the client-side TCP. As per the TCP connections state diagram (RFC 793), in which state does the client-side TCP connection wait for the FIN from the sever-side TCP?

(A) LAST-ACK (B) TIME-WAIT (C) FIN-WAIT-1 (D) FIN-WAIT-2

Key: (D)

Exp: Client* Server*

*or vice-versa, though requests typically originate at clients.



7 Fin – wait.2
Received acknowledgement.a
Still awaiting close – request.b
Or
10 closing
Received close – request.b
Sent acknowledgement.b
Still awating acknowledgement.a

9 Last – Ack
Sent close – request.b
Awaiting acknowledgement.b

11 Time – wait
Received acknowledgement.a
Received close – request.b
Sent acknowledgement.b
Allowing time for delivery
Of acknowledgement.b

1 closed
A "fictional" state;
There is no connection.

2 Listening
Awaiting connection request.

17. Consider the following context-free grammar over the alphabet $\Sigma = \{a, b, c\}$ with S as the start symbol.

$S \rightarrow abScT \mid abcT$

$T \rightarrow bT \mid b$

Which one of the following represents the language generated by the above grammar ?

(A) $\left\{(ab)^n (cb)^n \mid n \geq 1\right\}$

(B) $\left\{(ab)^n cb^{m_1} cb^{m_2} \ldots cb^{m_n} \mid n, m_1, m_2, \ldots m_n \geq 1\right\}$

(C) $\left\{(ab)^n (cb^m)^n \mid m, n \geq 1\right\}$

(D) $\left\{(ab)^n (cb^n)^m \mid m, n \geq 1\right\}$

Key: **(B)**

Exp: The given Grammar over $\Sigma = \{a, b, c\}$ with S as the start symbol is

$S \rightarrow abScT \mid abcT$

$T \rightarrow bT \mid b$

The minimum length string generated by the grammar is 1:

$S \rightarrow abcT \rightarrow abcb$; hence all variable greater than 1.

Other cases

$S \rightarrow abScT \rightarrow ab\ abScT\ cT \rightarrow ab\ ab\ abScT\ cT\ cT \rightarrow \ldots\ldots\ldots \rightarrow (ab)^n (cT)^n$.

Here T can generate any number of b's starting with single b.

Hence The language is $L = \{(ab)^n\ cb^{m_1} cb^{m_2} cb^{m_3} cb^{m_4} \ldots\ldots\ldots\ldots cb^{m_n} \mid m_1, m_2, m_3, m_4 \ldots\ldots m_n\ n \geq 1\}$

18. Consider the first-order logic sentence $F:\forall z(\exists yR(x,y))$. Assuming non-empty logical domains, which of the sentences below are *implied* by F?

I. $\exists y(\exists xR(x,y))$ II. $\exists y(\forall xR(x,y))$

III. $\forall y(\exists xR(x,y))$ IV. $\neg\exists x(\forall y\neg R(x,y))$

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

Key: (B)

Exp: $\forall x(\exists yR(x,y)) \Rightarrow \exists y\exists xR(x,y)$

$\exists y\forall x\, R(x,y) \Rightarrow \forall x\exists yR(x,y)$

$\forall x\exists yR(x,y) \not\Rightarrow \exists y\forall x\, R(x,y)$

$\neg\exists x(\forall y\neg R(x,y)) \Leftrightarrow \forall x\exists y\, R(x,y)$

19. When two 8-bit numbers $A_7....A_0$ and $B_7.....B_0$ in 2's complement representation (with A_0 and B_0 as the least significant bits) are added using a **ripple-carry adder**, the sum bits obtained are $S_7....S_0$ and the carry bits are $C_7....C_0$. An overflow is said to have occurred if

(A) the carry bit C_7 is 1 (B) all the carry bits ($C_7....C_0$) are 1

(C) $(A_7\, B_7.\overline{S_7} + \overline{A_7}.\overline{B_7}.S_7)$ is 1 (D) $(A_0.B_0.\overline{S_0} + \overline{A_0}.\overline{B_0}.S_0)$ is 1

Key: (C)

Exp: Overflow flag indicates an over flow condition for a signed operation. Some points to remember in a signed operation:

* MSB is always reserved to indicate sign of the number.

* Negative numbers are represented in 2's – complement.

* An overflow results in invalid operation.

2's complement overflow rules:

* If the sum of two positive numbers yields a negative result, the sum has- overflowed.

* If the sum of two negative number yields a positive result, the sum has overflowed.

* Otherwise, the sum has not overflowed.

Overflow for signed numbers occurs when the carry-in into the MSB (most significant bit) is not equal to carry-out. Conveniently, an XOR-operation on these two bits can quickly determine if an overflow condition exists.

Therefore, $((A_7.B_7)) \oplus S_7 = \overline{A}_7.\overline{B}_7.S_7 + A_7.B_7.S_7 = 1)$ has overflowed.

20. Consider a database that has the relation schema EMP (EmpId, EmpName, and DeptName). An instance of the schema EMP and a SQL query on it are given below.

EMP		
EmpId	**EmpName**	**DeptName**
1.	XYA	AA
2.	XYB	AA

3.	XYC	AA
4.	XYD	AA
5.	XYE	AB
6.	XYF	AB
7.	XYG	AB
8.	XYH	AC
9.	XYI	AC
10	XYJ	AC
11.	XYK	AD
12.	XYL	AD
13.	XYM	AE

```
SELECT  AVG(EC.Num)
FROM  EC
WHERE(DeptName, Num)IN
        (SELECT DeptName, COUNT(EmpId) AS
                        EC( DeptName, Num)
        FROM EMP
        GROUP BY DeptName)
```

The output of executing the SQL query is _____.

Key: (2.6)

Exp:

EC	
Dept Name	Num
AA	4
AB	3
AC	3
AD	2
AE	1

$$\text{Avg}(\text{NUM}) = \frac{13}{5} = 2.6$$

21. The following functional dependencies hold true for the relational schema R{V,W,X,Y,Z}:

$V \rightarrow W$

$VW \rightarrow X$

$Y \rightarrow VX$

$Y \rightarrow Z$

Which of the following is irreducible equivalent for this set of functional dependencies ?

(A) $V \to W$, $V \to X$, $Y \to V$, $Y \to Z$

(B) $V \to W$, $W \to X$, $Y \to V$, $Y \to Z$

(C) $V \to W$, $V \to X$, $Y \to V$, $Y \to X$, $Y \to Z$

(D) $V \to W$, $W \to X$, $Y \to V$, $Y \to X$, $Y \to Z$

Key: (A)

Exp: $\underline{V \to W}, \underline{VW \to X}, Y \to V, Y \to X, Y \to Z$ (W is extraneous)

$V \to W, \underline{V \to X}, \underline{Y \to V}, \underline{Y \to X}, Y \to Z$

$\therefore Y \to X$ is redundant

$\therefore \{V \to W,\ V \to X,\ Y \to V,\ Y \to Z\}$

22. Consider the following functions from positive integers to real numbers:

$10, \sqrt{n}, n, \log_2 n, \frac{100}{n}$

The CORRECT arrangement of the above functions in increasing order of asymptotic complexity is:

(A) $\log_2 n, \frac{100}{n}, 10, \sqrt{n}, n$

(B) $\frac{100}{n}, 10, \log_2 n, \sqrt{n}, n$

(C) $10, \frac{100}{n}, \sqrt{n}, \log_2 n, n$

(D) $\frac{100}{n}, \log_2 n, 10, \sqrt{n}, n$

Key: (B)

Exp: $\frac{100}{n} < 10 < \log_2 n < \sqrt{n}, n$

23. Let T be a tree with 10 vertices. The sum of the degrees of all the vertices in T is _____.

Key: (18)

Exp: A tree with 10 vertices has 9 edges.

$\text{As} \sum d(v_i) = 2|E|$

$\Rightarrow \sum d(v_i) = 2 \times 9 = 18$

24. Let T be a binary search tree with 15 nodes. The minimum and maximum possible heights of T are :

Note: *The height of a tree with a single node is 0.*

(A) 4 and 15 respectively

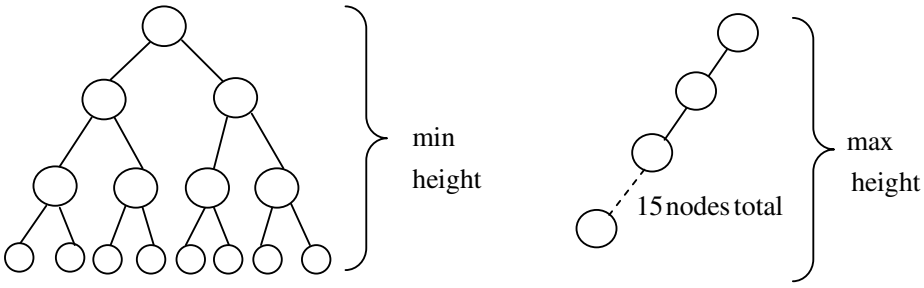
(B) 3 and 14 respectively

(C) 4 and 14 respectively

(D) 3 and 15 respectively

Key: (B)

Exp:



Min height = floor($\log_2$ N) = floor(log 15)= 3

Max height= 14, when the tree is either left skewed or right skewed.

25. Consider the following C code:

```
# include <stdio.h>
int * assignval (int *x, int val)  {
      *x = val;
      return x;
}
void main ( )  {
      int  * x= malloc (sizeof (int));
      if (NULL = = x) return;
      x = assignval (x,0);
      if(x)   {
      x=(int *) malloc (sizeof (int));
      if (NULL = = x) return;
      x = assignval (x, 10);
}
printf("%d\n",  *x);
free (x);
}
```

The code suffers from which one of the following problems:

(A) compiler error as the return of malloc is not typecast appropriately.

(B) compiler error because the comparison should be made as x==NULL and not as shown.

(C) compiles successfully but execution may result in dangling pointer.

(D) compiles successfully but execution may result in memory leak.

Key: (D)

Exp: (A) is wrong. We don't need to cast the result as void * is automatically and safely promoted to any other pointer type in this case.

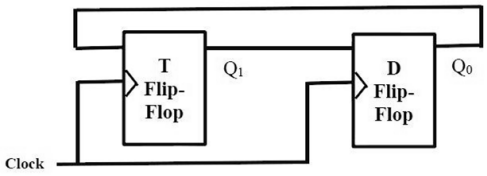
(B) It is discarded for obvious reason.

(C) is wrong, because dangling pointer is nothing but the pointer which is pointing to non-existing memory (deallocated or deleted memory) which is not happening here.

(D) is the answer. When you are calling malloc second time, new location is assigned to x and previous memory location is lost and now we don't have no reference to that location resulting in memory leak.

Q. No. 26 – 55 Carry Two Marks Each

26. Consider a combination of T and D flip-flops connected as shown below. The output of the D flip-flop is connected to the input of the T flip-flop and the output of the T Flip-flop is connected to the input of the D Flip-flop.



Initially, both Q_0 and Q_1 are set to 1 (before the 1st clock cycle). The outputs

(A) Q_1Q_0 after the 3rd cycle are 11 and after the 4th cycle are 00 respectively

(B) Q_1Q_0 after the 3rd cycle are 11 and after the 4th cycle are 01 respectively

(C) Q_1Q_0 after the 3rd cycle are 00 and after the 4th cycle are 11 respectively

(D) Q_1Q_0 after the 3rd cycle are 01 and after the 4th cycle are 01 respectively

Key: (B)

Exp:

CLK	Q_1	Q_0
0	1	1
1	0	1
2	1	0
3	1	1
4	0	1

After 3rd clock pulse :11

After 4th clock pulse: 01

27. The number of integers between 1 and 500 (both inclusive) that are divisible by 3 or 5 or 7 is _____.

Key: (271)

Exp: $D_3 = \{\text{integers between 1 to 500 divisible by 3}\}$

$D_5 = \{\text{integers between 1 to 500 divisible by 5}\}$

$D_7 = \{\text{integers between 1 to 500 divisible by 7}\}$

To find number of integers between 1 to 500 that are divisible by 3 or 5 or 7 is to find

$$|D_3 \cup D_5 \cup D_7|$$

$$= \left[|D_3| + |D_5| + |D_7|\right] - \left[|D_3 \cap D_5| + |D_3 \cap D_7| + |D_5 \cap D_7|\right] + \left[|D_3 \cap D_5 \cap D_7|\right]$$

$$= \left(\left[\frac{500}{3}\right] + \left[\frac{500}{5}\right] + \left[\frac{500}{7}\right]\right) - \left(\left[\frac{500}{15}\right] + \left[\frac{500}{21}\right] + \left[\frac{500}{35}\right]\right) + \left[\frac{500}{105}\right]$$

$$= (166 + 100 + 71) - (33 + 23 + 14) + 4$$

$$= 337 - 70 + 4 = 271$$

28. Consider a RISC machine where each instruction is exactly 4 bytes long. Conditional and unconditional branch instructions use PC- relative addressing mode with Offset specified in bytes to the target location of the branch instruction. Further the Offset is always with respect to the address of the next instruction in the program sequence. Consider the following instruction sequence.

Instr. No.	Instruction
i:	add R2, R3, R4
i +1:	sub R5, R6, R7
i + 2:	cmp R1, R9, R10
i + 3	beq R1, Offset

If the target of the branch instruction is i, then the decimal value of the Offset is _____.

Key: (-16)

Exp: I_1 0 – 3

I_2 4 – 7

I_3 8 – 11

I_4 12 – 15

16 –

I_4 is the branch instruction & I_1 is the target.

0 = 16+ relative value

$\therefore$ relative value = -16

29. Consider the C functions foo and bar given below:

```
int foo (int val ) {
    int x = 0;
    while (val > 0)  {
    x = x + foo ( val --);
}
    return val ;
}
int bar (int val )  {
int x = 0;
while (val > 0) {
    x = x + bar (val – 1) ;
```

```
    }
return val ;
}
```

Invocations of foo (3) and bar (3) will result in:

(A) Return of 6 and 6 respectively.

(B) Infinite loop and abnormal termination respectively.

(C) Abnormal termination and infinite loop respectively.

(D) Both terminating abnormally

Key: (B)

Exp: Foo (3) calls foo (3) which in turn calls foo(3). This goes on infinite number of times which causes memory overflow and causes abnormal termination.

Bar(3) $\rightarrow$ bar (2) $\rightarrow$bar (1) $\rightarrow$bar (0) (return 0) from here onwards bar (1) will call bar (0) and bar (0) will return 0 to bar (1) & this goes on forever without causing memory overflow.

30. In a RSA cryptosystem a participant A uses two prime numbers p = 13 and q =17 to generate her public and private keys. If the public key of A is 35. Then the private key of A is _____.

Key: (11)

Exp:

Given Data	As per RSA Algorithm
p=13	**Step1:**Calculate $n = p \times q = 13 \times 17 = 221$
q=17	**Step 2:** Calculate $\phi(n) = (p-1)(q-1) = (12)(16) = 192$
e=35	**Step 3:** $de \bmod \phi(n) = 1$ (or) $de = 1 \bmod \phi(n)$
d=?	$\Rightarrow d \times 35 \bmod 192 = 1 \Rightarrow d = 11$

31. Let A be an array of 31 numbers consisting of sequence of 0's followed by a sequence of 1's. The problem is to find the smallest index *i* that A[*i*] is 1 by probing the minimum numbers of locations in A. The *worst case* number of probes performed by an *optimal* algorithm is _____.

Key: (5)

Exp: In the given array the elements are 0's followed by 1's , which means array is already sorted.

So we can apply binary search. At each stage, we compare $A\left[\frac{low + high}{2}\right]$.

[Assuming 'A' is an array of 31 elements] with '1' and if it is 1 we check the left part recursively and if it is '0' we check the right part of the array recursively, which takes $\log_2 31$ comparisons in the worst case.

32. If G is grammar with productions

$S \rightarrow SaS|aSb|bSa|SS|\in$

where S is the start variable, then which one of the following is not generated by G?

(A) abab (B) aaab (C) abbaa (D) babba

Key: (D)

Exp: 1. $S \rightarrow SS \rightarrow aSbS \rightarrow abS \rightarrow abaSb \rightarrow abab$

2. $S \rightarrow aSb \rightarrow aSaSb \rightarrow aaaSb \rightarrow aaab$

3. $S \rightarrow SS \rightarrow aSbS \rightarrow abS \rightarrow abbSa \rightarrow abbSaSa \rightarrow abbaa$

Given grammar generates all strings where $n(a) \geq n(b)$

33. The value of $\lim_{x \to 1} \frac{x^7 - 2x^5 + 1}{x^3 - 3x^2 + 2}$

(A) is 0 (B) is -1 (C) is 1 (D) does not exist

Key: (C)

Exp: $\lim_{x \to 1} \frac{x^7 - 2x^5 + 1}{x^3 - 3x^2 + 2} = \lim_{x \to 1} \frac{7x^6 - 10x^4}{3x^2 - 6x} = 1.$ (Using L – Hospital's rule)

34. Instructions execution in a processor is divided into 5 stages. Instruction Fetch (IF), Instruction Decode (ID) , Operand Fetch (OF), Execute (EX), and Write Back (WB), These stages take **5,4,20, 10 and 3 nanoseconds (ns)** respectively. A pipelined implementation of the processor requires buffering between each pair of consecutive stages with a delay of 2ns. Two pipelined implementations of the processor are contemplated.

(i) a naïve pipeline implementation (NP) with 5 stages and

(ii) an efficient pipeline (EP) where the OF stage id divided into stages OF1 and OF2 with execution times of 12 ns and 8 ns respectively.

The speedup (correct to two decimals places) achieved by EP over NP in executing 20 independent instructions with no hazards is _____.

Key: (1.508)

Exp: Given,

For Navie pipeline (NP)

Number of stages (k) = 5

T_p = max (stage delay + buffer delay)

$T_p = \max(7,6,22,12,5) = 22$ n sec.

Number of instructions (n) = 20

So, erection time for navie pipeline

$ET_{NP} = (k + n - 1) \times T_P = (5 + 20 - 1) \times 22 = 528$ n sec

Now, for efficient pipeline

$k = 6,\ n = 20,\ T_P = 14$ n sec.

$E_{EP} = (k + n - 1) \times T_P = (6 + 20 - 1) \times 14 = 350$ n sec.

Therefore, Speedup $(s) = \frac{ET_{NP}}{E_{EP}} = \frac{528}{350}$

Speedup $(s) = 1.508$

35. Consider a database that has the relation schemas EMP(EmpId, EmpName, DepId). And DEPT(DeptName, DeptId). Note that the DeptId can be permitted to be NULL in the relation EMP. Consider the following queries on the database expressed in tuple relational calculus.

(I) $\{t \mid \exists u \in EMP(t[EmpName] = u[EmpName] \wedge \forall v \in DEPT(t[DeptId] \neq v[DeptId]))\}$

(II) $\{t \mid \exists u \in EMP(t[EmpName] = u[EmpName] \wedge \exists v \in DEPT(t[DeptId] \neq v[DeptId]))\}$

(III) $\{t \mid \exists u \in EMP(t[EmpName] = u[EmpName] \wedge \exists v \in DEPT(t[DeptId] \neq v[DeptId]))\}$

Which of the above queries are safe?

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

Key: (D)

Exp: Query which generates infinite number of tuples is called unsafe query. In the given question all the given queries generate finite number of tuples.

36. Recall that Belady's anomaly is that the pages-fault rate may increase as the number of allocated frames increases. Now consider the following statements:

S1: *Random page replacement* algorithm (where a page chosen at random is replaced) suffers from Belady's anomaly

S2: *LRU page replacement* algorithm suffers from Belady's anomaly

Which of the following is CORRECT ?

(A) S1 is true, S2 is true
(B) S1 is true, S2 is false
(C) S1 is false , S2 is true
(D) S1 is false, S2 is false

Key: (B)

Exp: **Statement 1** is "TRUE". Because there can be a case when page selected to be replaced is by FIFO policy.

Statement 2 is "FALSE". Because LRU page replacement algorithm does not suffers from Belady's Anomaly. Only FIFO page replacement algorithm suffers from Belady's Anomaly.

37. The output of executing the following C program is _____.

```
# include <stdio.h>
int  total (int v) {
while (v)   {
      count + = v & 1;
      v>> = 1;
}
      return count;
}
void main ( ) {
static int x = 0;
int  i = 5;
for (; i> 0; i--)  {
```

```
    x=x + total (i) ;
}
printf ("%d\n", x)  ;
}
```

Key: (23)

Exp: Count in the function total is static .

i	Count	total(i)
5	0	2
4	2	3(2+1)
3	3	5(3+2)
2	5	6(5+1)
1	6	7(6+1)
		= 23

38. Consider the following C program.

```
#include <stdio.h>
#include<string.h>
void printlength (char *s, char *t) {
    unsigned int c = 0;
    int len = ((strlen(s) – strlen (t)) > c) ? strlen(s): strlen(t);
    printf ("%d\n", len);
}
void main ( ) {
    char  *x = "abc";
    char  *y ="defgh";
    printlength (x,y);
```

Recall that strlen is defined in string.h as returning a value of type size_t, which is an unsigned int. The output of the program is _____.

Key: (3)

Exp: x is pointer of string "abc" which is length 3.

S is pointer, that pointed x.

y is pointer of string "defgh" which is length 5.

t is pointer that pointed y.

Now, $((\text{strlen}(s)-\text{strlen}(t))>c)$ is $((3-5)>0)$ is returns true, since $(3-5=-2)$ is non-zero value so, ternary operator '?' is returned strlen(s) which is 3 and assigned to len because ternary- operator returns first if condition is true else second. Therefore, final value is printed 3.

39. Consider the following languages over the alphabet $\sum=\{a,b,c\}$

Let $L_1 = \{a^n b^n c^m \mid m, n \geq 0\}$ and $L_2 = \{a^m b^n c^n \mid m, n \geq 0\}$

Which of the following are context-free languages ?

I. $L_1 \cup L_2$ II. $L_1 \cap L_2$

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

Key: (A)

Exp: The language given over alphabets Σ = {*a, b, c*} as $L_1 = \{a^n b^n c^m \mid n,m \geq 0\}$ and $L_2 = \{a^m b^n c^n \mid n,m \geq 0\}$.

$L_1 \cup L_2 = \{a^n b^m c^k \mid n=m \text{ or } m=k,\ n,m \geq 0\}$ is a context free language. The context free grammar is:

$S \rightarrow AB \mid CD$

$A \rightarrow aAb \mid \epsilon$

$B \rightarrow cB \mid \epsilon$

$C \rightarrow aC \mid \epsilon$

$D \rightarrow bSc \mid \epsilon$

$L_1 \cap L_2 = \{a^n b^m c^k \mid n=m \text{ and } m=k,\ n,m \geq 0\}$ or $\{a^n b^n c^n \mid n \geq 0\}$ is a non context free language.

40. Consider a 2-way set associative cache with 256 blocks and uses LRU replacement, Initially the cache is empty. Conflict misses are those misses which occur due the contention of multiple blocks for the same cache set. Compulsory misses occur due to first time access to the block. The following sequence of accesses to memory blocks.

(0,128,256,128,0,128,256,128,1,129,257,129,1,129,257,129)

is repeated 10 times. The number of *conflict misses* experienced by the cache is _____.

Key: (76)

Exp: A miss is not considered a conflict miss if the block is accessed for the first time.

1st round: (2+2) misses

2nd round: (4+4) misses

$\therefore \text{Total} = 4 + (8 \times 9) = 76$ conflict misses

41. Let u and v be two vectors in $\mathbf{R^2}$ whose Euclidean norms satisfy $\|u\| = 2\|v\|$. What is the value of α such that $w = u + \alpha v$ bisects the angle between u and v ?

(A) 2 (B) 1/2 (C) 1 (D) -1/2

Key: (A)

Exp: Let $u = \begin{pmatrix} 2 \\ 0 \end{pmatrix}$ and $v = \begin{pmatrix} 0 \\ 1 \end{pmatrix}$

$\Rightarrow \|u\| = z.\|v\|$ and $w = \begin{pmatrix} 2 \\ \alpha \end{pmatrix}$

Now $\cos(u,w) = \cos(v,w)$

$\Rightarrow \frac{4}{(2)\sqrt{\alpha^2+4}} = \frac{\alpha}{(1)\sqrt{\alpha^2+4}} \Rightarrow \alpha = 2$

42. Consider the following grammar:

$stmt \rightarrow if\ expr\ then\ else\ expr; stmt \mid 0$

$expr \rightarrow term\ relop\ term \mid term$

$term \rightarrow id \mid number$

$if \rightarrow a \mid b \mid c$

$number \rightarrow [0-9]$

where **relop** is a relational operate (e.g <, >,….) ---O refers to the empty statement, and **if** ,**then, else** are terminals.

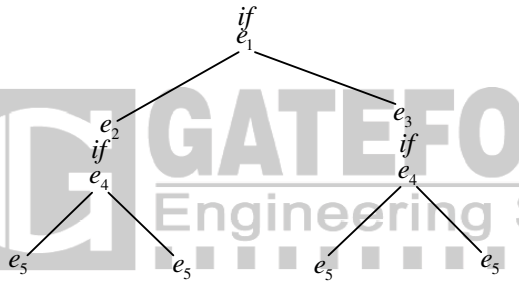
Consider a program P following the above grammar containing ten **if** terminals. The number of control flows paths in P is _____. For example the program

if e_1 **then** e_2 **else** e_3

has 2 controls flow paths $e_1 \rightarrow e_2$ and $e_1 \rightarrow e_3$

Key: (1024)

Exp: For 2 "if statements", 2^2=4 control flow paths are possible:



So for 10 "If statements", 2^{10} control flow paths will be there.

43. In a database system, unique time stamps are assigned to each transaction using Lamport's logical clock . Let $TS(T_1)$ and $TS(T_2)$ be the timestamps of transactions T_1 and T_2 respectively. Besides, T_1 holds a lock on the resource R, and T_2 has requested a conflicting lock on the same resource R. The following algorithm is used to prevent deadlocks in the database system assuming that a killed transaction is restarted with the same timestamp.

if $TS(T_2) < TS(T_1)$ then

T_1 is killed

else T_2 waits.

Assume any transactions that is not killed terminates eventually. Which of the following is TRUE about the database system that uses the above algorithm to prevent deadlocks?

(A) The database system is both deadlock-free and starvation- free.

(B) The database system is deadlock- free, but not starvation-free.

(C) The database system is starvation-free but not deadlock- free.

(D) The database system is neither deadlock- free nor starvation-free.

Key: (A)

Exp: Elder kills younger and youngers waits on elder. So both are not waiting for each other. Hence no deadlock and there won't be any starvation as well because the transaction who got killed will be starting with same time stamp.

44. Let A and B be infinite alphabets and let # be a symbol outside both A and B. Let f be a total functional from A^* to B^*. We say f is *computable* if there exists a Turning machine M which given an input x in A^*, always halts with *f(x)* on its tape. Let L_f denote the language $\{x\#f(x) | x \in A^*\}$ .Which of the following statements is true:

(A) f if computable if and only if L_f is recursive.

(B) f is computable if and only L_f recursively enumerable.

(C) If f is computable then L_f is recursive, but not conversely.

(D) If f is computable then L_f is recursively enumerable, but not conversely.

Key: (A)

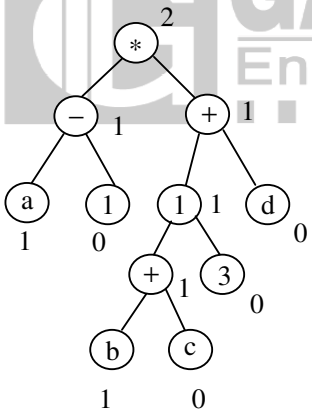
Exp: A TM is recursive iff it halts for every input string (either in accept or reject state).

Here, a computable function is defined in a similar way.

45. Consider the expression $(a-1)^*(((b+c)/3)+d))$. Let X be the minimum number of registers required by an *optimal* code generation (without any register spill) algorithm for a load/store architecture in which *(i) only loads and store instructions can have memory operands and (ii) arithmetic instructions can have only register or immediate operands*. The value of X is _____.

Key: (2)

Exp:



The given expression is *(a-1)*(((b+c)/3)+d))*

The optimal generated code is :

LOAD R_1 b	$R_1 \leftarrow$ b
LOAD R_2 C	$R_2 \leftarrow$ c
ADD R_1 R_2	$R_1 \leftarrow R_1+R_2$
DIV R_1 3	$R_1 \leftarrow R_1/3$
LOAD R_2 d	$R_2 \leftarrow$ d
ADD R_1 R_2	$R_1 \leftarrow R_1+R_2$
LOAD R_2 a	$R_2 \leftarrow$ a
SUB R_2 1	$R_2 \leftarrow R_2$-1
MUL R_2 R_1	$R_2 \leftarrow R_2*R_1$

46. Let G = (V, E) be any connected undirected edge-weighted graph. The weights of the edges in E are positive and distinct. Consider the following statements:

(I) Minimum spanning tree of G is always unique.

(II) Shortest path between any two vertices of G is always unique.

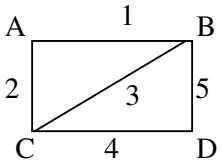
Which of the above statements is/are necessarily true?

(A) (I) only (B) (II) only

(C) Both (I) and (II) (D) Neither (I) nor (II)

Key: (A)

Exp:



Shortest path from B to C are two B-A-C and B-C both of weight '3'

47. A multithreaded program P executes with x number of threads and uses y number of locks for ensuring mutual exclusion while operating on shared memory locations. All locks in the program are *non-reentrant*, i.e., if a thread holds a lock *l*, then it cannot re-acquire lock *l* without releasing it. If a thread is unable to acquire a lock, it blocks until the lock becomes available. The *minimum* value of x and the *minimum* value of y together for which execution of P can result in a deadlock are:

(A) x = 1, y = 2 (B) x =2, y=1 (C) x = 2,y=2 (D) x = 1, y = 1

Key: (C)

Exp: As per given question, there 'x' number of threads and 'y' number of locks for ensuring mutual exclusion while operating on shared memory locations

Option (A): x=1;y=2

Means that 1 thread and 2 locks clearly showing that no deadlock situation

Option (B): x=2;y=1

Means that 2 threads and 1 lock → No deadlock situation

After usage of lock by 1 thread, it can release that lock and then 2nd thread can be used that lock. So no deadlock

Option(C):x=2;y=2

Means that 2 threads and 2 locks →Deadlock can arise

Both threads can hold 1 lock and can wait for release of another lock

Option(D) x=1; y=1

Means that 1 thread and 1 lock →No deadlock situation

Hence **Option(C)** is correct.

48. The values of parameters for the Stop-and – Wait ARQ protocol are as given below:

Bit rate of the transmission channel = 1Mbps

Propagation delay from sender to receiver = 0.75 ms

Time to process a frame = 0.25ms

Number of bytes in the information frame =1980

Number of bytes in the acknowledge frame = 20

Number of overhead bytes in the information frame = 20

Assume that there are no transmission errors. Then the transmission efficiency (expressed in percentage) of the Stop-and – Wait ARQ protocol for the above parameters is _____(correct to 2 decimal places)

Key: (89.33)

Exp: Given Data:

B= 1Mbps

T_{proc}=0.25ms

$T_p = 0.75$ ms

L=1980 Bytes

$L_{OH} = 20$ Bytes

$L_A = 20$ Bytes

$\text{Efficiency}(\eta) = ?$

$$\text{(i) } T_x = \frac{L}{B} = \frac{(1980+20)\times 8}{10^6} = \frac{2\times 8\times 10^3}{10^6} = 16 \text{ ms}$$

$$\text{(ii) } T_{ACK} = \frac{L_A}{B} = \frac{20\times 8}{10^6} = 0.16 \text{ ms}$$

In stop-and-wait ARQ, efficiency

$$\eta = \frac{T_x}{T_x + T_{ACK} + 2T_P + T_{proc}} = \frac{16 \text{ ms}}{17.91 \text{ ms}} = 0.8933 \approx 89.33\%$$

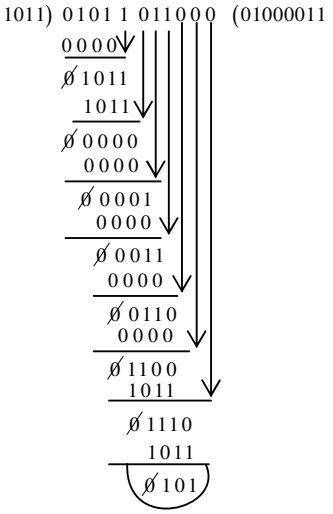
49. A computer network uses polynomials over *GF(2)* for error checking with 8 bits as information bits and uses $x^3 + x + 1$ as the generator polynomial to generate the check bits. In this network, the message 01011011 is transmitted as

(A) 01011011010 (B) 01011011011 (C) 01011011101 (D) 01011011100

Key: (C)

Exp: Given generator polynomial $G(x) = x^3 + x + 1 \Rightarrow 1011$

message $m(x) = 01011011$



50. Let p, q, and r be propositions and the expression $(p \to q) \to r$ be a contradiction. Then, the expression $(r \to p) \to q$ is

(A) a tautology
(B) a contradiction
(C) always TRUE when p is FALSE
(D) always TRUE when q is TRUE

Key: (D)

Exp: $(p \to q) \to r$ is contradiction only when

p	q	r
T	T	F
F	T	F
F	F	F

And now for the above combination, the expression $(r \to p) \to q$ is always true when q is true. When q is false in the above combination (third one) $(r \to p) \to q$ will be false.

51. A cache memory unit with capacity of N words and block size of B words is to be designed. If it is designed as a direct mapped cache, the length of the TAG field is 10 bits. If the cache unit is now designed as a 16-way set-associative cache, the length of the TAG field is _____ bits.

Key: (14)

Exp: $\text{Total bits} = 10 + \underbrace{\log_2\left(\frac{N}{B}\right)}_{\#\text{ of blocks}} + \underbrace{\log_2 B}_{\text{Offset}}$

$10 + \log_2(N) = \log_2\left(\frac{N}{16}\right) + T$

where T is the required length of TAG field

$\therefore T = 14$

52. Consider the following two functions.

```
void funl (int  n)  {
    if (n = =0 ) return;
    printf ("%d" , n);
    fun2 (n - 2);
    printf ("%d" , n);
}
```

```
void fun2 (int  n)  {
    if (n = = 0) return ;
    printf ("%d" , n);
    fun1(++n) ;
    printf ("%d" , n);
    }
```

The output printed when fun1 (5) is called is

(A) 53423122233445
(B) 53423120112233
(C) 53423122132435
(D) 53423120213243

Key: (A)

Exp: In this the fun1() is calling fun2() after printing value and after returning from fun2(),it prints the same value. In the fun2() also the same thing happens So by looking options we can judge the correct sequence of output.

53. Consider a database that has the relation schema CR (StudentName, CourseName). An instance of the schema CR is as given below.

CR	
Student Name	**Course Name**
SA	CA
SA	CB
SA	CC
SB	CB
SB	CC
SC	CA
SC	CB
SC	CC
SD	CA
SD	CB
SD	CC
SD	CD
SE	CD
SE	CA
SE	CB
SF	CA
SF	CB
SF	CC

The following query is made on the database.

$T1 \leftarrow \pi_{CourseName}\left(\sigma_{StudentName='SA'}(CR)\right)$

$T2 \leftarrow CR \div T1$

The number of rows in T2 is _____.

Key: (4)

Exp: $T1 = \{CA, CB, CC\}$

$T2 = \{SA, SC, SD, SF\}$

54. Let A be $n \times n$ real valued square symmetric matrix of rank 2 with $\sum_{i=1}^{n}\sum_{j=1}^{n} A_{ij}^2 = 50$. Consider the following statements.

(I) One eigen value must be in [-5, 5]

(II) The eigen value with the largest magnitude must be strictly greater than 5.

Which of the above statements about eigen values of A is/are necessarily CORRECT?

(A) Both (I) and (II) (B) (I) only

(C) (II) only (D) Neither (I) nor (II)

Key: (B)

Exp: $\rho(A) < n \Rightarrow |A| = 0 \Rightarrow$ one eigen value must be $'0' \in [-5,5]$

$\therefore$ (I) is true

Let $A = \begin{bmatrix} 5 & 0 & 0 \\ 0 & -5 & 0 \\ 0 & 0 & 0 \end{bmatrix} \Rightarrow \sum_{i=1}^{3}\sum_{j=1}^{3} A_{ij}^2 = 50$ and $\rho(A) = 2$

but eigen values of A are $0, -5, 5$

$\therefore$ The eigen value with the largest magnitude is not greater than 5

For n=2 and Let $A = \begin{bmatrix} 5 & 0 \\ 0 & 5 \end{bmatrix} \Rightarrow$ eigen values= 5,5

$\therefore$ One eigen value must be in $[-5,5]$ and largest eigen value magnitude is not greater than 5

$\therefore$ **(II)** is false

55. Consider the context-free grammars over the alphabet {a,b,c} given below. S and T are non-terminals

$G_1 : S \to aSb \mid T, T \to cT \mid \in$

$G_2 : S \to bSa \mid T, T \to cT \mid \in$

The language $L(G_1) \cap L(G_2)$ is

(A) Finite. (B) Not finite but regular.

(C) Context-free but not regular. (D) Recursive but not context-free.

Key: (B)

Exp: The Context free grammar given over alphabets $\Sigma = \{ a, b, c\}$ with S and T as non terminals are:

$G_1 : S \to aSb \mid T,\ T \to cT \mid \epsilon$

$G_2 : S \to bSa \mid T,\ T \to cT \mid \epsilon$

Lets $L(G_1)$ is the language for grammar G_1 and $L(G_2)$ is the language for grammar G_2

$L(G_1) = \{a^n c^m b^n \mid n, m \geq 0\}$

$L(G_1) = \{b^n c^m a^n \mid n, m \geq 0\}$

$L_1 \cap L_2 = \{ c^m \mid m \geq 0 \}$; which is infinite and regular

General Aptitude

Q. No. 1 - 10 Carry One Mark Each

1. Research in the workplace reveals that people work for many reason _____.

(A) money beside (B) beside money (C) money besides (D) besides money

Key: (D)

2. After Rajendra chola returned from his voyage to Indonesia, he _____ to visit the temple in Thanjavur.

(A) was wishing (B) is wishing (C) wished (D) had wished

Key: (C)

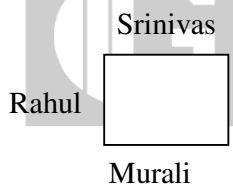
3. Rahul Murali, Srinivas and Arul are seated around a square table. Rahul is sitting to the left of Murali. Srinivas is sitting to the right of Arul. Which of the following pairs are seated opposite each other ?

(A) Rahul and Murali (B) Srinivas and Arul

(C) Srinivas and Murali (D) Srinivas and Rahul

Key: (C)

Exp:



4. Find the smallest number y such that $y \times 162$ is a perfect cube.

(A) 24 (B) 27 (C) 32 (D) 36

Key: (D)

Exp:

Factorization of 162 is $2 \times 3 \times 3 \times 3 \times 3$

$y \times 162$ is a perfect cube

$y \times 2 \times 3 \times 3 \times 3 \times 3 = \text{Perfect cube}$

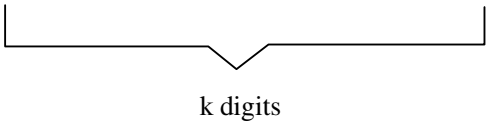
For perfect cube 2's & 3's are two more required each.

5. The probability that a k-digit number does NOT contain the digits 0,5,or 9 is

(A) 0.3^k (B) 0.6^k (C) 0.7^k (D) 0.9^k

Key: (C)

Exp:

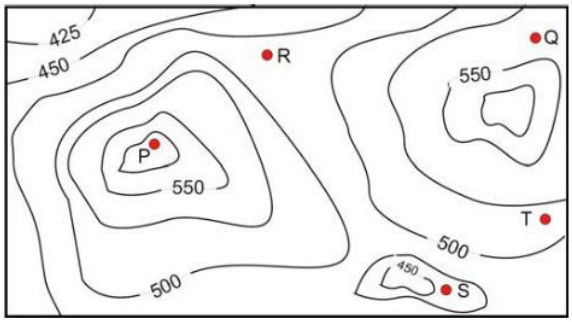


Each digit can be filled in 7 ways as 0, 5 and 9 are not allowed. So each of these places can be filled by 1, 2, 3, 4, 6, 7, 8.

So required probability is $\left(\frac{7}{10}\right)^k$ or 0.7^k.

Q. No. 6 – 10 Carry Two Marks Each

6. A contour line joins locations having the same height above the mean sea level. The following is a contour plot of a geographical region. Contour lines are shown at 25m intervals in this plot. If in a flood, the water level rises to 525m, which of villages P,Q, R, S,T get submerged ?



(A) P,Q (B) P,Q,T (C) R,S,T (D) Q,R,S

Key: (C)

Exp: The given contour is a hill station, the peak point of this hill station is P, it is under a contour of 550 . At floods, the water level is 525m. So the village of R, S and T are under a contour of 500. Therefore these villages are submerged.

7. "The hold of the nationalist imagination on our colonial past is such that anything inadequately or improperly nationalist is just not history"

Which of the following statements best reflects the author's opinion ?

(A) Nationalists are highly imaginative.

(B) History is viewed through the filter of nationalism.

(C) Our colonial past never happened.

(D) Nationalism has to be both adequately and properly imagined.

Key: (B)

8. The expression $\frac{(x+y)-|x-y|}{2}$ is equal to

(A) the maximum of x and y (B) the minimum of x and y

(C) 1 (D) None of the above

Key: (B)

Exp: If $x > y$; then $|x-y| = x-y$

$$\text{Exp} = \frac{x+y-(x-y)}{2} = y_{min}$$

If $x < y$; then $|x-y| = -(x-y) = y-x$

$$\text{Exp} = \frac{x+y-(y-x)}{2} = x_{min}$$

$\therefore$ The expression $\frac{(x+y)-|x-y|}{2}$ is equal to minimum of x & y

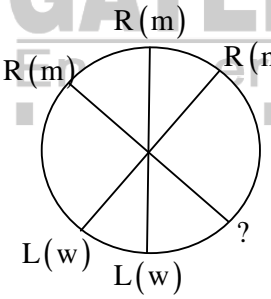
9. Six people are seated around a circular table. There are at least two men and two women . There are at least three right-handed persons. Every woman has a left-handed person to her immediate right. None of the women are right-handed. The number of women at the table is

(A) 2 (B) 3

(C) 4 (D) Cannot be determined

Key: (A)

Exp: Out of six people, 3 place definitely occupied by right handed people as atleast 2 women are there so these two will sit adjacently. Now as only one seat is left it will be occupied by a left handed man because on right side of this seat is sitting an right handed man.



Therefore, answer should be 2 women.

10. Arun, Gulab, Neel and Shweta must choose one shirt each from a pile of four shirts coloured red, pink, blue and white respectively. Arun dislikes the colour red and Shweta dislikes the colour white. Gulab and Neel like all the colours. In how many different ways can they choose the shirts so that no one has a shirt with a colour he or she dislikes ?

(A) 21 (B) 18 (C) 16 (D) 14

Key: (D)

Exp: As there are 4 people A,G,N,S and 4 colours so without any restriction total ways have to be $4 \times 4 = 16$

Now, Arun $\rightarrow$ dislikes Red and

Shweta $\rightarrow$ dislikes white

So 16-2=14 ways

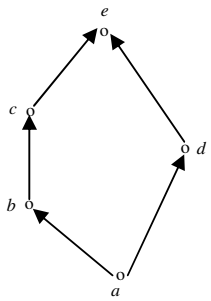
Computer Science and Information Technology

Q. No. 1 – 25 Carry One Mark Each

1. Consider the set $X=\{a,b,c,d,e\}$ under the partial ordering

$R=\{(a,a),(a,b),(a,c),(a,d),(a,e),(b,b),(b,c),(b,e),(c,c),(c,e),(d,d),(d,e),(e,e)\}$.

The Hasse diagram of the partial order (X, R) is shown below.



The minimum number of ordered pairs that need to be added to R to make (X, R) a lattice is _____.

Key: (0)

Exp: Given POSET is already a lattice so no need to add any ordered pairs.

2. Which of the following statements about parser is/are CORRECT?

I. Canonical LR is more powerful than SLR.

II. SLR is more powerful than LALR

III. SLR is more powerful than Canonical LR.

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

Key: (A)

Exp: Bottom up parsers in decreasing order of their power: CLR≫ LALR≫ SLR≫ LR (0)

The given statements:

I. Canonical LR is more powerful than SLR is **CORRECT**.

II. SLR is more powerful than LALR is **INCORRECT**

III. SLR is more powerful than Canonical LR is **INCORRECT**.

3. Match the following:

P.	static char var;	**i.**	Sequence of memory locations to store addresses
Q.	m= malloc (10); m = NULL;	**ii.**	A variable located in data section of memory
R.	char * ptr [10]	**iii.**	Request to allocate a CPU register to store data
S.	register int var1;	**iv.**	A lost memory which cannot be freed

(A) P-(ii), Q-(iv), R-(i), S-(iii) (B) P-(ii), Q-(i), R-(iv), S-(iii)

(C) P-(ii), Q-(iv), R-(iii), S-(i) (D) P-(iii), Q-(iv), R-(i), S-(ii)

Key: (A)

Exp: P. static char var:

var is defined as character variable whose associated storage class is static because of this it is given memory from data segment .

Q. $m = \text{malloc}(10);$

$m = \text{NULL};$

10 contiguous bytes of memory is allocated is address of first byte is stored in 'm' and later it is updated with NULL. Now we lost the address of first bytes of that chunk of memory completely. So we can't free that space as we need the address of first byte to free it up

R. char * ptr [10]:

ptr is an array of 10 pointers pointing to character variables.

S. register int varl:

Suggesting the complier to store the var1 "value" in CPU register.

4. Let L_1, L_2 be any two context free languages and R be any regular language. Then which of the following is/are CORRECT ?

I. $L_1 \cup L_2$ is context – free II. $\overline{L_1}$ is context – free

III. $L_1 - R$ is context – free IV. $L_1 \cap L_2$ is context – free

(A) I, II and IV only (B) I and III only

(C) II and IV only (D) I only

Key: (B)

Exp: Given L_1 and L_2 are context free languages and R is a regular language.

I. $L_1 \cup L_2$ is context free is **CORRECT**, context free language are closed under union operation.

II. $\overline{L_1}$ is context free is **INCORRECT**, context free languages are not closed under complement operation.

III. L_1 –R is Context free is **CORRECT**.

$L_1 - R = L_1 \cap \overline{R}$, Context free intersection Regular is always Context free.

IV. $L_1 \cap L_2$ is context free is **INCORRECT**; context free languages are not closed under complement operation.

5. G is undirected graph with n vertices and 25 edges such that each vertex of G has degree at least 3. Then the maximum possible value of n is _____.

Key: (16)

Exp: If every vertex has degree at least k then

$$K|V| \le 2(E)$$
$$3|V| \le 2\times 25$$
$$|V| \le \left\lfloor \frac{50}{3} \right\rfloor$$
$$|V| \le 16$$

6. Let p, q, r denote the statements *"It is raining ," " It is cold", and " It is pleasant,"* respectively. Then the statement *"It is not raining and it is pleasant, and it is not pleasant only if it is raining and it is cold"* is represented by

(A) $(\neg p \wedge r) \wedge (\neg r \rightarrow (p \wedge q))$ (B) $(\neg p \wedge r) \wedge ((p \wedge q) \rightarrow \neg r)$

(C) $(\neg p \wedge r) \vee ((p \wedge q) \rightarrow \neg r)$ (D) $(\neg p \wedge r) \vee (r \rightarrow (p \wedge q))$

Key: (A)

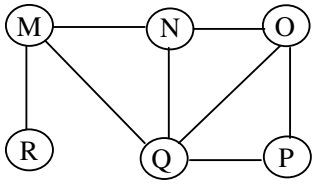
Exp: X only if Y is same as $X \Rightarrow Y$

"it is not raining and it is pleasant" $= \neg p \wedge r$

"it is not pleasant only if it is raining and it is cold" $= \neg r \rightarrow (p \wedge q)$

$\therefore (\neg p \wedge r) \wedge (\neg r \rightarrow (p \wedge q))$

7. The Breadth First Search (BFS) algorithm has been implemented using the queue data structure. Which one of the following is a possible order of visiting the nodes in the graph below?



(A) MNOPQR (B) NQMPOR (C) QMNROP (D) POQNMR

Key: (D)

Exp: **BFS:** Start at root (some arbitrary node of a graph, sometimes referred to as "search key") and explore the neighbor nodes first, before and moving to the next level neighbors.

8. Let $P = \begin{bmatrix} 1 & 1 & -1 \\ 2 & -3 & 4 \\ 3 & -2 & 3 \end{bmatrix}$ and $Q = \begin{bmatrix} -1 & -2 & -1 \\ 6 & 12 & 6 \\ 5 & 10 & 5 \end{bmatrix}$ be two matrices.

Then the rank of P +Q is _____.

Key: (2)

Exp:

$$P+Q=\begin{bmatrix}0 & -1 & 12\\ 8 & 9 & 10\\ 8 & 8 & 8\end{bmatrix}$$

$$R_1 \leftrightarrow R_2 \sim \begin{bmatrix}8 & 9 & 10\\ 0 & -1 & -2\\ 1 & 1 & 1\end{bmatrix}$$

$$\frac{R_3}{8}$$

$$8R_3 - R_1 \sim \begin{bmatrix}8 & -9 & 10\\ 0 & -1 & -2\\ 0 & -1 & -2\end{bmatrix}$$

$$R_3 - R_2 \sim \begin{bmatrix}8 & -9 & 10\\ 0 & -1 & -2\\ 0 & 0 & 0\end{bmatrix}$$

$\therefore$ Rank is 2

9. Consider socket API on a Linux machine that supports connected UDP sockets. A connected UDP socket is a UDP socket on which **connect** function has already been called. Which of the following statements is/are CORRECT ?

I. A connected UDP socket can be used to communicate with multiple peers simultaneously.

II. A process can successfully call **connect** function again for an already connected UDP socket.

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

Key: (B)

Exp: A process with a connected UDP socket can call connect again for that socket for one of two reasons:

(1) To specify a new IP address and port.

(2) To unconnect the socket.

10. The minimum possible number of states of a deterministic automaton that accepts the regular language

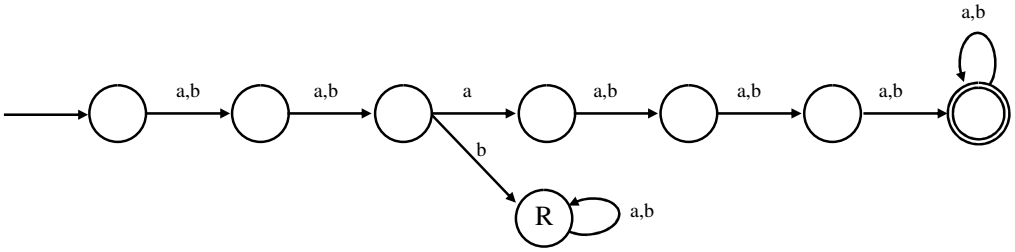
$L = \{w_1 a w_2 \mid w_1, w_2 \in \{a,b\}^*, |w_1| = 2, |w_2| \geq 3\}$ is _____.

Key: (8)

Exp: The Given regular language is

$L = \{w_1 a w_2 | w_1,\ w_2 \in \{a,b\}^*,\ |w_1| = 2\ |w_2| \geq 3\}$

The minimal Deterministic finite automata accepting L is:



11. Consider the following tables T1 and T2.

P	Q
2	2
3	8
7	3
5	8
6	9
8	5
9	8

R	S
2	2
8	3
3	2
9	7
5	7
7	2

In table T1, **P** is the primary key and **Q** is the foreign key referencing **R** in table T2 with on-delete cascade and on-update cascade. In table T2, **R** is the primary key and **S** is the foreign key referencing **P** in table T1 on-delete set NULL and on-update cascade. In order to delete record $\langle 3,8 \rangle$ from table T1, the number of additional records that need to be deleted from table T1 is _____.

Key: (0)

Exp: Only (8,3) will be deleted from T2.

12. Which of the following is/are shared by all the threads in a process ?

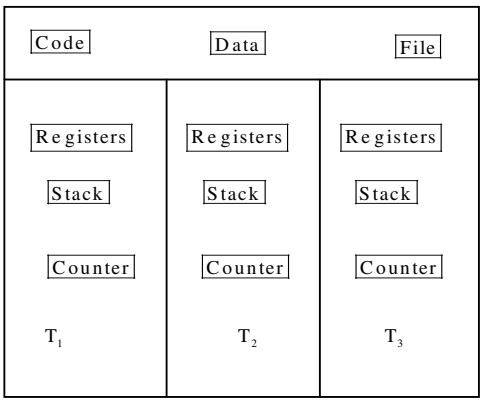
I. Program counter **II.** Stack

III. Address space **IV.** Registers

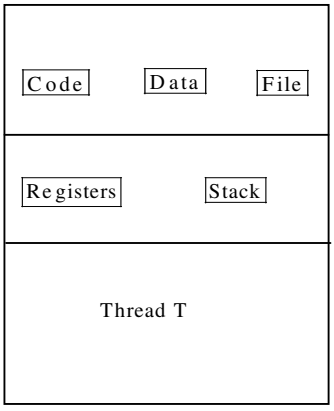
(A) I and II only (B) III only (C) IV only (D) III and IV only

Key: (B)

Exp:



Single process P with 3 threads Multi threading



Single threaded process

13. A circular queue has been implemented using a single linked list where each node consists of a value and a single pointer pointing to the next node. We maintain exactly two external pointers **FRONT** and **REAR** pointing to the front node and the rear node of the queue, respectively. Which of the following statements is/are **CORRECT** for such a circular queue, so that insertion and deletion operation can be performed in O (1) time ?

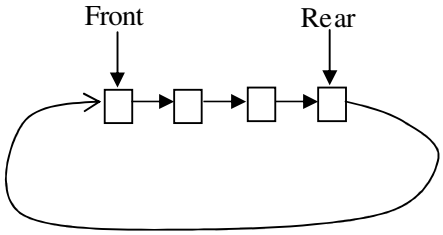
I. Next pointer of front node points to the rear node.

II. Next pointer of rear node points to the front node.

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

Key: (B)

Exp: Next pointer of the front node would point to the second node, if any.



14. Given the following binary number in 32-bit (single precision) IEEE-754 format:

00111110011011010000000000000000

The decimal value closest to this floating- point number is

(A) 1.45×10^{1} (B) 1.45×10^{-1} (C) 2.27×10^{-1} (D) 2.27×10^{1}

Key: (C)

Exp: Sign

0 01111100 11011010000000000000000

+1 124

$+1 \quad 2^{-3}$

$\left[2^{-1}+2^{-2}+-----\right]$ =0.227....

$[1+]0.8515625$

15. An ER model of a database consists of entity types A and B. These are connected by a relationship R which does not have its own attribute. Under which one of the following conditions, can the relational table for R be merged with that of A?

(A) Relationship R is one-to-many and the participation of A in R is total

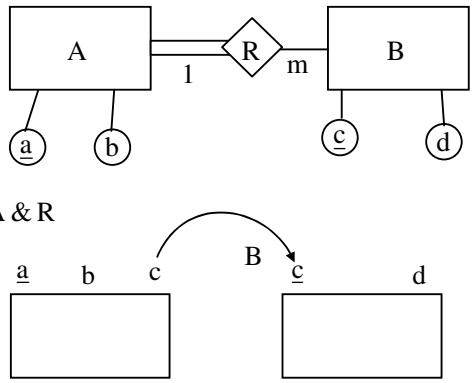
(B) Relationship R is one-to-many and the participation of A in R is partial

(C) Relationship R is many-to one and the participation of A in R is total

(D) Relationship R is many-to one and the participation of A in R is partial

Key: (C)

Exp:



Note: only M ! N relationship needs exclusive table: If a relationship is 1 ! M or M ! 1 then that relation could be included in the many side table with the help of foreign key concept.

16. Match the algorithms with their time complexities:

	Algorithm	**Time complexity**	
P.	Towers of Hanoi with *n* disks	i.	$\theta(n^2)$
Q.	Binary search given *n* sorted numbers	ii.	$\theta(n\log n)$
R.	Heap sort given *n* numbers at the worst case	iii.	$\theta(2^n)$
S.	Addition of two $n \times n$ matrices	iv.	$\theta(\log n)$

(A) P-(iii),Q-(iv), R-(i), S-(ii)
(B) P-(iv),Q-(iii), R-(i), S-(ii)
(C) P-(iii),Q-(iv), R-(ii), S-(i)
(D) P-(iv),Q-(iii), R-(ii), S-(i)

Key: (C)

Exp: P. Towers of Hanoi $\Rightarrow T(n) = 2T(n-1)+1 \Rightarrow \theta(2^n)$

Q. Binary search $\Rightarrow T(n) = T\left(\frac{n}{2}\right)+C \Rightarrow \theta(\log n)$

R. Heap sort $\Rightarrow \theta(n\log n)$

S. Addition of two $n \times n$ matrices $\Rightarrow \theta(n^r)$

17. Match the following according to input (from the left column) to the complier phase (in the right column) that processes it.

Column-1		**Column-2**	
P.	Syntax tree	i.	Code generator
Q.	Character stream	ii.	Syntax analyzer
R.	Intermediate representation	iii.	Semantic analyzer
S.	Token stream	iv.	Lexical analyzer

(A) P-(ii),Q-(iii), R-(iv), S-(i) (B) P-(ii),Q-(i), R-(iii), S-(iv)

(C) P-(iii),Q-(iv), R-(i), S-(ii) (D) P-(i),Q-(iv), R-(ii), S-(iii)

Key: **(C)**

Exp: Lexical Analysis phase processes character stream and generates tokens, e.g. identifier or keywords.

Tokens are processed by Syntax analysis analyzer.

Syntax tree is processed by Semantic analyzer.

Intermediate code such as 3 –address code is used for code generation process.

18. Consider the following statements about the routing protocols, Routing Information Protocol (RIP) and Open Shortest Path First (OSPF) in an IPv4 network.

I. RIP uses distance vector routing

II. RIP packets are sent using UDP

III. OSPF packets are sent using TCP

IV. OSPF operation is based on link-state routing

Which of the statements above are CORRECT?

(A) I and IV only (B) I, II and III only

(C) I, II and IV only (D) II, III and IV only

Key: **(C)**

Exp: **Statement (1):** RIP uses distance vector routing. "CORRECT"

RIP is one of the oldest DVR protocol which employ the hop count as a routing metric.

Statement (2): RIP packets are sent using UDP. "CORRECT"

RIP uses the UDP as its transport protocol, and is assigned the reserved port no 520.

Statement (3): OSPF packets are sent using TCP. "INCORRECT"

OSPF does not use a transport protocol , such as UDP (or) TCP, but encapsulates its data directly in IP packets.

Statement (4): OSPF operation is based on link state routing. "CORRECT"

OSPF is a routing protocol which uses link state routing (LSR) and works within a single autonomous system.

Hence Option "C" is correct.

19. If $f(x)=R\sin\left(\frac{\pi x}{2}\right)+S, f'\left(\frac{1}{2}\right)=\sqrt{2}$ and $\int_0^1 f(x)dx=\frac{2R}{\pi}$, then the constants R and S are, respectively

(A) $\frac{2}{\pi}$ and $\frac{16}{\pi}$ (B) $\frac{2}{\pi}$ and 0 (C) $\frac{4}{\pi}$ and 0 (D) $\frac{4}{\pi}$ and $\frac{16}{\pi}$

Key: **(C)**

Exp: $f^1(x)=\frac{R\pi}{2}\cos\left(\frac{\pi x}{2}\right)$

$\Rightarrow f^1(1/2)=\sqrt{2}$ gives $\frac{R\pi}{2\sqrt{2}}=\sqrt{2}\Rightarrow R=\frac{4}{\pi}$

$$\text{Also}\int_0^1 f(x)dx=\frac{2R}{\pi}\ \text{gives}\frac{-2R}{\pi}\left(\cos\frac{\pi x}{2}\right)_0^1+S(x)_0^1=2R/\pi$$

$$\Rightarrow S=0$$

20. In a file allocation system, which of the following allocation schemes(s) can be used if no external fragmentation is allowed?

I. Contiguous II. Linked III. Indexed

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

Key: (D)

Exp: Contiguous allocation suffer from external fragmentation. But linked and indexed allocation schemes free from external fragmentation. Hence, option D is correct.

21. Consider a quadratic equation $x^2-13x+36=0$ with coefficients in a base b. The solutions of this equation in the same base b are x = 5 and x = 6. Then b = _____.

Key: (8)

Exp: Clearly $13=1\times10+3$ and $36=3\times10+6\Rightarrow \text{base}\,b=10$

The quadratic equation with solutions x = 5 and x = 6 is $x^2-11x+30=0$

According to the given condition, we have $b+3=11$ and $3b+6=30\Rightarrow b=8$

Answer is 8.

Alternate solution:

$x^2-13x+36=0(\text{given quadratic equation})$

In base b, $13=1\times b^1+3\times b^0=b+3$ and

$$36=3\times b^1+6\times b^0=3b+6$$

So the equation becomes $x^2-(b+3)x+(3b+6)=0$

Since x=5 is a solution

$\therefore 5^2-(b+3)5+(3b+6)=0\Rightarrow b=8$

Similarly, by putting x = 6, we get b = 8

22. Identify the language generated by the following grammar, where S is start variable.

$S\rightarrow XY$

$X\rightarrow aX|a$

$Y\rightarrow aYb|\in$

(A) $\{a^m b^n | m\geq n, n>0\}$ (B) $\{a^m b^n | m\geq n, n\geq 0\}$

(C) $\{a^m b^n | m> n, n\geq 0\}$ (D) $\{a^m b^n | m> n, n> 0\}$

Key: (C)

Exp: The given grammar with *S* as start symbol is

S→XY

$X \rightarrow aX|a$

$Y \rightarrow aYb|\epsilon$

From Non terminal X we can generate any number of a's including a single 'a' and from Y equal number of a's and b's.

Hence $L = \{a^m b^n | m > n, n \geq 0\}$

23. The representation of the value of a 16-bit unsigned integer X in hexadecimal number system is BCA9. The representation of the value of X in octal number system is

(A) 571244 (B) 736251 (C) 571247 (D) 136251

Key: (D)

Exp: $(BCA9)_{16} \rightarrow (136251)_8$

Convert hexadecimal to octal number system.

24. Consider the following function implemented in C:

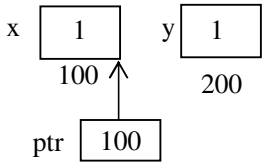
```
void printxy (int x, int y) {
int *ptr ;
x = 0;
ptr = &x;
y = * ptr;
* ptr = l;
print f ("%d, %d," x, y);
}
```

The output of invoking printxy (l, l) is

(A) 0,0 (B) 0,1 (C) 1,0 (D) 1,1

Key: (C)

Exp:



$\therefore$ 1,0 is printed

25. The maximum number of IPv4 router addresses that can be listed in the record route (RR) option field of an IPv4 header is _____.

Key: (9)

Exp: A record route option is used to record the internet routers that handles the datagram. It can list up to nine router addresses. It can be used for debugging and management purpose.

Q. No. 26 – 55 Carry Two Marks Each

26. Consider a binary code that consists of only four valid code words as given below:

00000,01011,10101,11110

Let the minimum Hamming distance of the code be p and the maximum number of erroneous bits that can be corrected by the code be q. Then the values of p and q are

(A) p = 3 and q = 1 (B) p = 3 and q = 2

(C) p = 4 and q = 1 (D) p = 4 and q = 2

Key: (A)

Exp: Given :

code1 00000

code2 01011

code3 10101

code4 11110

Hamming distance between code 1 and code 2 is 3.

Hamming distance between code 1 and code 3 is 3.

Hamming distance between code 1 and code 4 is 4.

Hamming distance between code 2 and code 3 is 4.

Hamming distance between code 2 and code 4 is 3.

Hamming distance between code 3 and code 4 is 3.

So, as per Hamming code, minimum Hamming distance of all code words is considered as Hamming distance i.e., 3 (p).

Now, the max number of erroneous bits that can be corrected by the Hamming code is 2d + 1. So,

$2d+1=3 \Rightarrow d=1$

So option A is correct.

27. A system shares 9 tape drives. The current allocation and maximum requirement of tape drives for three processes are shown below:

Process	Current Allocation	Maximum Requirement
P1	3	7
P2	1	6
P3	3	5

Which of the following best describes current state of the system ?

(A) Safe, Deadlocked (B) Safe, Not Deadlocked

(C) Not Safe, Deadlocked (D) Not Safe, Not deadlocked

Key: (B)

Exp:

PID	Current Allocation	Max need	Available	Need
P_1	3	3	2	4
P_2	1	6	-	5
P_3	3	5	-	2

With the above state of systems, we can get the following 2 safe sequences.

(1) $< P_3, P_2, P_1 >$

(2) $< P_3, P_1, P_2 >$

Hence, system is in safe state, no deadlocked option B is correct.

28. Two transactions T_1 and T_2 are given as:

$$T_1 : r_1(X)\, w_1(X)\, r_1(Y)\, w_1(Y)$$

$$T_2 : r_2(Y)\, w_2(Y)\, r_2(Z)\, w_2(Z)$$

where $r_i(V)$ denotes a read operation by transaction T_i on a variable V and $w_i(V)$ denotes a *write* operations by transaction T_i on a variable V. The total number of conflict serializable schedules that can be formed by T_1 and T_2 is _____.

Key: (54)

Exp: Conflict conditions RW WR WW

$\therefore$ 5 conflicts

$$T_1 - T_2$$

a b c d

$r_1(X)$ $w_1(X)$ $r_1(Y)$ $w_1(Y)$

$r_2(Y)$ $w_2(Y)$ $r_2(Z)$ $r_2(Z)$

1 2 3 4

Constraints:

$a < b < c < d$

$1 < 2 < 3 < 4$

$d < 1$ (or) $2 < c$

only 1 way

$$\text{Total} = 70 = 70 - (12 + 5)$$

a, b, c, d before 2 a, b, c before 2

Therefore, 53+1=54

29. If w, x, y, z are Boolean variables, then which one of the following is INCORRECT ?

(A) $wx+w(x+y)+x(x+y)=x+wy$

(B) $\overline{w\bar{x}(y+\bar{z})}+\bar{w}x=\bar{w}+x+\bar{y}z$

(C) $(w\bar{x}(y+x\bar{z})+\bar{w}\bar{x})y=x\bar{y}$

(D) $(w+y)(wxy+wyz)=wxy+wyz$

Key: (C)

Exp:

(A) $LHS: wx+w(x+y)+x(x+y)=x+wy$

$RHS:$

$\Rightarrow wx+wx+wy+xx+xy$

$\Rightarrow wx+wy+x+xy \quad [\because xx=x]$

$\Rightarrow x[1+y+w]+wy \quad [\because 1+x=1]$

$\Rightarrow x+wy$

$\Rightarrow L.H.S=R.H.S$

(B) $L.H.S: \overline{w\bar{x}(y+\bar{z})}+\bar{w}x=\bar{w}x+\bar{y}z$

$R.H.S: \overline{w\bar{x}(y+\bar{z})}+\bar{w}x$

Apply De'Morgan theorem

$\Rightarrow \bar{w}\bar{x}+\overline{(y+\bar{z})}+\bar{w}x \quad [\overline{x+y}=\bar{x}.\bar{y}]$

$\Rightarrow (\bar{w}+x)+(\bar{y}z)+\bar{w}x$

$\Rightarrow \bar{w}+x+\bar{y}z+\bar{w}x$

$\Rightarrow \bar{w}+x+\bar{y}z=R.H.S$

$L.H.S=R.H.S$

(C) $\{[w\bar{x}(y+\bar{z})]+\bar{w}\bar{x}\}y=x\bar{y}$

$L.H.S \neq R.H.S$

(D) $L.H.S: (w+y)(wxy+wyz)=wxy+wyz$

$(w+y)(wxy+wyz)$

$\Rightarrow wxy+wyz+wxy+wyz$

$\Rightarrow wxy+wyz$

$L.H.S=R.H.S$

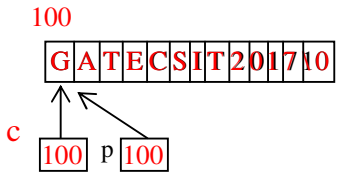
30. Consider the following C Program.

```
# include <stdio.h>
#include< string.h>
#int main ( ) {
    char*  c = "GATECSIT2017";
    char*  p = c;
printf("%d", (int) strlen (c+2[p]-6[p]-1));
return 0;
}
```

The output of the program is _____.

Key: **(2)**

Exp:



$\text{strlen}(c+2[p]-6[p]-1)$

$\downarrow \quad \downarrow \quad \downarrow$

$100+T- \quad I-1$

Note: Whenever we have characters in the arithmetic expressions, we can replace those with their ASCII values

$\text{Strlen}(100+x+11-x-1)$ [assume x has the ASCII value of I]

$\Rightarrow \text{Strlen}(110)$

$\therefore 2$ is printed

31. P and Q are considering to apply for a job. The probability that P applies for the job is $\frac{1}{4}$. The probability that P applies for the job given that Q applies for the job is $\frac{1}{2}$, and the probability that Q applies for the job given that P applies for the job $\frac{1}{3}$. Then the probability that P does not apply for the job given that Q does not apply for the job is

(A) $\frac{4}{5}$ (B) $\frac{5}{6}$ (C) $\frac{7}{8}$ (D) $\frac{11}{12}$

Key: **(A)**

Exp: Let A,B be the events denote that P, Q respectively applies for a job

$\Rightarrow P_r(A)=\frac{1}{4}, P_r(A/B)=\frac{1}{2}---(1)$ and $P_r(B/A)=\frac{1}{3}--(2)$

$(2) \text{gives} P_r(A\cap B)=\frac{1}{12}$

$$\therefore (1) \text{ gives } \Pr(B)=\frac{1}{6}$$

$$\therefore \Pr\left(\frac{\overline{A}}{B}\right)=\frac{\Pr\left(\overline{A}\cap\overline{B}\right)}{\Pr\left(\overline{B}\right)}=\frac{1-\Pr(A\cup B)}{1-\Pr(B)}=\frac{1-\left(\frac{1}{4}+\frac{1}{6}-\frac{1}{12}\right)}{1-\frac{1}{6}}=\frac{2}{3}\times\frac{6}{5}=\frac{4}{5}$$

$$\left(\text{Here Pr is Probability and } P(A/B)=\frac{P(A\cap B)}{P(B)}\right)$$

32. If the characteristics polynomial of 3×3 matrix M over R (the set of real numbers) is $\lambda^3-4\lambda^2+a\lambda+30, a\in R$, and one eigenvalue of M is 2, then the largest among the absolute values of the eigenvalues of M is _____.

Key: (5)

Exp: $E(X)=5\Rightarrow\left(X^2\right)=30$, where $X\sim P(\lambda), \lambda=5$

$$\therefore E\left[(X+2)^2\right]=E\left(X^2\right)+4.E(X)+4=30+20+4=54$$

$$\left(\because V(X)=E\left(X^2\right)-(E(X))^2\right)$$

Since one eigen value of M is 2

$\therefore 2^3-4(2)^2+a(2)+30=0$

$\Rightarrow a=-11$

$\therefore$ Characteristic polynomial is

$\lambda^3-4\lambda^2-11\lambda+30=0$

$(\lambda-2)(\lambda-5)(\lambda+3)=0$

$\therefore\lambda=2,5,-3$

Largest absolute value of $'\lambda'$ is 5

33. Consider the following expression grammar G:

$E\rightarrow E-T\mid T$

$T\rightarrow T+F\mid F$

$F\rightarrow(E)\mid id$

Which of the following grammars is not left recursive, but is equivalent to G?

(A) $E\rightarrow E-T\mid T$
$T\rightarrow T+F\mid F$
$F\rightarrow(E)\mid id$

(B) $E\rightarrow TE'$
$E'\rightarrow -TE'\mid\in$
$T\rightarrow T+F\mid F$
$F\rightarrow(E)\mid id$

(C) $E \rightarrow TX$
$X \rightarrow -TX \mid \in$
$T \rightarrow FY$
$Y \rightarrow +FY \mid \in$
$F \rightarrow (E) \mid id$

(D) $E \rightarrow TX \mid (TX)$
$X \rightarrow -TX \mid +TX \mid \in$
$T \rightarrow id$

Key: **(C)**

Exp: The rule for removal of left recursion is

$A \rightarrow A\alpha \mid \beta$ will be

$A \rightarrow \beta A'$

$A' \rightarrow \alpha A' \mid \epsilon$

The given grammar is:

$E \rightarrow E - T \mid T$; in this α is "– T" and β is T

$T \rightarrow T + F \mid F$, In this α is "+ F" and β is F

$F \rightarrow (E) \mid id$

Hence after removal of the left recursion:

$E \rightarrow TX$

$X \rightarrow -TX \mid \epsilon$

$T \rightarrow FY$

$Y \rightarrow +FY \mid \epsilon$

$F \rightarrow (E) \mid id$

34. In a two-level cache system, the access times of L_1 and L_2 caches are 1 and 8 clock cycles, respectively. The miss penalty from L_2 cache to main memory is 18 clock cycles . The miss rate of L_1 cache is twice that of L_2. The average memory access time (AMAT) of this cache system is 2 cycles. This miss rates of L_1 and L_2 respectively are :

(A) 0.111 and 0.056
(B) 0.056 and 0.111
(C) 0.0892 and 0.1784
(D) 0.1784 and 0.0892

Key: **(A)**

Exp: $2 = 1 + 2m \times 8 + m \times 18$

$\therefore m = \frac{1}{34}$

35. Consider two hosts X and Y, connected by a single direct link of rate 10^6 bits/sec . The distance between the two hosts is 10,000 km and the propagation speed along the link is 2×10^8 m/sec . Host X sends a file of 50,000 bytes as one large message to host Y continuously. Let the transmission and propagation delays be p milliseconds and q milliseconds, respectively . Then the values of p and q are

(A) p = 50 and q = 100
(B) p = 50 and q = 400
(C) p = 100 and q = 50
(D) p = 400 and q = 50

Key: **(D)**

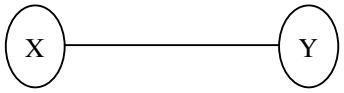
Exp: Given data

$B = 10^6$ bits / sec

$d = 10,000\text{km} = 10^4 \times 10^3$ m

$V = 2 \times 10^8$ m / s

$L = 50,000$ Bytes



$\therefore$ Transmission time (p) $= \frac{L}{B} = \frac{50,000 \times 8}{10^6} = 400$ ms

$\therefore$ Propagation Time (q) $= \frac{d}{v} = \frac{10^7}{2 \times 10^8} = 50$ ms

36. Consider the recurrence function

$$T(n) = \begin{cases} 2T\left(\sqrt{n}\right) + 1, & n > 2 \\ 2, & 0 < n \le 2 \end{cases}$$

Then T(n) in terms of θ notation is

(A) $\theta(\log\log n)$ (B) $\theta(\log n)$ (C) $\theta\left(\sqrt{n}\right)$ (D) $\theta(n)$

Key: (B)

Exp: $T(n) = 2T\left(\sqrt{n}\right) + 1$

Put $n = 2^K$

$T\left(2^K\right) = 2T\left(2^{K/2}\right) + 1$

Assume $T\left(2^K\right) = \delta(K)$

$\Rightarrow \delta(K) = 2\delta\left(\frac{K}{2}\right) + 1$

By master's theorem

$\delta(K) = \theta(K)$

$T\left(2^K\right) = \theta(K)$

$T(n) = \theta(\log n) \quad \because 2^k = n$

37. If a random variable X has a Poisson distribution with mean 5, then the expectation $E\left[(X+2)^2\right]$ equals _____.

Key: (54)

Exp: $E(X) = 5 \Rightarrow E\left(X^2\right) = 30$, where $X \sim P(\lambda), \lambda = 5$

$\therefore E\left[(X+2)^2\right] = E\left(X^2\right) + 4E(X) + 4$

$= 30 + 20 + 4 = 54$

$\left(\because V(X) = E\left(X^2\right) - \left(E(X)\right)^2\right)$

38. Consider the following C function

```
int fun (int n) {
    int i, j;
     for (i = 1; i < = n; i++)    {
              for (j = 1 ; j < n ; j+=i)    {
                        printf ("%d %d , i, j ) ;
                    }
     }
}
```

Time complexity of fun in terms of θ notation is

(A) $\theta\left(n\sqrt{n}\right)$ (B) $\theta\left(n^2\right)$ (C) $\theta\left(n\log n\right)$ (D) $\theta\left(n^2\log n\right)$

Key: (C)

Exp: for i = 1

j will run from 1 to n by incrementing by '1' in each step $\Rightarrow$ 'j 'will run for n times

For i = 2

j will run from 1 ton by incrementing by '2' in each step $\Rightarrow$ j will run for $\frac{n}{2}$ times and so on

$$\text{Time Complexity}(Tc) = n+\frac{n}{2}+\frac{n}{3}+.....+\frac{n}{n}$$

$$= n\left(1+\frac{1}{2}+\frac{1}{3}+....+\frac{1}{n}\right) = \theta\left(n\log n\right)$$

39. The pre-order transversal of a binary search tree is given by 12, 8, 6, 2, 7, 9, 10, 16, 15, 19, 17, 20. Then the post-order traversal of this tree is:

(A) 2,6,7,8,9,10,12,15,16,17,19,20 (B) 2,7,6,10,9,8,15,17,20,19,16,12

(C) 7,2,6,8,9,10,20,17,19,15,16,12 (D) 7,6,2,10,9,8,15,16,17,20,19,12

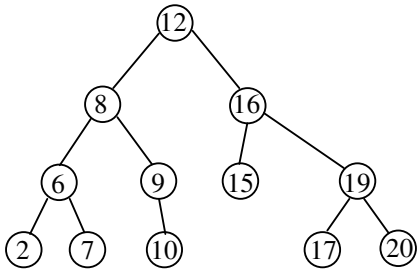
Key: (B)

Exp: Given: Preorder ! 12, 8, 6, 2, 7, 9, 10, 16, 15, 19, 17, 20

In order! 2, 6, 7, 8, 9, 10, 12, 15, 16, 17, 19, 20

Note: BST In order will give ascending order

Corresponding BST is



$\therefore$ Post order is 2, 7, 6, 10, 9, 8, 15, 17, 20, 19, 16, 12

40. Consider the C program fragment below which is meant to divide x by y using repeated subtractions. The variables x, y, q and r are all unsigned int.

```
while (r >= y)  {
r = r – y;
q = q +1;
}
```

Which of the following conditions on the variables x, y, q and r before the execution of the fragment will ensure that the loop terminates in a state satisfying the condition x = = (y*q + r)?

(A) (q = = r) && (r = =0)

(B) (x > 0) && (r = =x) && (y > 0)

(C) (q = = 0) && (r = = x) && (y > 0)

(D) (q = = 0) && (y > 0)

Key: (C)

Exp: Given, program is:

```
while (r ≥ y){
r = r – y;
q = q + 1;
}
```

If we want to final value as $x = = (y \times q + r)$. Then initial value of r should be equal to x (Since y is subtracted from r each time in given code). q incremented by 1 (q is quotient here). To avoid undefined behavior , value of y should be greater than zero.

Therefore, $(q == 0) \&\& (r == x) \&\& (y > 0)$

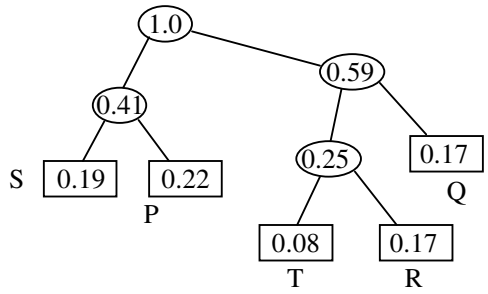
41. A message is made up entirely of characters from the set X= {P,Q,R,S,T}. The table of probabilities for each of the characters is shown below:

Character	Probability
P	0.22
Q	0.34
R	0.17
S	0.19
T	0.08
Total	1.00

If a message of 100 characters over X is encoded using Huffman coding, then the expected length of the encoded message in bits is_____

Key: (225)

Exp: Huffman tree is as follows



Average length of the character

$= 2(0.19 + 0.22) + 2(0.34) + 3(0.08 + 0.17)$

$= 2(0.41) + 2(0.34) + 3(0.25)$

$= 0.82 + 0.68 + 0.75$

$= 2.25 \text{ bits}$

$\therefore \text{Message length} = 100 \times 2.25 \text{ bits} = 225 \text{ bits}$

42. The next state table of a 2-bit saturating up-counter is given below.

Q_1	Q_0	Q_1^+	Q_0^+
0	0	0	1
0	1	1	0
1	0	1	1
1	1	1	1

The counter is built as a synchronous sequential circuit using T flip-flops. The expression for T_1 and T_0 are

(A) $T_1 = Q_1 Q_0, \quad T_0 = \overline{Q_1}\,\overline{Q_0}$

(B) $T_1 = \overline{Q_1} Q_0, \quad T_0 = \overline{Q_1} + \overline{Q_0}$

(C) $T_1 = Q_1 + Q_0, \quad T_0 = \overline{Q_1} + \overline{Q_0}$

(D) $T_1 = Q_1 Q_0, \quad T_0 = \overline{Q_1} + \overline{Q_0}$

Key: (B)

Exp:

Q_1	Q_0	Q_1^+	Q_0^+	T_1	T_0
0	0	0	1	0	1
0	1	1	0	1	1
1	0	1	1	0	1
1	1	1	1	0	0

$T_1 = \overline{Q_1} Q_0$

$T_0 = \overline{Q_1} + \overline{Q_0}$

43. Consider the set of processes with arrival time (in milliseconds). CPU burst time (in milliseconds), and priority (0 is the highest priority) shown below. None of the processes have I/O burst time.

Process	Arrival Time	Burst Time	Priority
$\mathbf{P_1}$	0	11	2
$\mathbf{P_2}$	5	28	0
$\mathbf{P_3}$	12	2	3
$\mathbf{P_4}$	2	10	1
$\mathbf{P_5}$	9	16	4

The average waiting time (in milliseconds) of all the processes using preemptive priority scheduling algorithm is _____

Key: (29)

Exp:

PID	AT	BT	Priority	CT	TAT	Waiting Time
P_1	0	11	2	49	49	38
P_2	5	28	0	33	28	0
P_3	12	2	3	51	39	37
P_4	2	10	1	40	38	28
P_5	9	16	4	67	58	42

Gantt Chart:

P_1	P_4	P_2	P_4	P_1	P_3	P_6

0 2 5 33 40 49 51 67

Therefore Average waiting time $= \frac{(38+0+37+28+42)}{5} = \frac{145}{5} = 29$ ms

44. For any discrete random variable X, with probability mass function

$P(X=j) = p_j, p_j \geq 0, j \in \{0,.....N\}$ and $\sum_{j=0}^{N} p_j = 1,$ define the polynomial function

$g_x(z) = \sum_{j=0}^{N} p_j z^j$ For a certain discrete random variable Y, there exists a scalar $\beta \in [0,1]$ such that $g_Y(z) = (1-\beta+\beta z)^N$. The expectation of Y is

(A) $N\beta(1-\beta)$

(B) $N\beta$

(C) $N(1-\beta)$

(D) Not expressible in terms of N and β alone

Key: (B)

45. The read access times and the hit ratios for different caches in a memory hierarchy are as given below.

Cache	Read access time (in nanoseconds)	Hit ratio
I-cache	2	0.8
D-cache	2	0.9
L2-cache	8	0.9

The read access time of main memory is 90 nanoseconds. Assume that the caches use the referred word-first read policy and the write back policy. Assume that all the caches are direct mapped caches. Assume that the dirty bit is always 0 for all the blocks in the caches. In execution of a program, 60% of memory reads are for instruction fetch and 40% are for memory operand fetch. The average read access time in nanoseconds (up to 2 decimal places) is_____.

Key: (4.72)

Exp: Given,

Cache	I-Cache	D-Cache	L_2-Cache	Main Memory
Read Access Time (in ns)	2	2	8	90
Hit Ratio	0.8	0.9	0.9	1.0

And in execution of program 60% of memory reads are for instruction fetch and 40% are for memory operand fetch.

Now,

Average instruction fetch time=I-cache access time+ I-cache miss ratio * L_2-cache access time + I-cache miss rate * L_2-cache miss ratio * main memory access time

$$=2+(1-0.8)\times 8+(1-0.8)\times(1-0.9)\times 90=5.4\text{n sec}$$

And average data fetch time = D-cache access time +D-cache miss ratio* L_2-cache access time+ D-cache miss ratio *L_2-cache miss ratio* main memory access time

$$2+(1-0.9)\times 8+(1-0.9)\times(1-0.9)\times 90=3.7\text{n sec}$$

Therefore, average memory access time = Fraction of instruction fetch * average instruction fetch time + fraction of data fetch * Average data fetch time

$$=0.6\times 5.4+0.4\times 3.7=4.72(\text{in n sec})$$

46. If the ordinary generating function of a sequence $\{a_n\}_{n=0}^{\infty}$ is $\frac{1+z}{(1-z)^3}$, then a_3-a_0 is equal to _____.

Key: (15)

Exp: $f(z)=\frac{1}{1-z}=1+z+z^2+.....$

$$f'(z)=\frac{1}{(1-z)^2}=1+2z+3z^2+....$$

Consider $\frac{1+z}{(1-z)^3}=\frac{1}{(1-z)^2}+\frac{2z}{(1-z)^3}$

$$\frac{1}{(1-z)^2}=1+2z+3z^2+4z^3...$$

$$f''(z)=\frac{2}{(1-z)^3}=+2+6z+12z^2.....$$

$$\frac{1}{(1-z)^2}+\frac{2z}{(1-z)^3}=\left(1+2z+3z^2+4z^3-...\right)+\left(2z+6z^2+12z^3....\right)$$

$$=1+4z+9z^2+16z^3.....$$

$$=a_0+a_1z+a_2z^2+a_3z^3.....$$

$$a_0=1$$

$$a_3=16$$

$$a_3-a_0=16-1=15$$

47. Consider the following snippet of a C program. Assume that swap (&x, &y) exchanges the contents of x and y.

```
int main ( )   {
int array[]={3,5,1,4,6,2};
int done =0 ;
int  i ;
while (done = = 0)   {
      done = 1;
      for (i = 0; i <=4; i ++)   {
      if (array [i] < array [i +1])   {
                swap (& array [i], &array [i+1]);
                done = 0;
      }
}
for (i = 5 ; i > =1; i --)   {
if (array [i] > array [ i-1])   {
swap ( & array [i] , &array [i-1]);
done = 0;
}
      }
```

```
}
printf ( " %d " , array [3] );
 }
```

The output of the program is _____.

Key: (3)

Exp: The final contents of the array is

6	5	4	3	2	1

$\therefore a[3] = 3$ will be printed

48. Consider the following C program.

```
# include <stdio.h>
int main ( )  {
    int m = 10;
    int n, n1;
    n = ++m;
    n1 = m++;
n--;
    --n1;
    n - = nl;
printf ("%d", n) ;
    return 0;
}
```

The output of the program is _____.

Key: (0)

Exp: m= 10

$n = ++m$ will increment m & assign it to $n \Rightarrow n = 11$ & $m = 1$

$n_1 = m++$ will assign m to n_1 and then increment m by 1

$\Rightarrow n_1 = 11,\ m = 12$

$n--;$ decrement n by $1 \Rightarrow n = 10$

$--n_1;$ decrement n by $1 \Rightarrow n_1 = 10$

$n -= n_1;$ $[\text{same as } n = n - n = 10 - 10 = 0]$

$\therefore$ '0' is printed

49. Consider the following database table named *top _scorer.*

top _scorer.

Player	**Country**	**Goals**
Klose	Germany	16
Ronald	Brazil	15
G Muller	Germany	14

Fontaine	France	13
Pele	Brazil	12
Klinsmann	Germany	11
Kocsis	Hungary	11
Batistuta	Argentina	10
Cubillas	Peru	10
Lato	Poland	10
Lineker	England	10
T Miller	Germany	10
Rahn	Germany	10

Consider the following SQL query:

```
SELECT ta.player FROM top _scorer AS ta
WHERE ta.goals > ALL (SELECT tb. goals
                      FROM top _ scorer AS tb
                      WHERE tb.country = 'Spain')
AND ta.goals > ANY ( SELECT tc. goals
                     FROM top_ scorer AS tc
                     WHERE tc.country = 'Germany')
```

The number of tuples returned by the above SQL query is _____.

Key: (7)

Exp: Player

K lose
Ronaldo
G Muller
Fontaine
Pele
Klinsmann
Kocsis

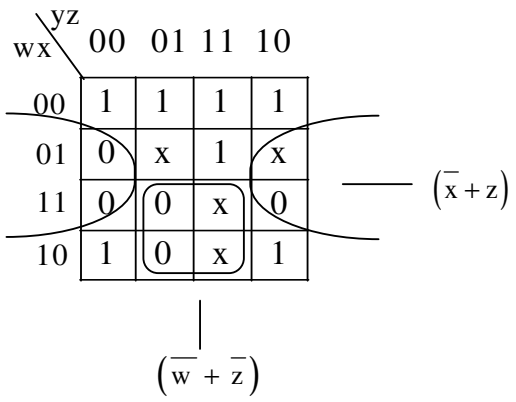
50. Given $f(w,x,y,z) = \sum_m (0,1,2,3,7,8,10) + \sum_d (5,6,11,15)$, where *d* represents the don't care condition in Karnaugh maps. Which of the following is a minimum product-of-sums (POS) form of f(w,x,y,z) ?

(A) $f = (\overline{w} + \overline{z})(\overline{x} + z)$ (B) $f = (\overline{w} + z)(x + z)$

(C) $f = (w + z)(\overline{x} + z)$ (D) $f = (w + \overline{z})(\overline{x} + z)$

Key: (A)

Exp:



$=(\bar{w}+\bar{z})(\bar{x}+z)$

51. In a B^+ tree, if the search –key value is 8 bytes long, the block size is 512 bytes and the block pointer size is 2 bytes, then maximum order of the B^+ tree is _____.

Key: (52)

Exp: Let 'K' be the order

$K(2)+(K-1)(8) \le 512$

$\Rightarrow 2K+8k-8 \le 512$

$\Rightarrow 10K \le 520 \Rightarrow K \le \frac{520}{10}$

$\therefore K \le 52$

52. Let L(R) be the language represented by regular expression R. Let L(G) be the language generated by a context free grammar G. Let L (M) be the language accepted by a Turning machine M. Which of the following decision problems are undecidable ?

I. Given a regular expression R and a string w, is $w \in L(R)$?

II. Given a context-free grammar G, $L(G)=\varnothing$?

III. Given a context-free grammar G, is $L(G)=\Sigma^*$ for some alphabet Σ?

IV. Given a Turning machine M and a string w, is $w \in L(M)$?

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

Key: (D)

Exp: *L*(*R*) is the language represented by regular expression

L(G) is the language generated by context free grammar

L(M) is the language accepted by Turing Machine

I. The problem a given regular expression *R* and a string *w*, is $w \in L(R)$? , is a membership problem. Membership problem is decidable for Finite state machine and regular expression.

II. Given Context free grammar *G*, is *L*(*G*) is ϕ? , is emptiness problem for context free grammar. Emptiness problem is decidable for CFG by checking usefulness of start symbol.

III. A given context free grammar G, is $L(G)$ is Σ^* for some alphabet Σ?, is undecidable problem. We can't check whether $L(G) = \Sigma^*$ or not but rather we can check complement of $L(G)$ is ϕ .Since context free language are not closed under complement operation $\overline{L(G)}$ may be language accepted by Turing Machine and we can't check emptiness for Turing machine.

IV. Given a Turing Machine M and a string w, is $w \in L(M)$? , is a membership problem for TM. Membership problem is not a decidable problem for TM.

53. Consider a machine with a byte addressable main memory of 2^{32}bytes divided into blocks of size 32 bytes. Assume that a direct mapped cache having 512 cache lines is used with this machine. The size of the tag field in bits is _____.

Key: (18)

Exp:

$32-(5+9)=18$

Total block size — block identifier

54. Let δ denote that transition function and $\hat{\delta}$ denote the extended transition function of the $\in$ – NFA whose transition table is given below:

δ	$\in$	a	b
$\rightarrow q_0$	$\{q_2\}$	$\{q_1\}$	$\{q_0\}$
q_1	$\{q_2\}$	$\{q_2\}$	$\{q_3\}$
q_2	$\{q_0\}$	$\varnothing$	$\varnothing$
q_3	$\varnothing$	$\varnothing$	$\{q_2\}$

Then $\hat{\delta}(q_2, aba)$ is

(A) $\varnothing$ (B) $\{q_0, q_1, q_3\}$ (C) $\{q_0, q_1, q_2\}$ (D) $\{q_0, q_2, q_3\}$

Key: (C)

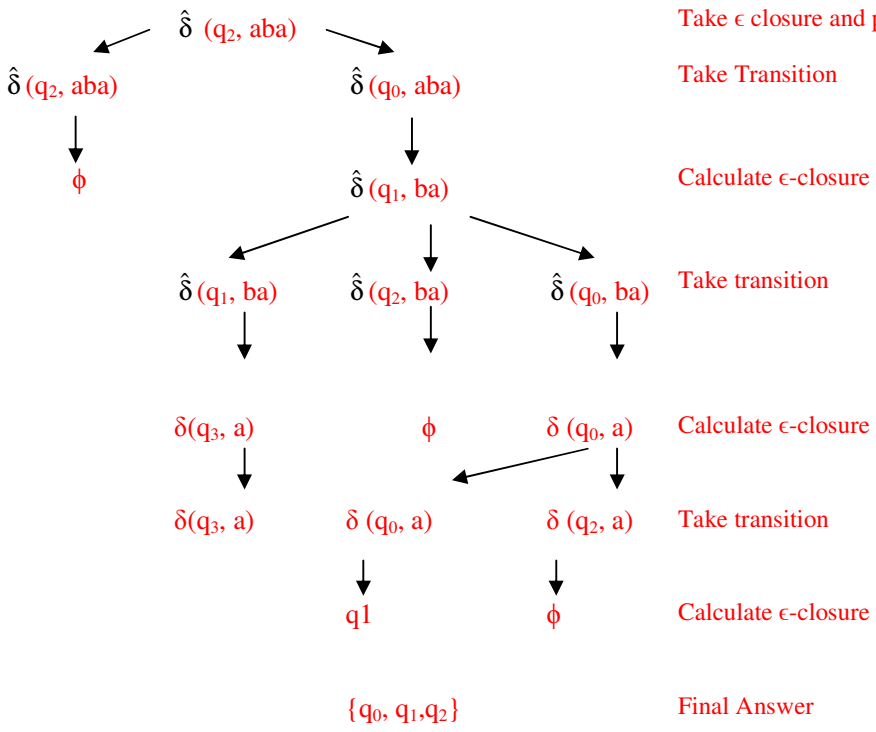
Exp:

The given table for NFA-ϵ Transition is

δ	ϵ	a	b
$\rightarrow q_0$	$\{q_2\}$	$\{q_1\}$	$\{q_0\}$
q_1	$\{q_2\}$	$\{q_2\}$	$\{q_3\}$
q_2	$\{q_0\}$	Φ	Φ
q_3	Φ	Φ	$\{q_2\}$

The process is we start with ϵ-closure of q2 then for each input first take the transition then calculate ϵ-closure

q_2 is the start for processing we take ϵ-closure which is $\{q_0, q_2\}$ and process "aba"



55. Consider the following languages.

$L_1 = \{a^p \mid p \text{ is a prime number}\}$

$L_2 = \{a^n b^m c^{2m} \mid n \geq 0, m \geq 0\}$

$L_3 = \{a^n b^n c^{2n} \mid n \geq 0\}$

$L_4 = \{a^n b^n \mid n \geq 1\}$

Which of the following are CORRECT ?

I. L_1 is context-free but not regular.

II. L_2 is not context-free.

III. L_3 is not context-free but recursive.

IV. L_4 is deterministic context-free.

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

Key: (D)

Exp: The given languages are

$L_1 = \{a^p \mid p \text{ is a prime number}\}$

$L_2 = \{a^n b^m c^{2m} \mid n \geq 0, m \geq 0\}$

$L_3 = \{a^n b^n c^{2n} \mid n \geq 0\}$

$L4 = \{a^n b^n \mid n \geq 1\}$

Statements are:

I. L_1 is context free but not regular is **INCORRECT**, It required a Turing machine to accept L_1.

II. L_2 is not context free is **INCORRECT**; the context free grammar is

$S \rightarrow XY$

$X \rightarrow aX|\epsilon$

$Y \rightarrow bYcc|\epsilon$

III. L_3 is not context free but recursive is **CORRECT**. L_3 is standard context sensitive language.

IV. L_4 is deterministic context free is **CORRECT**; the grammar is

$S \rightarrow aSb|ab$

General Aptitude

Q. No. 1 - 5 Carry One Mark Each

1. There are 3 red socks, 4 green socks and 3 blue socks, you choose 2 socks. The probability that they are of the same colour is _____.

(A) 1/5 (B) 7/30 (C) 1/4 (D) 4/15

Key: (D)

Exp: Required probability $= \frac{3_{C_2} + 4_{C_2} + 3_{C_2}}{10_{C_2}} = \frac{4}{15}$

2. Choose the option with words that are not synonyms.

(A) aversion, dislike (B) luminous, radiant

(C) plunder, loot (D) yielding, resistant

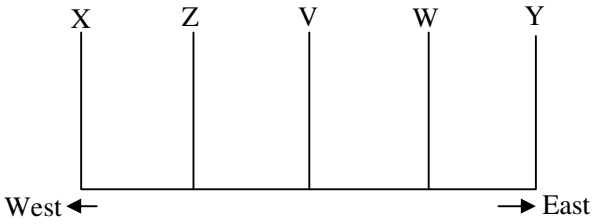
Key: (D)

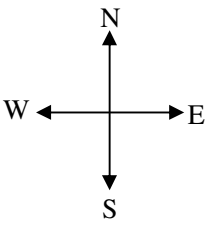
3. There are five buildings called V, W, X, Y and Z in a row (not necessarily in that order). V is to the west of W. Z is to the East of X and the West of V. W is to the West of Y. Which is the building in the middle ?

(A) V (B) W (C) X (D) Y

Key: (A)

Exp: From the given data, the following is formed





$\therefore$ The building 'V' is in the middle

4. A test has twenty questions worth 100 marks in total. There are two types of questions, multiple choice questions are worth 3 marks each and essay questions are worth 11 marks each. How many multiple choice questions does the exam have?

(A) 12 (B) 15 (C) 18 (D) 19

Key: **(B)**

Exp: $x + y = 20 \qquad (x = \text{MCQ}, y = \text{Essay type})$

$3x + 11y = 100$

$\Rightarrow x = 15, y = 5$

5. Saturn is ____ to be seen on a clear night with the naked eye.

(A) enough bright (B) bright enough

(C) as enough bright (D) bright as enough

Key: **(B)**

Q. No. 6 – 10 Carry Two Marks Each

6. "We lived in a culture that denied any merit to literary works, considering them important only when they were handmaidens to something seemingly more urgent - namely ideology. This was a country where all gestures, even the most private, were interpreted in political terms."

The author's belief that ideology is not as important as literature is revealed by the word:

(A) 'culture' (B) 'seemingly' (C) 'urgent' (D) 'political'

Key: **(B)**

7. X is a 30 digit number starting with the digit 4 followed by the digit 7, then the number X^3 will have

(A) 90 digits (B) 91 digits (C) 92 digits (D) 93 digits

Key: **(A)**

Exp: $X = (47.....)30 \text{ digits}$

Suppose $(47)^3_{30\text{digits}} = (2+2+2)$ digits in $(47)^3$

Similarly $(47)^3_{30\text{digits}}$ = contains (30 + 30 + 30) digits = 90 digits.

8. There are three boxes, one contains apples, another contains oranges and the last one contains both apples and oranges. All three are known to be incorrectly labelled. If you are permitted to open just one box and then pull out and inspect only one fruit, which box would you open to determine the contents of all three boxes?

(A) The box labelled 'Apples' (B) The box labelled 'Apples and Oranges'

(C) The box labelled 'Oranges' (D) Cannot be determined

Key: **(B)**

Exp: The person who is opening the boxes, he knew that all 3 are marked wrong.

Suppose if 3 boxes are labelled as below.

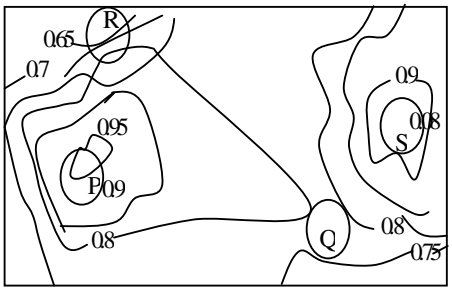
(1) Apples (2) Oranges (3) Apples & Oranges

If he inspected from Box(1), picked one fruit, found orange, then he don't know whether box contains oranges (or) both apples and oranges.

Similarly, if he picked one fruit from box(2), found apple then he don't know whether box contain apples (or) both apples and oranges.

But if he picked one fruit from box(3), i.e., labelled is "apples and oranges', if he found apple then he can decide compulsorily that box(3) contains apples and as he knew all boxes are labelled as incorrect, he can tell box(2) contains both apples and oranges, box(1) contain remaining oranges. So, he should open box labelled 'Apples and Oranges' to determine contents of all the three boxes.

9. An air pressure contour line joins locations in a region having the same atmospheric pressure . The following is an air contour plot of a geographical region . Contour lines are shown at 0.05 bar intervals in this plot.



If the possibility of a thunderstorm is given by how fast air pressure rises or drops over a region, which of the following regions is most likely to have a thunderstorm?

(A) P (B) Q (C) R (D) S

Key: (C)

Exp:

Region	Air pressure difference
P	0.95 – 0.90 = 0.05
Q	0.80 – 0.75 = 0.05
R	0.85 – 0.65 = 0.20
S	0.95 – 0.90 = 0.05

In general thunder storms are occurred in a region where suddenly air pressure changes (i.e.,) sudden rise (or) sudden fall of air pressure. From the given contour map in 'R' region only more changes in air pressure. So, the possibility of a thunder storms in this region.

So option (C) is correct.

10. The number of roots of $e^x + 0.5x^2 - 2 = 0$ in the range [-5,5] is

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

Key: (A)

Exp: $f(x) = e^x + 0.5x^2 - 2$

$f(-5) = 10.50; f(-4) = 6.01, f(-2) = 0.135; f(-1) = -1.13;$

$f(0) = -1, f(1) = 1.21, f(2) = 7.38, f(3), f(4), f(5)$ also + ve.

$\therefore$ As there are 2 sign changes from +ve to –ve and –ve to +ve, two roots will be there in the range [-5, 5].