BYJU'S EXAM PREP

GATE 2023

Computer Science & IT Engineering

Official Question Paper

General Aptitude

1. We reached the station late, and _____ missed the train.

A. near
B. nearly
C. utterly
D. mostly

[MCQ - 1 Mark]

Ans. B

Sol. Nearly is the answer for this question.

2. Kind : _____ : : Often : Frequently
(By word meaning)

A. Mean
B. Type
C. Cruel
D. Kindly

[MCQ - 1 Mark]

Ans. B

Sol. Often and frequently are synonym. So, answer be similar to the meaning of the word kind. Kind is an adjective. It has two meanings (i) Nice, (ii) Type. Kindly can be used as adjective also and adverb also. Kind is generally related an individual act. Whereas kindly refers to general character of a person.

Ex. The kindly woman helped the poor.

3. A series of natural numbers $F_1, F_2, F_3, F_4, F_5, F_6, F_7, \ldots$ obeys $F_{n+1} = F_n + F_{n-1}$ for all integers $n \geq 2$. If $F_6 = 37$, and $F_7 = 60$, then what is F_1 ?

A. 4
B. 5
C. 8
D. 9

[MCQ - 1 Mark]

Ans. A

Sol. $f_{n+1} = f_n + f_{n-1}$

$f_{n-1} = f_{n+1} - f_n$

$n = 6$	$f_5 = f_7 - f_6 = 60 - 37 = 23$
$n = 5$	$f_4 = f_6 - f_5 = 37 - 23 = 14$
$n = 4$	$f_3 = f_5 - f_4 = 23 - 14 = 9$
$n = 3$	$f_2 = f_3 - f_3 = 14 - 9 = 5$
$n = 2$	$f_1 = f_3 - f_2 = 9 - 5 = 4$

4. A survey for a certain year found that 90% of pregnant women received medical care at least once before giving birth. Of these women, 60% received medical care from doctors, while 40% received medical care from other healthcare providers.

Given this information, which one of the following statements can be inferred with certainty?

A. More than half of the pregnant women received medical care at least once from a doctor.

B. Less than half of the pregnant women received medical care at least once from a doctor.

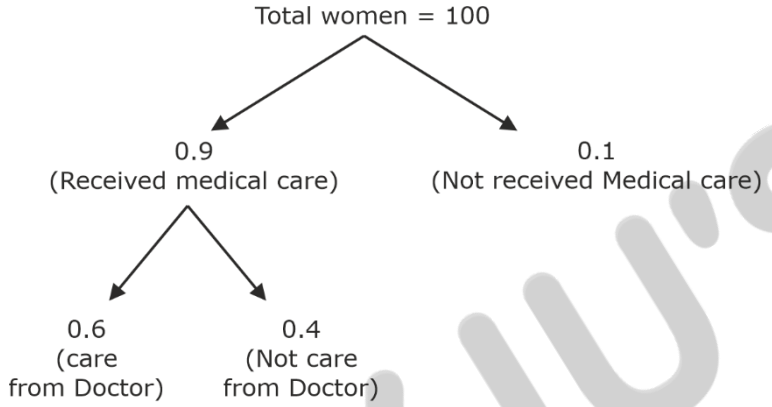
C. More than half of the pregnant women received medical care at most once from a doctor.

D. Less than half of the pregnant women received medical care at most once from a doctor.

[MCQ - 1 Mark]

Ans. A

Sol. Let us consider total women as = 100



- So, the no. of pregnant women who received medical care from Doctor = 0.9 × 0.6 × 100 = 54
- The number of pregnant women not received medical care = 0.4 × 0.9 × 100 = 36

So, option (A) is correct.

5. Looking at the surface of a smooth 3-dimensional object from the outside, which one of the following options is TRUE?

A. The surface of the object must be concave everywhere.

B. The surface of the object must be convex everywhere.

C. The surface of the object may be concave in some places and convex in other places.

D. The object can have edges, but no corners.

[MCQ - 1 Mark]

Ans. C

Sol. The surface of the object may be concave in some places and convex in same places.

therefore, option C is correct.

6. The country of Zombieland is in distress since more than 75% of its working population is suffering from serious health issues. Studies conducted by competent health experts concluded that a complete lack of physical exercise among its working population was one of the leading causes of their health issues. As one of the measures to address the problem, the Government of Zombieland has decided to provide monetary incentives to those who ride bicycles to work.

Based only on the information provided above, which one of the following statements can be logically inferred with certainty?

A. All the working population of Zombieland will henceforth ride bicycles to work.

B. Riding bicycles will ensure that all of the working population of Zombieland is free of health issues.

C. The health experts suggested to the Government of Zombieland to declare riding bicycles as mandatory.

D. The Government of Zombieland believes that riding bicycles is a form of physical exercise.

[MCQ - 2 Marks]

Ans. D

Sol. By this we can conclude that, In Zombieland, workers are affected by some problem, for which health expert say "It is due to lack of "Physical exercise" and recommend the physical exercise. So option (D) is correct that the Government of Zombieland believes that riding bicycles is a form of physical exercise.

7. Consider two functions of time (t),

$$f(t) = 0.01\ t^2$$

$$g(t) = 4\ t$$

where $0 < t < \infty$.

Now consider the following two statements:

(i) For some $t > 0$, $g(t) > f(t)$.

(ii) There exists a T, such that $f(t) > g(t)$ for all $t > T$.

Which one of the following options is TRUE?

A. only (i) is correct

B. only (ii) is correct

C. both (i) and (ii) are correct

D. neither (i) nor (ii) is correct

[MCQ - 2 Marks]

Ans. C

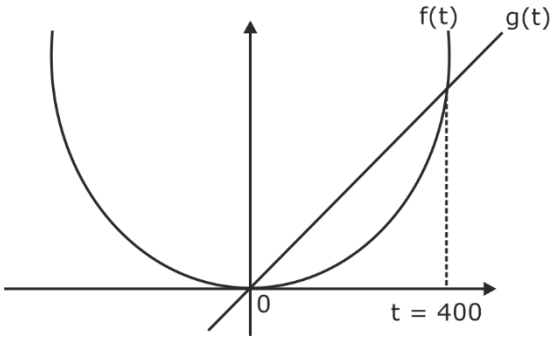
Sol.

$f(t) = 0.01(t)^2$

$g(t) = 4(t)$

Intersection at $0.01(t)^2 = 4(t)$

$\Rightarrow\ t = 0, 400$



(i) True, because for $0 < t < 400$

$$g(t) > f(t)$$

(ii) True, because for $t > 400$

$$f(t) > g(t)$$

8. Which one of the following sentence sequences creates a coherent narrative?

(i) Once on the terrace, on her way to her small room in the corner, she notices the man right away.

(ii) She begins to pant by the time she has climbed all the stairs.

(iii) Mina has bought vegetables and rice at the market, so her bags are heavy.

(iv) He was leaning against the parapet, watching the traffic below.

A. (i), (ii), (iv), (iii)
B. (ii), (iii), (i), (iv)
C. (iv), (ii), (i), (iii)
D. (iii), (ii), (i), (iv)

[MCQ - 2 Marks]

Ans. D

Sol. The correct order for the question given

(iii) Mina has bought vegetables and rice at the market, so her bags are heavy.

(ii) She begins to pant by the time she has climbed all the stairs.

(i) Once on the terrace, on her way to her small room in the corner, she notices the man right away.

(iv) He was leaning against the parapet, watching the traffic below.

Option D is correct.

9. $f(x)$ and $g(y)$ are functions of x and y, respectively, and $f(x) = g(y)$ for all real values of x and y. Which one of the following options is necessarily TRUE for all x and y?

A. $f(x) = 0$ and $g(y) = 0$

B. $f(x) = g(y) =$ constant

C. $f(x) \neq$ constant and $g(y) \neq$ constant

D. $f(x) + g(y) = f(x) - g(y)$

[MCQ - 2 Marks]

Ans. B

Sol. When we define "functions", we should also have to define domain and co-domain but sometimes it is not defined in gate.

Here, domain is defined but co-domain is not defined, so I am taking it as set of real numbers.

So, we have $f: R \rightarrow R$ and $g: R \rightarrow R$

Now, two functions f and g are equal if they have the same domain and codomain and for every element x in the domain (because dom(f)=dom(g)),

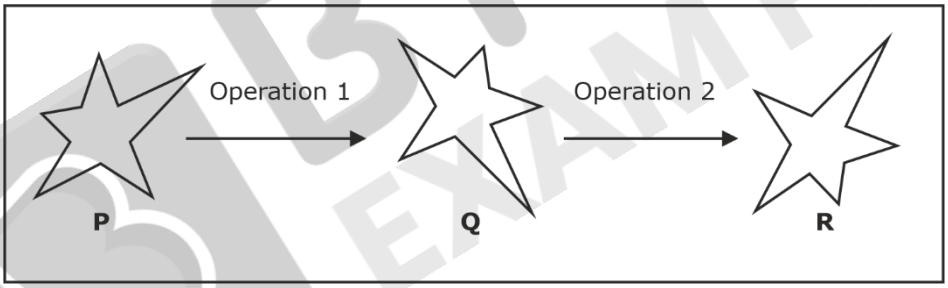
$$f(x) = g(x).$$

for example, $f(x) = \frac{x}{2}$ and $g(x) = \frac{2x}{4}$

But, here, we have given two equal functions where x and y may or may not be same i.e. $f(x) = g(y)$ where x and y belongs to the set of real numbers.

So, $\forall x, y \in R$, $f(x) = g(y)$ and it is true when all $x \in R$ maps to some element, say, c where c belongs to set R which is the codomain of f and similarly, all $y \in R$ maps to same element c where c belongs to set R which is the codomain of g and in this way both domain and codomain of f and g are equal and $\forall x,y \in R$, $f(x) = f(y) = c$ where c is some arbitrary constant.

10. Which one of the options best describes the transformation of the 2-dimensional figure **P** to **Q**, and then to **R**, as shown?



A. Operation 1: A clockwise rotation by 90º about an axis perpendicular to the plane of the figure
Operation 2: A reflection along a horizontal line

B. Operation 1: A counter clockwise rotation by 90º about an axis perpendicular to the plane of the figure
Operation 2: A reflection along a horizontal line

C. Operation 1: A clockwise rotation by 90º about an axis perpendicular to the plane of the figure
Operation 2: A reflection along a vertical line

D. Operation 1: A counter clockwise rotation by 180º about an axis perpendicular to the plane of the figure
Operation 2: A reflection along a vertical line

[MCQ - 2 Marks]

Ans. A

Sol. Operation 1: A clockwise rotation by 90º about an axis perpendicular to the plane of the figure

Operation 2: A reflection along a horizontal line

Hence, Option A is correct.

11. Consider the following statements regarding the front-end and back-end of a compiler.

S1: The front-end includes phases that are independent of the target hardware.

S2: The back-end includes phases that are specific to the target hardware.

S3: The back-end includes phases that are specific to the programming language used in the source code.

Identify the CORRECT option.

A. Only S1 is TRUE.

B. Only S1 and S2 are TRUE.

C. S1, S2, and S3 are all TRUE.

D. Only S1 and S3 are TRUE.

[MCQ - 1 Mark]

Ans. B

Sol. Only S_1 and S_2 are true

The Back-end of a compiler is responsible for generating the actual machine code that can be executed by the target hardware. This phase is typically hardware specific & includes task such as instruction & code optimization. So Back end of the compiler does not include the phases that are specific to programming language.

So (S_3 is false)

The Back-end o the compiler is responsible for generating the actual machine code that can be executed by target hardware. So this phase is hardware specific (S_2 is true).

The front end of the compiler is responsible for analyzing the source code & generating an intermediate representation. So this phase is language specific & incudes task such as parsing, Semantic analysis, & type checking. It does not depends on target hardware (So, S_1 is true).

12. Which one of the following sequences when stored in an array at locations A[1],...,A[10] forms a max-heap?

A. 23, 17, 10, 6, 13, 14, 1, 5, 7, 12

B. 23, 17, 14, 7, 13, 10, 1, 5, 6, 12

C. 23, 17, 14, 6, 13, 10, 1, 5, 7, 15

D. 23, 14, 17, 1, 10, 13, 16, 12, 7, 5

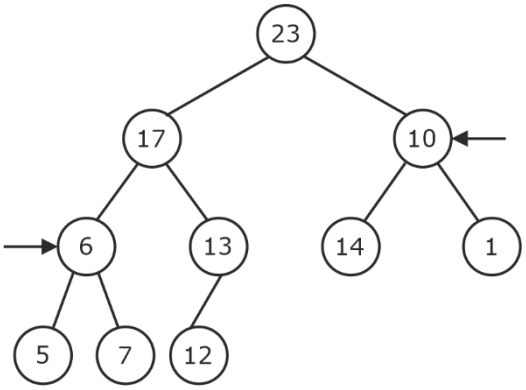
[MCQ - 1 Mark]

Ans. B

Sol. A max-heap must satisfy 2 properties

1. **Structuring property:** It must be a complete Binary Tree
2. **Ordering property:** Parent value must be greater than all children values at each level.

Option A:

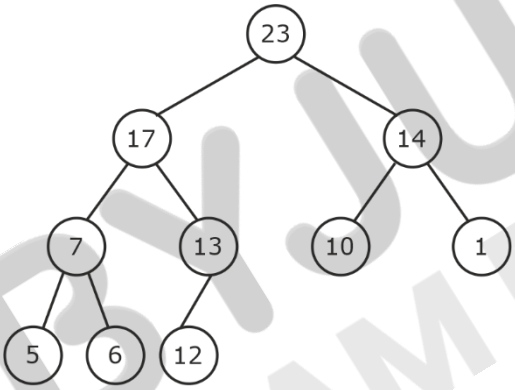


Not max heap

Parent value 1 < children values 12, 7.

It's not max-heap.

Option B :

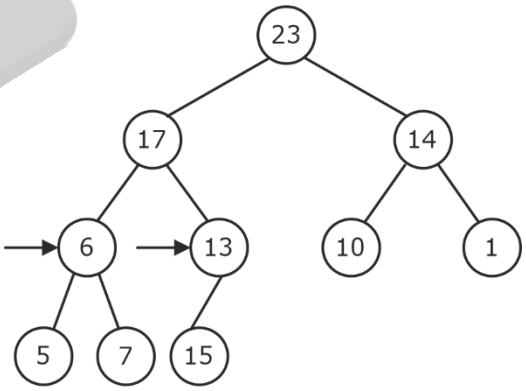


Max heap

It satisfy both properties.

Hence, It is max-heap.

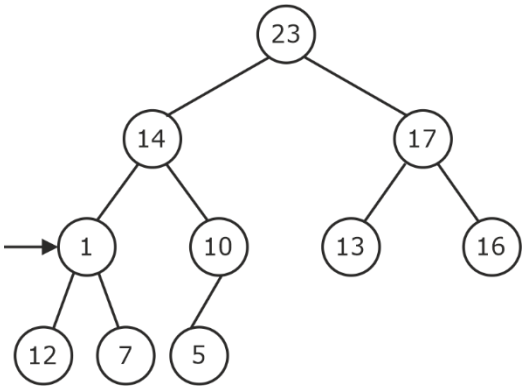
Option C:



Not max heap

6 < 9, Hence it is not max-heap.

Option D:



Not max heap

6 < 7 and 13 < 15.

Hence it's Not max-heap.

13. Let **SLLdel** be a function that deletes a node in a singly-linked list given a pointer to the node and a pointer to the head of the list. Similarly, let **DLLdel** be another function that deletes a node in a doubly-linked list given a pointer to the node and a pointer to the head of the list.

Let n denote the number of nodes in each of the linked lists. Which one of the following choices is TRUE about the worst-case time complexity of **SLLdel** and **DLLdel**?

A. **SLLdel** is O(1) and **DLLdel** is O(n) B. Both **SLLdel** and **DLLdel** are O(log(n))

C. Both **SLLdel** and **DLLdel** are O(1) D. **SLLdel** is O(n) and **DLLdel** is O(1)

[MCQ - 1 Mark]

Ans. D

Sol. Singly linked list:

Worst case deletion means deleting a last node or last but one node. As ptr points to node to be deleted, it may be deleted directly. But, to connect it's before node to it's next node need to traverse whole list. Hence, it takes O(n) time.

struct node item; item = head;

while(item → next ! = ptr)

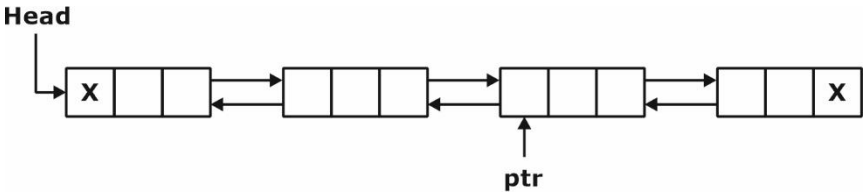
item – item → next;

item → next = ptr → next;

free (ptr);

(DLLdel)

Doubly linked list:



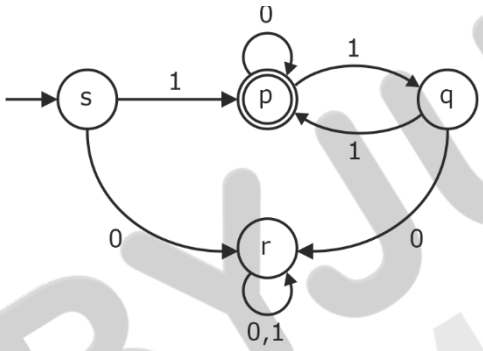
As ptr points to the node to be deleted, it can be deleted in O(1) time

ptr → prev → next = ptr → next;

ptr → next → prev = ptr → prev;

free(ptr);

14. Consider the Deterministic Finite-state Automaton (DFA) A shown below. The DFA runs on the alphabet {0, 1}, and has the set of states {s, p, q, r}, with s being the start state and p being the only final state.



Which one of the following regular expressions correctly describes the language accepted by A?

A. 1(0*11)*

B. 0(0 + 1)*

C. 1(0 + 11)*

D. 1(110*)*

[MCQ - 1 Mark]

Ans. C

Sol. Option A: 1(0*11)*, In this expression strings link "1110" not possible.

Option B: It generates strings link, 0, 01, 010, 0110, …., which are not accepted by DFA.

Option D: 1(110*)*, Here we don't get strings like 1011 …….

15. The Lucas sequence L_n is defined by the recurrence relation:

$$L_n = L_{n-1} + L_{n-2}, \text{ for } n \geq 3,$$

with $L_1 = 1$ and $L_2 = 3$.

Which one of the options given is TRUE?

A. $L_n = \left(\frac{1+\sqrt{5}}{2}\right)^n + \left(\frac{1-\sqrt{5}}{2}\right)^n$

B. $L_n = \left(\frac{1+\sqrt{5}}{2}\right)^n - \left(\frac{1-\sqrt{5}}{3}\right)^n$

C. $L_n = \left(\frac{1+\sqrt{5}}{2}\right)^n + \left(\frac{1-\sqrt{5}}{3}\right)^n$

D. $L_n = \left(\frac{1+\sqrt{5}}{2}\right)^n - \left(\frac{1-\sqrt{5}}{2}\right)^n$

[MCQ - 1 Mark]

Ans. A

Sol. $L_n - L_{n-1} - L_{n-2} = 0$

$t^2 - t - 1 = 0$

$t = \frac{1 \pm \sqrt{1+4}}{2} = \frac{1 \pm \sqrt{5}}{2}$ → option C and D are wrong.

Option A: $L_1 = \frac{1+\sqrt{5}}{2} + \frac{1-\sqrt{5}}{2} = 1$

16. Which one of the options given below refers to the degree (or arity) of a relation in relational database systems?

A. Number of attributes of its relation schema.

B. Number of tuples stored in the relation.

C. Number of entries in the relation.

D. Number of distinct domains of its relation schema.

[MCQ - 1 Mark]

Ans. A

Sol. Arity refers to the number of columns in a table.

For example, If a relation has 6 attributes say R(A, B, C, D, E, F) then the arity is 6.

17. Suppose two hosts are connected by a point-to-point link and they are configured to use **`Stop-and-Wait`** protocol for reliable data transfer. Identify in which one of the following scenarios, the utilization of the link is the lowest.

A. Longer link length and lower transmission rate

B. Longer link length and higher transmission rate

C. Shorter link length and lower transmission rate

D. Shorter link length and higher transmission rate

[MCQ - 1 Mark]

Ans. B

Sol.

- If link length is more, then the propagation time will be more, so that there will be more idle time for the sender, which can reduce the utilization as the utilization of stop and wait protocol is as follows.
- If transmission rate is high then the time for transmission is less and hence the sender sits idle after the fast transmission.

Utilization = h = $\frac{T_t}{T_t + 2 \times T_p}$

18. Let

$$A = \begin{bmatrix} 1 & 2 & 3 & 4 \\ 4 & 1 & 2 & 3 \\ 3 & 4 & 1 & 2 \\ 2 & 3 & 4 & 1 \end{bmatrix}$$

and

$$B = \begin{bmatrix} 3 & 4 & 1 & 2 \\ 4 & 1 & 2 & 3 \\ 1 & 2 & 3 & 4 \\ 2 & 3 & 4 & 1 \end{bmatrix}$$

Let det(A) and det(B) denote the determinants of the matrices A and B, respectively.

Which one of the options given below is TRUE?

A. det(A) = det(B)

B. det(B) = −det(A)

C. det(A)=0

D. det(AB) = det(A) + det(B)

[MCQ - 1 Mark]

Ans. B

Sol.

$$A = \begin{bmatrix} 1 & 2 & 3 & 4 \\ 4 & 1 & 2 & 3 \\ 3 & 4 & 1 & 2 \\ 2 & 3 & 4 & 1 \end{bmatrix} \quad B = \begin{bmatrix} 3 & 4 & 1 & 2 \\ 4 & 1 & 2 & 3 \\ 1 & 2 & 3 & 4 \\ 2 & 3 & 4 & 1 \end{bmatrix}$$

Clearly $\boxed{A}\ R_1 \leftrightarrow R_3\ \boxed{B}$

By determinant properties, $|A| = -|B|$ and $|B| = -|A|$

19. Consider the following definition of a lexical token id for an identifier in a programming language, using extended regular expressions:

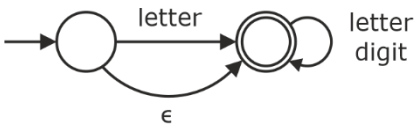
letter → [A-Za-z]

digit → [0-9]

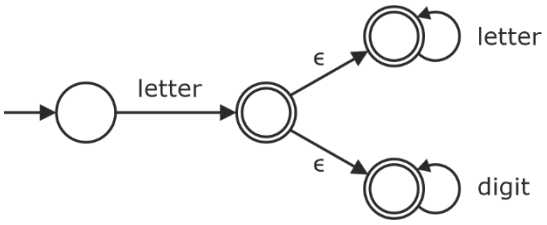
id → letter (letter | digit)*

Which one of the following Non-deterministic Finite-state Automata with ϵ-transitions accepts the set of valid identifiers? (A double-circle denotes a final state)

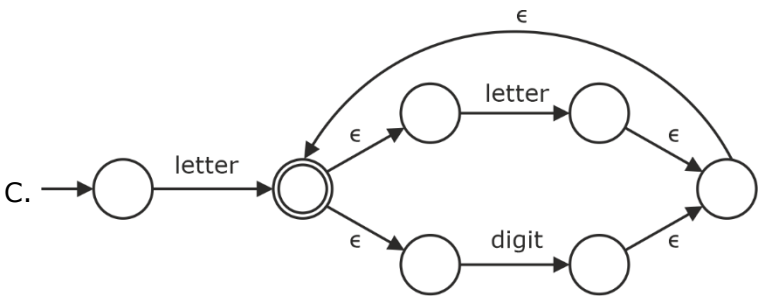
A.



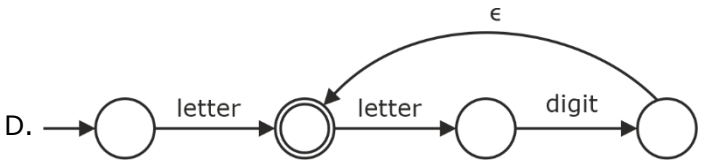
B.



C.



D.



[MCQ - 1 Mark]

Ans. C

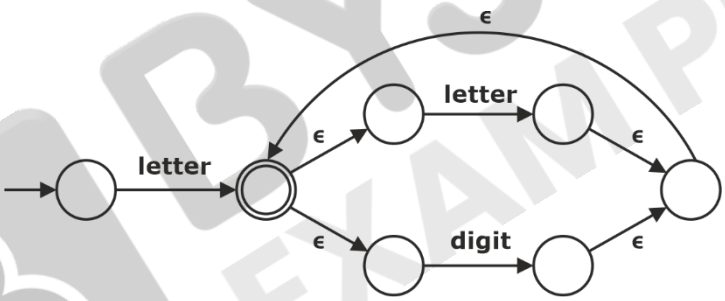
Sol. This expression covers all the strings starts with letter and followed by any combinations of letters and digits.

L(L + D)*

L : Letters

D = Digits

NFA



20. An algorithm has to store several keys generated by an adversary in a hash table. The adversary is malicious who tries to maximize the number of collisions.

Let k be the number of keys, m be the number of slots in the hash table, and k>m.

Which one of the following is the best hashing strategy to counteract the adversary?

A. Division method, i.e., use the hash function h(k) = k mod m.

B. Multiplication method, i.e., use the hash function $h(k) = \lfloor m(kA - \lfloor kA \rfloor) \rfloor$, where *A* is a carefully chosen constant.

C. Universal hashing method.

D. If k is a prime number, use Division method. Otherwise, use Multiplication method.

[MCQ - 1 Mark]

Ans. C

Sol. Universal Hashing

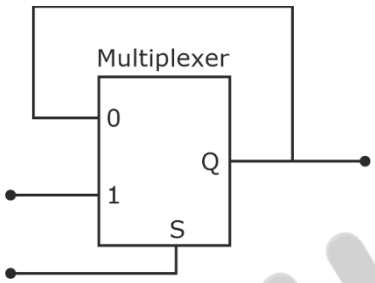
Create a set of hash functions H, from which a random has function h is selected (i.e., use many hash functions and choose one randomly)

The collection is called universal if for any randomly choose function h from H and two keys K and I

$$P[h(k) = h(I)] \leq \frac{1}{m} \qquad \text{(m size of table)}$$

i.e., universal hashing on average, will produce collision between two random keys 1/m of the time for table size m.

21. The output of a 2-input multiplexer is connected back to one of its inputs as shown in the figure.



Match the functional equivalence of this circuit to one of the following options.

A. D Flip-flop

B. D Latch

C. Half-adder

D. Demultiplexer

[MCQ - 1 Mark]

Ans. B

Sol. For $S = O, Q^+ = I_0 = Q_2$

For $S = 1, Q^+ = I_1 = X$

Let $S = \text{Clock and } X = D$

So, If $\text{clock} = 1, Q^+ = D$

If $\text{clock} = 0, Q^+ = Q$

So, it is a level triggered circuit, So it is D latch.

22. Which one or more of the following need to be saved on a context switch from one thread (T1) of a process to another thread (T2) of the same process?

A. Page table base register

B. Stack pointer

C. Program counter

D. General purpose registers

[MSQ - 1 Mark]

Ans. B, C, D

Sol. While switching from one thread to another, program counter value, stack register value and GPR values for local variables are stored in memory. Base address will not stored in memory.

23. Which one or more of the following options guarantee that a computer system will transition from user mode to kernel mode?

A. Function Call

B. malloc Call

C. Page Fault

D. System Call

[MSQ - 1 Mark]

Ans. C, D

Sol. **a)** **Page fault :** When a page fault occurs, required page must be loaded from secondary to main memory. means, RAM should be written. It will be done in privileged mode.

b) **Malloc () call:** It may be done in both user and kernel modes. Hence, It cannot guarantee switching.

c) **function call:** As the functions may be user defined, It also does not guarantee mode switching.

d) **System call :** System calls are executed (or) processed in kernel mode only. Hence, It guarantees mode switching.

24. Which of the following statements is/are CORRECT?

A. The intersection of two regular languages is regular.

B. The intersection of two context-free languages is context-free.

C. The intersection of two recursive languages is recursive.

D. The intersection of two recursively enumerable languages is recursively enumerable.

[MSQ - 1 Mark]

Ans. A, C, D

Sol. • Recursive languages are closed under complementation.

• Regular languages are closed under intersection and every regular is also recursive.

• R.E languages are also closed under complementation.

• CFL's are NOT closed under intersection.

So, A, C and D are true.

25. Which of the following statements is/are INCORRECT about the OSPF (Open Shortest Path First) routing protocol used in the Internet?

A. OSPF implements Bellman-Ford algorithm to find shortest paths.

B. OSPF uses Dijkstra's shortest path algorithm to implement least-cost path routing.

C. OSPF is used as an inter-domain routing protocol.

D. OSPF implements hierarchical routing.

[MSQ - 1 Mark]

Ans. C, D

Sol.
- Dijkstra algorithm is used to create a shortest path tree.
- Bellmen ford is not used in shortest path identification.
- OSPF supports hierarchical
- OSPF is an intra-domain routing, not inter-domain.

26. Geetha has a conjecture about integers, which is of the form

$$\forall x\left(P(x) \Rightarrow \exists y Q(x, y)\right),$$

where P is a statement about integers, and Q is a statement about pairs of integers.

Which of the following (one or more) option(s) would imply Geetha's conjecture?

A. $\exists x\left(P(x) \wedge \forall y Q(x, y)\right)$

B. $\forall x \forall y Q(x, y)$

C. $\exists y \forall x\left(P(x) \Rightarrow Q(x, y)\right)$

D. $\exists x\left(P(x) \wedge \exists y Q(x, y)\right)$

[MSQ - 1 Mark]

Ans. B, C

Sol.

Option C:	$\exists y\ \forall x[P(x) \Rightarrow Q(x, y)]$
Use the rule	$\exists y\ \forall x\ A(x, y) \Rightarrow \forall x\ \exists y\ A(x, y)$
So, option C implied	$\forall x[P(x) \Rightarrow \exists y\ Q(x, y)]$
Option D:	$\forall x\ \forall y\ Q(x, y)$
	$\forall x\ \forall y\ Q(x, y)$ is true
$\Rightarrow$	$\forall x\ \forall y\ P(x) \Rightarrow Q(x, y)$ is true
$\Rightarrow$	$\forall x\ [P(x) \Rightarrow \exists y\ Q(x, y)]$ is true

27. Which one or more of the following CPU scheduling algorithms can potentially cause starvation?

A. First-in First-Out

B. Round Robin

C. Priority Scheduling

D. Shortest Job First

[MSQ - 1 Mark]

Ans. C, D

Sol. a) In FIFO policy, process may under go waiting but it is due to convoy effect.

b) In SJF, when short jobs keep arriving, then a longer job might need to wait for longer time. Hence, It could cause starvation.

c) Priority policy also may cause low priority processes to wait. So, starvation possible.

d) In round robin, as CPU time is shared to all processes, no process starve.

28. Let

$$f(x) = x^3 + 15x^2 - 33x - 36$$

be a real-valued function.

Which of the following statements is/are TRUE?

A. f(x) does not have a local maximum.

B. f(x) has a local maximum.

C. f(x) does not have a local minimum.

D. f(x) has a local minimum.

[MSQ - 1 Mark]

Ans. B, D

Sol. $F(x) = x^3 + 15x^2 - 33x - 36$

$F'(x) = 3x^2 + 30x - 33$

$F'(x) = 0 \Rightarrow x^2 + 10x - 11 = 0 \Rightarrow x = 1, -11.$

$F''(x) = 6x + 30$

At $x = 1$: $F''(1) = 36 > 0 \Rightarrow$ f has local minimum

At $x = -11$: $F''(-11) = -36 < 0 \Rightarrow$ has local maximum

$\therefore$ So, option B and D are true.

29. Let f and g be functions of natural numbers given by $f(n) = n$ and $g(n) = n^2$.

Which of the following statements is/are TRUE?

A. $f \in O(g)$ B. $f \in \Omega(g)$

C. $f \in o(g)$ D. $f \in \Theta(g)$

[MSQ - 1 Mark]

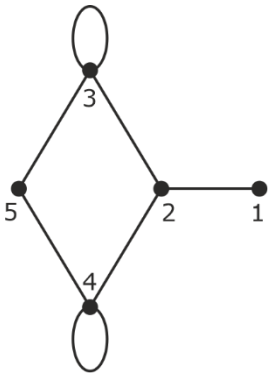
Ans. A, C

Sol. $f(n) = n$ $g(n) = (n)^2$

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

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

30. Let A be the adjacency matrix of the graph with vertices {1, 2, 3, 4, 5}.



Let λ_1, λ_2, λ_3, λ_4, and λ_5 be the five eigenvalues of A. Note that these eigenvalues need not be distinct.

The value of $\lambda_1 + \lambda_2 + \lambda_3 + \lambda_4 + \lambda_5$ = _____.

[NAT - 1 Mark]

Ans. 2

Sol. Adjacency matrix

$$\begin{bmatrix} 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 1 & 1 & 0 \\ 0 & 1 & 1 & 0 & 1 \\ 0 & 1 & 0 & 1 & 1 \\ 0 & 0 & 1 & 1 & 0 \end{bmatrix}$$

Sum of eigen value $\lambda_1 + \lambda_2 + \lambda_3 + \lambda_4 + \lambda_5 = 2$

31. The value of the definite integral

$$\int_{-3}^{3}\int_{-2}^{2}\int_{-1}^{1}\left(4x^2y - z^3\right)dz\,dy\,dx$$

is _____. (Rounded off to the nearest integer)

[NAT - 1 Mark]

Ans. 0

Sol. $I = \int_{-3}^{3}\int_{-2}^{2}\int_{-1}^{1}\left(4x^2y - z^3\right)dzdydx = \int_{-3}^{3}\int_{-2}^{2}\int_{-1}^{1} 4x^2y\,dzdydx - \int_{-3}^{3}\int_{-2}^{2}\int_{-1}^{1} 2^3\,dzdydx$

$4x^2y$: y is odd function ↓

2^3: odd function ↓

So, integral is 0

So, integral is 0

$= 0 - 0 = 0$

32. A particular number is written as 132 in radix-4 representation. The same number in radix-5 representation is _____.

[NAT - 1 Mark]

Ans. 110

Sol. $(132)_4 = (?)_5$

$(132)_4 = (?)_{10} = (?)_5$

$(132)_4 = 1 \times 4^2 + 3\times4^1 + 2 \times 4^0$

$= (30)_{10}$

$(30)_{10} = (?)_5$

	Q	R
30 / 5	6	0
6 / 5	1	1
1 / 5	0	1

Ans: $(110)_5$

33. Consider a 3-stage pipelined processor having a delay of 10 ns (nanoseconds), 20 ns, and 14 ns, for the first, second, and the third stages, respectively. Assume that there is no other delay and the processor does not suffer from any pipeline hazards. Also assume that one instruction is fetched every cycle.

The total execution time for executing 100 instructions on this processor is _____ ns.

[NAT - 1 Mark]

Ans. 2040 ns

Sol. Each cycle has max(10, 20, 14) ns which is 20 n.s.

Total cycles = (k + n − 1) × 1 cycle

Here K = 3 [Number of stages]

n = Number of instruction

Here n = 100, 1 cycle = 20 ns

Total cycles = (3 + 100 − 1) × 20 ns

= 102 × 20

= 2040 ns

34. A keyboard connected to a computer is used at a rate of 1 keystroke per second. The computer system polls the keyboard every 10 ms (milli seconds) to check for a keystroke and consumes 100 µs (micro seconds) for each poll. If it is determined after polling that a key has been pressed, the system consumes an additional 200 µs to process the keystroke. Let T_1 denote the fraction of a second spent in polling and processing a keystroke.

In an alternative implementation, the system uses interrupts instead of polling. An interrupt is raised for every keystroke. It takes a total of 1 ms for servicing an interrupt and processing a keystroke. Let T_2 denote the fraction of a second spent in servicing the interrupt and processing a keystroke.

The ratio $\frac{T_1}{T_2}$ is _____. (Rounded off to one decimal place)

[NAT - 1 Mark]

Ans. 10.2

Sol. For polling:

1 poll → 10 msec

n poll → 1 sec

⇒ for 1 sec ⇒ 100 polls

each polls took 100 µsec

So total polling time = $100 \times 100 \times 10^{-6}$ sec

⇒ 10000 µsec

Service time ⇒ 200 µsec

Total time for keyboard stroke = 10000 + 200 = 10200 µsec

For Interrupts

Interrupt time = 1 sec = 1000 msec

Interrupt processing time = 1 msec

T_1 = Fraction of time taken for polling

$$= \left[\frac{10200\ \mu\text{sec}}{1000000\ \mu\text{sec}}\right] \times 100 = 1.02$$

T_2 = Fraction of time taken for Interrupt

$$= \left[\frac{1\ \text{ms}}{1000\ \text{ms}}\right] \times 100 = 0.1$$

$$\frac{T_1}{T_2} = \frac{1.02}{0.1} = 10.2$$

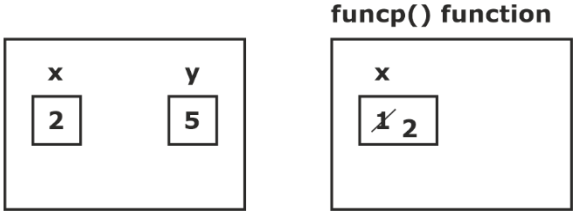
35. The integer value printed by the ANSI-C program given below is _____.

```
#include<stdio.h>

int funcp(){
        static int x = 1;
        x++;
        return x;
}

int main(){
        int x,y;
        x = funcp();
        y = funcp()+x;
        printf("%d\n", (x+y));
        return 0;
}
```

[NAT - 1 Mark]

Ans. 7

Sol. Program Execution starts from main() function.



x = funcp() call funcp function, initialise static variable x as 7. then x++ increments 'x' to 2 and return 2. Hence main() function's x = 2

y = funcp() + x calls funcp function again, Increment x to 3 and return 3.

y = 3 + 2 (main function x value) ⇒ y = 5

print (x + y) prints 7.

36. Consider the following program:

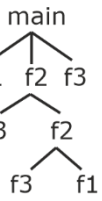
```
int main()
{
    f1();
    f2(2);
    f3();
    return(0);
}
```

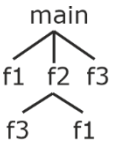
```
int f1()
{
  return(1);
}
```

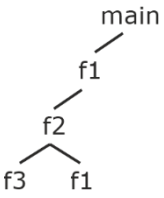
```
int f2(int X)
{
   f3();
  if (X==1)
    return f1();
  else
    return (X*f2(X-1));
}
```

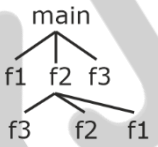
```
int f3()
{
  return(5);
}
```

Which one of the following options represents the activation tree corresponding to the main function?

A.


B.


C.


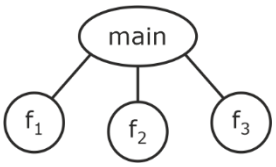
D.


[MCQ - 2 Marks]

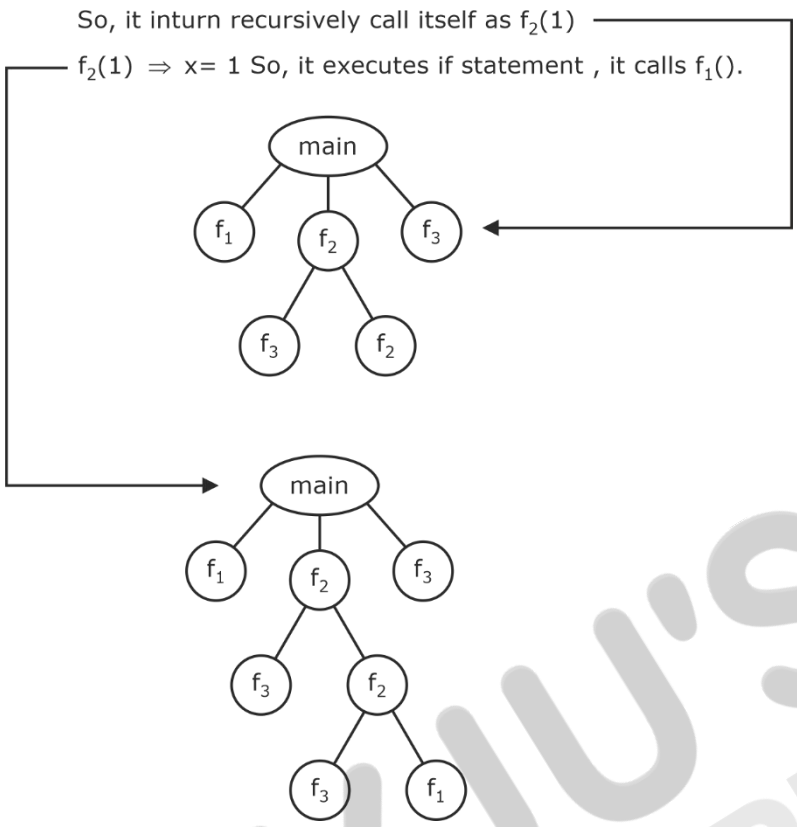
Ans. A

Sol. Program Execution starts from main() function. So, main() would be Root node of activation tree.

In main(), $f_1()$, $f_2()$, $f_3()$ are called directly. so, these will be direct children for main().

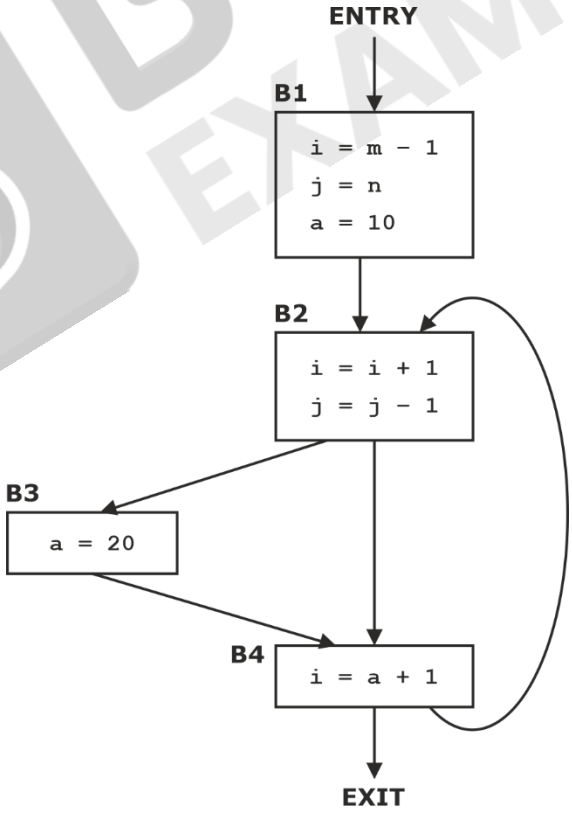


$f_2(2)$ first when called X = 2, So else statement Executes,



Hence option A is answer.

37. Consider the control flow graph shown.



Which one of the following choices correctly lists the set of live variables at the exit point of each basic block?

A. B1: {}, B2: {a}, B3: {a}, B4: {a}

B. B1: {i, j}, B2: {a}, B3: {a}, B4: {i}

C. B1: {a, i, j}, B2: {a, i, j}, B3: {a, i}, B4: {a}

D. B1: {a, i, j}, B2: {a, j}, B3: {a, j}, B4: {a, i, j}

[MCQ - 2 Marks]

Ans. D

Sol. At the end of B1 ⇒

live varialbes ⇒ {i, j, a}

live variable a is possible when we consider the flow form B2 to B4

At the end of B2 ⇒

i ⇒ not possible (wirte into ;)

a ⇒ possible (B2 to B4)

j ⇒ possible (B2 → B4 → B2)

⇒ {a, j}

38. Consider the two functions incr and decr shown below.

```
incr(){
 wait(s);
 X = X+1;
 signal(s);
}
```

```
decr(){
 wait(s);
 X = X-1;
 signal(s);
}
```

There are 5 threads each invoking incr once, and 3 threads each invoking decr once, on the same shared variable X. The initial value of X is 10.

Suppose there are two implementations of the semaphore s, as follows:

I-1: s is a binary semaphore initialized to 1.

I-2: s is a counting semaphore initialized to 2.

Let V1, V2 be the values of X at the end of execution of all the threads with implementations **I-1**, **I-2**, respectively.

Which one of the following choices corresponds to the minimum possible values of V1, V2, respectively?

A. 15, 7

B. 7, 7

C. 12, 7

D. 12, 8

[MCQ - 2 Marks]

Ans. B

Sol. I - 1: Binary semaphore S = 1

5 threads increment x value

3 threads decrement x value.

As, we want minimum value, consider a thread read x value 10 and preempted. Then all incrementing threads executed, making x to 15.

Now, Decrementing thread which is preempted make x to 9.

other two decrementing threads make x to 7.

I – III Counting Semaphore, S=2

Though it is a counting semaphore, at most 2 processor can access 'x' value at a time, as we want minimum value, again last decrementing threads update X value as 7.

Hence, $V_1 = 7$, $V_2 = 7$.

39. Consider the context-free grammar G below

$$S \rightarrow aSb \mid X$$

$$X \rightarrow aX \mid Xb \mid a \mid b \ ,$$

where S and X are non-terminals, and a and b are terminal symbols. The starting non-terminal is S.

Which one of the following statements is CORRECT?

A. The language generated by G is (a + b)*

B. The language generated by G is a*(a + b)b*

C. The language generated by G is a*b*(a + b)

D. The language generated by G is not a regular language

[MCQ - 2 Marks]

Ans. B

Sol.

$s \rightarrow aSb|X$

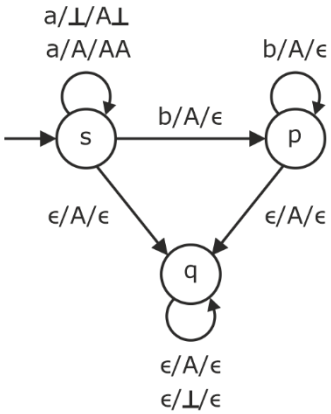
$x \rightarrow ax|xb|a|b$

The string "ba" cannot be generated by grammar, so option A is wrong string "ba" is also present in option C expression.

L(G) is a CFL but regular.

So, L(G) = (a)* (a + b) (b)*

40. Consider the pushdown automaton (PDA) P below, which runs on the input alphabet {a, b}, has stack alphabet {⊥, A}, and has three states {s, p, q}, with s being the start state. A transition from state u to state v, labelled c/X/γ, where c is an input symbol or ϵ, X is a stack symbol, and γ is a string of stack symbols, represents the fact that in state u, the PDA can read c from the input, with X on the top of its stack, pop X from the stack, push in the string γ on the stack, and go to state v. In the initial configuration, the stack has only the symbol ⊥ in it. The PDA accepts by empty stack.



Which one of the following options correctly describes the language accepted by P?

A. $\{a^m b^n \mid 1 \leq m \text{ and } n<m\}$

B. $\{a^m b^n \mid 0 \leq n \leq m\}$

C. $\{a^m b^n \mid 0 \leq m \text{ and } 0 \leq n\}$

D. $\{a^m \mid 0 \leq m\} \cup \{b^n \mid 0 \leq n\}$

[MCQ - 2 Marks]

Ans. A

Sol. PDA transmission are as follows

1. $\delta(S, a, A) = (S, AA)$
2. $\delta(S, a, \perp) = (S, A\perp)$
3. $\delta(S, b, A) = (S, \epsilon)$
4. $\delta(S, \epsilon, A) = (q, \epsilon)$
5. $\delta(P, b, A) = (P, \epsilon)$
6. $\delta(P, \epsilon, A) = (q, \epsilon)$
7. $\delta(q, \epsilon, A) = (q, \epsilon)$
8. $\delta(q, \epsilon, \perp) = (q, \epsilon)$

Strings accepted are aab, aaab, aaabb, …., etc. [with empty stack]

So, $L(M) = \{a^m b^n \mid 1 \leq m \text{ and } n < m\}$

41. Consider the given C-code and its corresponding assembly code, with a few operands U1–U4 being unknown. Some useful information as well as the semantics of each unique assembly instruction is annotated as inline comments in the code.

The memory is byte-addressable.

//C-code	;assembly-code (; indicates comments) ;r1-r5 are 32-bit integer registers ;initialize r1=0, r2=10 ;initialize r3, r4 with base address of a, b

int a[10], b[10], i;
// int is 32-bit
for (i=0; i<10;i++)
a[i] = b[i] * 8;
	L01: jeq r1, r2, end ;if(r1==r2) goto end
	L02: lw r5, 0(r4) ;r5 <- Memory[r4+0]
	L03: shl r5, r5, U1 ;r5 <- r5 << U1
	L04: sw r5, 0(r3) ;Memory[r3+0] <- r5
	L05: add r3, r3, U2 ;r3 <- r3+U2
	L06: add r4, r4, U3
	L07: add r1, r1, 1
	L08: jmp U4 ;goto U4
	L09: end

Which one of the following options is a CORRECT replacement for operands in the position (U1, U2, U3, U4) in the above assembly code?

A. (8, 4, 1, L02)
B. (3, 4, 4, L01)
C. (8, 1, 1, L02)
D. (3, 1, 1, L01)

[MCQ - 2 Marks]

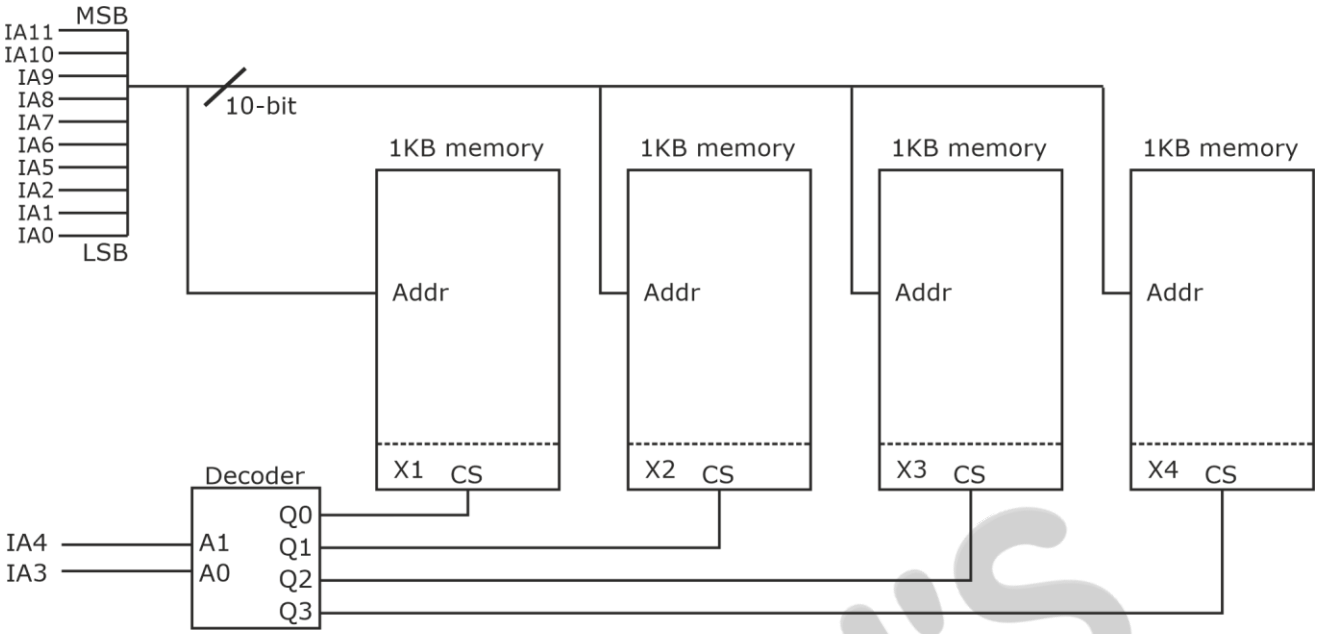
Ans. B

Sol. This loop is repeated for 10 times, when $r_1 = r_2$ then the program ends, $U_1 = 3$, since, if we do shift left for three times, then, it is multiplied by 8..

U_2 and U_3 should be 4, as the memory is byte addressable and one integer is given as 32 bits which is 4 bytes, next integer in the array will be after 4-locations in memory.

U_4 should be L01 as the program should end after r_1 becomes equal to r_2 which happens after 10 iterations.

42. A 4 kilobyte (KB) byte-addressable memory is realized using four 1 KB memory blocks. Two input address lines (IA4 and IA3) are connected to the chip select (CS) port of these memory blocks through a decoder as shown in the figure. The remaining ten input address lines from IA11–IA0 are connected to the address port of these blocks. The chip select (CS) is active high.



The input memory addresses (IA11–IA0), in decimal, for the starting locations (Addr=0) of each block (indicated as X1, X2, X3, X4 in the figure) are among the options given below. Which one of the following options is CORRECT?

A. (0, 1, 2, 3)

B. (0, 1024, 2048, 3072)

C. (0, 8, 16, 24)

D. (0, 0, 0, 0)

[MCQ - 2 Marks]

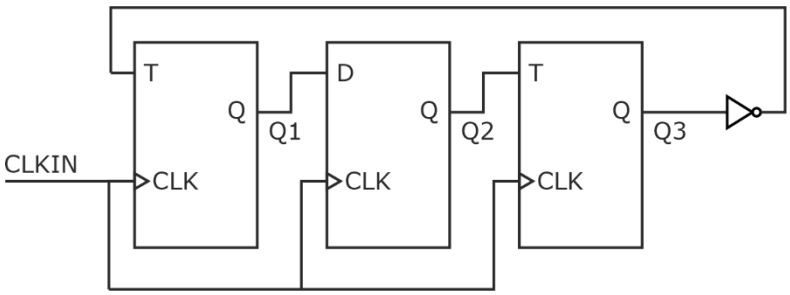
Ans. C

Sol. Only inputs A_4 and A_3 are used as decoder inputs when $A_4A_3 = 00$, then memory block X_1 will be selected, $A_4A_3 = 01$, then X_2 will be selected, $A_4A_3 = 10$ then X_3 selected, $A_4A_3 = 11$ then X_4 selected.

	A_{11}	A_{10}	A_9	A_8	A_7	A_6	A_5	A_4	A_3	A_2	A_1	A_0
X_1:	0	0	0	0	0	0	0	0	0	0	0	0
X_2:	0	0	0	0	0	0	0	0	1	0	0	0
X_3:	0	0	0	0	0	0	0	1	0	0	0	0
X_4:	0	0	0	0	0	0	0	1	1	0	0	0

So the values of X1, X2, X4 and X4 in decimal are (0, 8, 16, 24) respectively.

43. Consider a sequential digital circuit consisting of T flip-flops and D flip-flops as shown in the figure. CLKIN is the clock input to the circuit. At the beginning, Q1, Q2 and Q3 have values 0, 1 and 1, respectively.



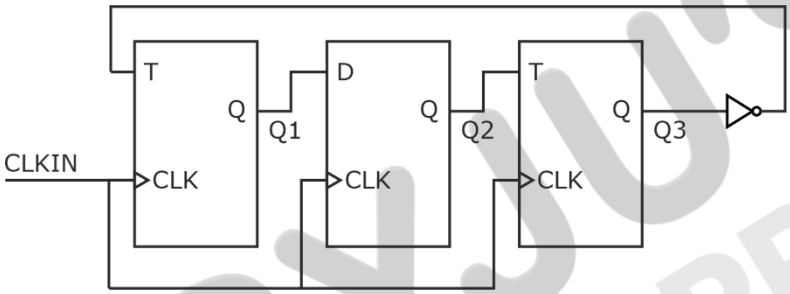
Which one of the given values of (Q1, Q2, Q3) can NEVER be obtained with this digital circuit?

A. (0, 0, 1)
B. (1, 0, 0)
C. (1, 0, 1)
D. (1, 1, 1)

[MCQ - 2 Marks]

Ans. A

Sol. (0,0,1)



Note $Q_2^+ = D = Q_1$

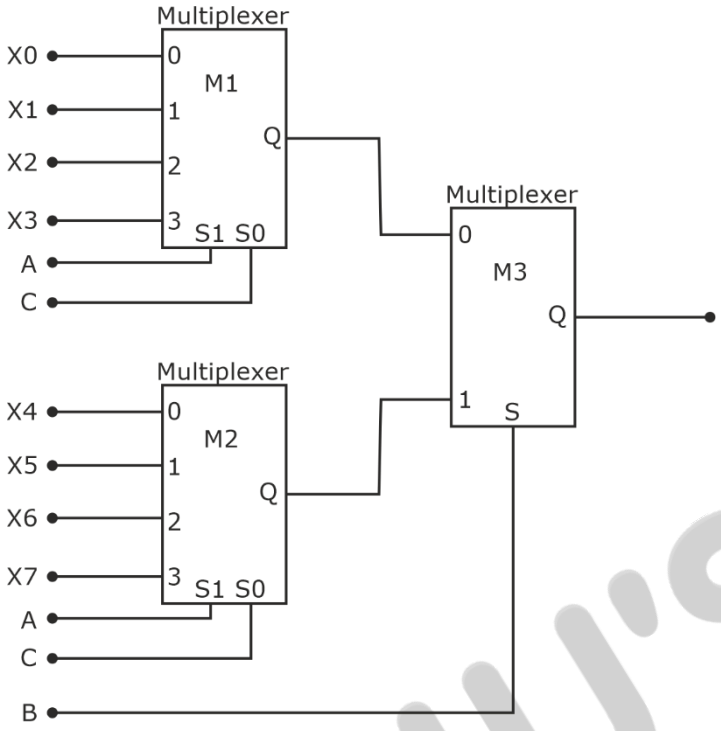
If $Q_3 = 0$ Toggle Q_1

If $Q_2 = 1$ Toggle Q_3

Q_1	Q_2	Q_3	
0	1	1	→ Initially
0	0	0	
1	0	0	
0	1	0	
1	0	1	
1	1	1	
1	1	0	
0	1	1	

So, (0, 0, 1) does not occur

44. A Boolean digital circuit is composed using two 4-input multiplexers (M1 and M2) and one 2-input multiplexer (M3) as shown in the figure. X0–X7 are the inputs of the multiplexers M1 and M2 and could be connected to either 0 or 1. The select lines of the multiplexers are connected to Boolean variables A, B and C as shown.



Which one of the following set of values of (X0, X1, X2, X3, X4, X5, X6, X7) will realise the Boolean function $\bar{A} + \bar{A}.\bar{C} + A.\bar{B}.C$?

A. (1, 1, 0, 0, 1, 1, 1, 0)

B. (1, 1, 0, 0, 1, 1, 0, 1)

C. (1, 1, 0, 1, 1, 1, 0, 0)

D. (0, 0, 1, 1, 0, 1, 1, 1)

[MCQ - 2 Marks]

Ans.

Sol. $\bar{A} + \bar{A}\bar{C} + A\bar{B}C$

$\bar{A}(1 + \bar{C}) + A\bar{B}C$

$\bar{A} + A\bar{B}C$

⇒ Consider MUX M_1, M_2 & M_3 with selection lines

$S_1 = A$, $S_0 = C$, $S = B$

	B	A	C		$Q(M_3)$
$\bar{A}$	0	0	0	X_0	1
$\bar{A}$	0	0	1	X_1	1
	0	1	0	X_2	0
$A\bar{B}C$	0	1	1	X_3	1
$\bar{A}$	1	0	0	X_4	1
$\bar{A}$	1	0	1	X_5	1
	1	1	0	X_6	0
	1	1	1	X_7	0

For $\bar{A}$ ⇒ X_0 X_1 X_4 X_4

For $A\bar{B}C \Rightarrow A = 1$

$B = 0 \Rightarrow X_3$

$C = 1$

So,

X_0	X_1	X_2	X_3	X_4	X_5	X_6	X_7
1	1	0	1	1	1	0	0

45. Consider the IEEE-754 single precision floating point numbers P=0xC1800000 and Q=0x3F5C2EF4.
Which one of the following corresponds to the product of these numbers (i.e., P × Q), represented in the IEEE-754 single precision format?

A. 0x404C2EF4

B. 0x405C2EF4

C. 0xC15C2EF4

D. 0xC14C2EF4

[MCQ - 2 Marks]

Ans. C

Sol. $P = 0\times C1800000$

$Q = 0\times 3F5C2EF4$

P:

1	100 00011	000 0000 0000 ....
S	BE	M
[–ve]	[131]	[0]

Data: $-(1.0) * 2^{131 - 127}$ [Bias = 127]

$-(1.0) * 2^{+4}$

Q:

0	01111110	10111000010111011110100
S	BE	M
[+ve]	[126]	

Data: $+(1.10111000010111011110100) * 2^{126 - 127}$

$\Rightarrow$ $+(1.10111000010111011110100) * 2^{-1}$

Product: [P * Q]

$S = (-ve) * (ve) -ve$

$AE = (+4) + (-1) + 3$

$M = (1.0)* (1.10111000010111011110100)$

$= 1.10111000010111011110100$

Storage:

1	10000010	10111000010111011110100

C 1 5 C 2 E F 4

Answer is $(C15C2EF4)_H$

46. Let A be a priority queue for maintaining a set of elements. Suppose A is implemented using a max-heap data structure. The operation Extract-Max(A) extracts and deletes the maximum element from A. The operation Insert(A,key) inserts a new element key in A. The properties of a max-heap are preserved at the end of each of these operations.

When A contains n elements, which one of the following statements about the worst case running time of these two operations is TRUE?

A. Both Extract-Max(A) and Insert(A,key) run in O(1).

B. Both Extract-Max(A) and Insert(A,key) run in O(log(n)).

C. Extract-Max(A) runs in O(1) whereas Insert(A,key) runs in O(n).

D. Extract-Max(A) runs in O(1) whereas Insert(A,key) runs in O(log(n)).

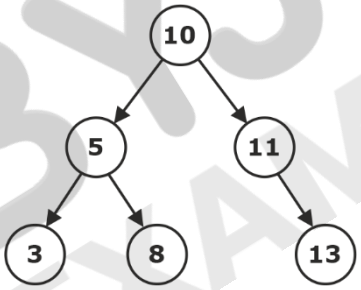
[MCQ - 2 Marks]

Ans. B

Sol. Extract-max (A): swap root element with last element and max heapify (root) → O(logn)

Insert (A, key): Insert and Heaping taken → O(logn)

47. Consider the C function foo and the binary tree shown.




```
typedef struct node {
  int val;
  struct node *left, *right;
} node;
int foo(node *p) {
  int retval;
  if (p == NULL)
    return 0;
  else {
    retval = p->val + foo(p->left) + foo(p->right);
    printf("%d ", retval);
    return retval;
  }
}
```

When foo is called with a pointer to the root node of the given binary tree, what will it print?

A. 3 8 5 13 11 10

B. 3 5 8 10 11 13

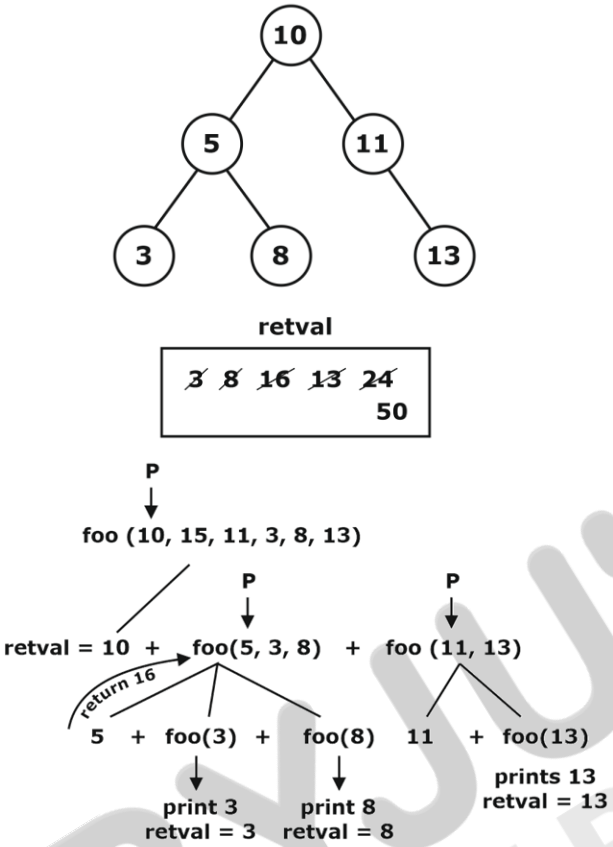
C. 3 8 16 13 24 50

D. 3 16 8 50 24 13

[MCQ - 2 Marks]

Ans. C

Sol.



foo(5, 3, 8) prints 16 retval = 16

foo (11, 13) prints 24 retval = 24

finally foo(10, 5, 11, 3, 8, 13) prints 10 + 16 + 24 = 60, retval = 50

Output: 3, 8, 16, 13, 24, 50

48. Let U = {1, 2,...,n}, where n is a large positive integer greater than 1000. Let k be a positive integer less than n. Let A, B be subsets of U with |A| = |B| = k and A ∩ B = ∅. We say that a permutation of U separates A from B if one of the following is true.

- All members of A appear in the permutation before any of the members of B.
- All members of B appear in the permutation before any of the members of A.

How many permutations of U separate A from B?

A. n!

B. $\binom{n}{2k}(n-2k)!$

C. $\binom{n}{2k}(n-2k)!\,(k!)^2$

D. $2\binom{n}{2k}(n-2k)!\,(k!)^2$

[MCQ - 2 Marks]

Ans. D

Sol.

Select 2K position for set A and B	Arrange remaining element	Select the set (A or B) whose element appear first	Arrange elements of first set in first K positions	Arrange element of second set in next K position
$\binom{n}{2K}$	(n – 2K)!	2	K!	K!

49. Let f : A → B be an onto (or surjective) function, where A and B are nonempty sets. Define an equivalence relation ~ on the set A as

$$a_1 \sim a_2 \text{ if } f(a_1) = f(a_2),$$

where $a_1, a_2 \in A$. Let $\varepsilon = \{[x] : x \in A\}$ be the set of all the equivalence classes under ~. Define a new mapping F : ε → B as

$$F([x]) = f(x), \text{ for all the equivalence classes } [x] \text{ in } \varepsilon.$$

Which of the following statements is/are TRUE?

A. F is NOT well-defined.

B. F is an onto (or surjective) function.

C. F is a one-to-one (or injective) function.

D. F is a bijective function.

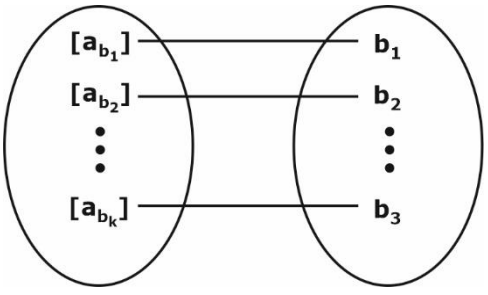
[MSQ - 2 Marks]

Ans. B, C, D

Sol. Let $A = \{a_1, a_2, \ldots, a_n\}$, $B = \{b_1, b_2, \ldots, b_k\}$. $(n \geq k)$. Since f : A → B is onto ⇒ function is 1 – 1 (or) many – 1. Let us denote the elements which are mapped to b_i as $[a_{b_i}]$.

⇒ $\varepsilon = \{[a_{b_1}], [a_{b_2}], \ldots [a_{b_2}]\}$

F : ε → B



Clearly F is 1 – 1 and onto ⇒ Bijection

50. Suppose you are asked to design a new reliable byte-stream transport protocol like TCP. This protocol, named `myTCP`, runs over a 100 Mbps network with Round Trip Time of 150 milliseconds and the maximum segment lifetime of 2 minutes.

Which of the following is/are valid lengths of the **Sequence Number** field in the `myTCP` header?

A. 30 bits

B. 32 bits

C. 34 bits

D. 36 bits

[MSQ - 2 Marks]

Ans. B, C, D

Sol. Bandwidth = 100 mbps

$\Rightarrow$ $100 \text{ mb} \rightarrow 1 \text{ sec}$

$120 \times 100 \text{ mb} \rightarrow 120 \text{ sec (2 mins)}$

$\Rightarrow$ $12000 \times 10^6 \text{ bits} \Rightarrow 2 \text{ mins}$

$\Rightarrow$ $\frac{12000 \times 10^6}{8} \text{ bytes} \rightarrow 2 \text{ mins}$

$\Rightarrow$ $1500 \text{ MB} \rightarrow 2 \text{ mins}$

$\Rightarrow$ $\log_2[1500 \times 10^6] = 30.4 \approx 31 \text{ bits}$

minimum 31 bits required $\Rightarrow$

B, C, D are correct option

51. Let X be a set and 2^X denote the powerset of X.

Define a binary operation Δ on 2^X as follows:

$$A \Delta B = (A - B) \cup (B - A) .$$

Let $H = (2^X, \Delta)$. Which of the following statements about H is/are correct?

A. H is a group.

B. Every element in H has an inverse, but H is NOT a group.

C. For every $A \in 2^X$, the inverse of A is the complement of A.

D. For every $A \in 2^X$, the inverse of A is A.

[MSQ - 2 Marks]

Ans. A, D

Sol. x-set 2^x - power set of x

$(2x - \Delta)$ Algebraic structure

1. Identity property

   φ is identity element since

   $A \Delta \varphi = A = \varphi \Delta A$

2. Inverse property

   Clearly for each A,

   $A \Delta A = \varphi = A \Delta A$

So, A is inverse of A

Hence, $(2^x - \Delta)$ is a group

∴ Option A and C are true.

52. Suppose in a web browser, you click on the www.gate-2023.in URL. The browser cache is empty. The IP address for this URL is not cached in your local host, so a DNS lookup is triggered (by the local DNS server deployed on your local host) over the 3-tier DNS hierarchy in an iterative mode. No resource records are cached anywhere across all DNS servers.

Let RTT denote the round trip time between your local host and DNS servers in the DNS hierarchy. The round trip time between the local host and the web server hosting www.gate-2023.in is also equal to RTT. The HTML file associated with the URL is small enough to have negligible transmission time and negligible rendering time by your web browser, which references 10 equally small objects on the same web server.

Which of the following statements is/are CORRECT about the minimum elapsed time between clicking on the URL and your browser fully rendering it?

A. 7 RTTs, in case of non-persistent HTTP with 5 parallel TCP connections.

B. 5 RTTs, in case of persistent HTTP with pipelining.

C. 9 RTTs, in case of non-persistent HTTP with 5 parallel TCP connections.

D. 6 RTTs, in case of persistent HTTP with pipelining.

[MSQ - 2 Marks]

Ans. A, D

Sol. Persistent mode

By default inpipelining

1 RTT for connection

1 RTT for sending 10 objects

1 RTT for closing connections

⇒ 3RTT

For iterative mode

1 RTT for ROOT

1 RTT for TOP domain

1 RTT for Authorative

⇒ 3 RTT

⇒ Total 6 RTT's required with pipelining

None persistance mode

5 parallel TCP connection

3 RTT ⇒ Iterative mode

2 RTT ⇒ connection

2 RTT ⇒ 5 TCP Parallel ⇒

7RTT's required in non persistent mode.

53. Consider a random experiment where two fair coins are tossed. Let A be the event that denotes HEAD on both the throws, B be the event that denotes HEAD on the first throw, and C be the event that denotes HEAD on the second throw.

Which of the following statements is/are TRUE?

A. A and B are independent.

B. A and C are independent.

C. B and C are independent.

D. Prob(B|C) = Prob(B)

[MSQ - 2 Marks]

Ans. C, D

Sol. When two coins tossed we have

Sample space S = [HH, HT, TH, TT]

P(A) = Probability of getting head in both toss = $\frac{1}{4}$

P(B) = Probability getting head on first toll = $\frac{2}{4}=\frac{1}{2}$

P(C) = Probability of getting head on second toss $=\frac{2}{4}=\frac{1}{2}$

$$P(A \cap B)=\frac{1}{4} \neq P(A)\cdot P(B)$$

∴ A and B are not independent.

$$P(B \cap C)=\frac{1}{4}=P(B)\cdot P(C)$$

∴ B and C are not independent.

$$P(A \cap C)=\frac{1}{4} \neq P(A)\cdot P(C)$$

∴ A, C are not independent.

$P(B|C)=P(B)$ is true

$$P(B|C)=\frac{P(B \cap C)}{P(C)}=\frac{\left(\frac{1}{4}\right)}{\frac{1}{2}}=\frac{1}{2}=P(B)$$

54. Consider functions **Function_1** and **Function_2** expressed in pseudocode as follows:

Function_1

```
while n > 1 do
    for i = 1 to n do
        x = x + 1;
    end for
    n = ⌊n/2⌋;
end while
```

Function_2

```
for i = 1 to 100 * n do
    x = x + 1;
end for
```

Let $f_1(n)$ and $f_2(n)$ denote the number of times the statement "x = x + 1" is executed in **Function_ 1** and **Function_2**, respectively.

Which of the following statements is/are TRUE?

A. $f_1(n) \in \Theta(f_2(n))$

B. $f_1(n) \in o(f_2(n))$

C. $f_1(n) \in \omega(f_2(n))$

D. $f_1(n) \in O(n)$

[MSQ - 2 Marks]

Ans. A, D

Sol. while (n>1)

for (1 = 1 to $\overset{\downarrow}{n}$)

$x = x + 1$

end for

$n = \left\lfloor \frac{n}{2} \right\rfloor$

and while

Let $\frac{n}{2^k} = 1$

$$f1 \quad n + \frac{n}{2} + \frac{n}{2^2} + \ldots + \frac{n}{2^k} - 1$$

$$= n\left(1 + \frac{1}{2} + \frac{1}{2^2} + \ldots + \frac{1}{2^{K-1}}\right)$$

$$= n\frac{\left(1 - \frac{1}{2K}\right)}{1 - \frac{1}{2}} = 2n\left(1 - \frac{1}{n}\right) = 2n - 2$$

$f1 = O(n)$

$f2 = O(n)$

A. f1 = 0(f2) true

B. f2 = Θ(f2) true

C. f1 = w(f2) false

D. f1 = 0(f2) false

55. Let G be a simple, finite, undirected graph with vertex set $\{v_1,...,v_n\}$. Let $\Delta(G)$ denote the maximum degree of G and let $\mathbb{N} = \{1, 2,...\}$ denote the set of all possible colors. Color the vertices of G using the following greedy strategy:

for i = 1,...,n

$$\text{color}(v_i) \leftarrow \min\{j \in \mathbb{N} : \text{no neighbour of } v_i \text{ is colored } j\}$$

Which of the following statements is/are TRUE?

A. This procedure results in a proper vertex coloring of G.

B. The number of colors used is at most $\Delta(G) + 1$.

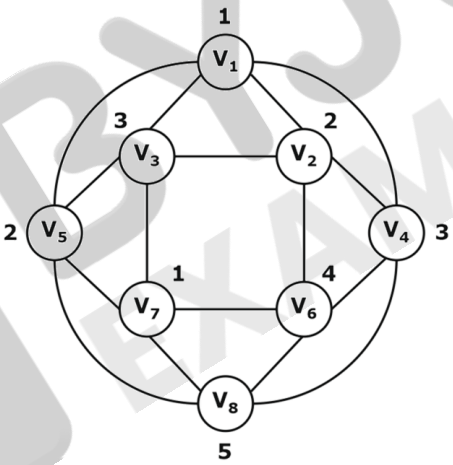
C. The number of colors used is at most $\Delta(G)$.

D. The number of colors used is equal to the chromatic number of G.

[MSQ - 2 Marks]

Ans. A, B

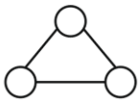
Sol.



but 5 not chromatic No

(d) false

(b) No. of colors used 4 max degree – 1 (true)



(c) false

(a) procedure results in proper vertex coloring

⇒ True

(It will not give optimum solution)

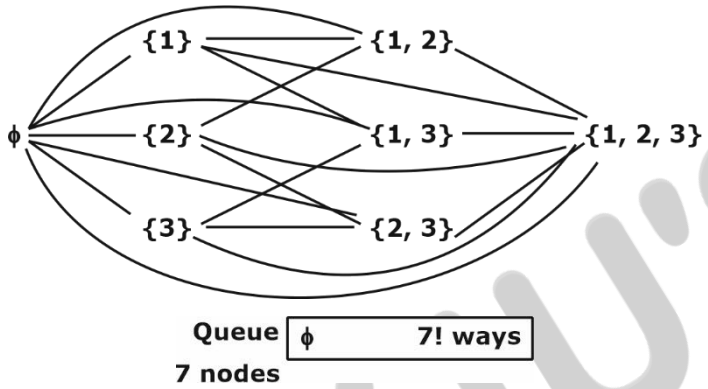
56. Let U = {1, 2, 3}. Let 2^U denote the powerset of U. Consider an undirected graph G whose vertex set is 2^U. For any A, B $\in 2^U$, (A, B) is an edge in G if and only if (i) A ≠ B, and (ii) either A ⊊ B or B ⊊ A. For any vertex A in G, the set of all possible orderings in which the vertices of G can be visited in a Breadth First Search (BFS) starting from A is denoted by B(A).

If ∅ denotes the empty set, then the cardinality of B(∅) is _____.

[MSQ - 2 Marks]

Ans. 5040

Sol.



BFS{ϕ} Since all other nodes are adjacent to ϕ. They can be inserted into queue in 7! Ways.

57. Consider the following two-dimensional array `D` in the C programming language, which is stored in row-major order:

```
int D[128][128];
```

Demand paging is used for allocating memory and each physical page frame holds 512 elements of the array `D`. The Least Recently Used (LRU) page-replacement policy is used by the operating system. A total of 30 physical page frames are allocated to a process which executes the following code snippet:

```
for (int i = 0; i < 128; i++)
   for (int j = 0; j < 128; j++)
        D[j][i] *= 10;
```

The number of page faults generated during the execution of this code snippet is _____.

[NAT - 2 Marks]

Ans. 4096

Sol. Given that, 1 frame hold 512 Element,

Array size is 128 × 128 = 2^{14} elements.

Hence, to hold array Total $\frac{2^{14}}{2^9} = 2^5$ frames = 32 frames needed,

But, Given 30 frames only allocated to process, So, replacement occurs

1 frame can hold 512 elements ⇒ 4 rows.

Array is accessed column wise in the given code.

So, For each row, 1 fault occur initially.

D[0][0] fault ⇒ copy D[0][0] - [0] [127]

D[1][0] – [1][127]

D[2][0] – [2] [127]

D[3][0] – [3] [127] in a frame.

So, for 4 rows 1 fault.

But, as Array need Extra 2 frames they keep replacing frames in LRU order.

So, Total faults = Number of frames required for array * Number of columns.

$= 32 \times 128$

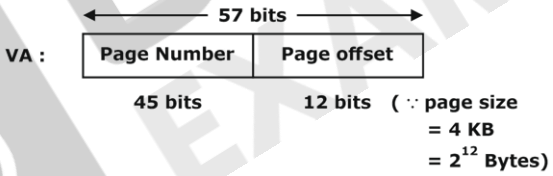
$= 2^5 \times 2^7 = 4096$

58. Consider a computer system with 57-bit virtual addressing using multi-level tree-structured page tables with L levels for virtual to physical address translation.
The page size is 4 KB (1 KB = 1024 B) and a page table entry at any of the levels occupies 8 bytes.
The value of L is _____.

[NAT – 2 Marks]

Ans. 5

Sol.



- Page table size

  = No. of PTE's * PTE size

  $= 2^{45} * 8$ bytes $= 2^{48}$ bytes …(1)

- To store 2^{48} bytes page table, No. of pages required = $\frac{2^{48}B}{2^{12}B} = 2^{36}$

  2^{36} pages, page table size

  $= 2^{36}$ PTE's * 8 bytes

  $= 2^{39}$ bytes …(2)

- To store 2^{39} bytes table, page required

  $= \frac{2^{39}\text{bytes}}{2^{12}\text{bytes}} = 2^{27}$

  2^{27} pages, page table size

  = 227 PTE's * 8 bytes

  = 230 bytes …(3)

- 2^{30} bytes table is divided into $\frac{2^{30}}{2^{12}} = 2^{18}$ Pages.
- 2^{18} pages, page table size = 2^{18} PTE's * 8 bytes = 2^{21} bytes …(4)
- 2^{21} bytes table is divided into $\frac{2^{21}}{2^{12}} = 2^{9}$ pages.

  2^{9} pages, page table size = 29 * 8 bytes = 2^{12} bytes …(5)

Hence, It can be stored in one frame of main memory.

So, number of levels of paging, L = 5

59. Consider a sequence a of elements $a_0 = 1$, $a_1 = 5$, $a_2 = 7$, $a_3 = 8$, $a_4 = 9$, and $a_5 = 2$. The following operations are performed on a stack S and a queue Q, both of which are initially empty.

I: push the elements of a from a_0 to a_5 in that order into S.
II: enqueue the elements of a from a_0 to a_5 in that order into Q.
III: pop an element from S.
IV: dequeue an element from Q.
V: pop an element from S.
VI: dequeue an element from Q.
VII: dequeue an element from Q and push the same element into S.
VIII: Repeat operation VII three times.
IX: pop an element from S.
X: pop an element from S.

The top element of S after executing the above operations is _____.

[NAT - 2 Marks]

Ans. 8

Sol. Given a sequence of element 1, 5, 7, 8, 9, 2.

According to the question the following operation are performed as follows:

I.

2
9
8
7
5
1

Stack S

II.

1	5	7	8	9	2

Queue Q

III.

9
8
7
5
1

Pop 2

IV.

	5	7	8	9	2

Queue Q Dequeue 1

V. Pop 9

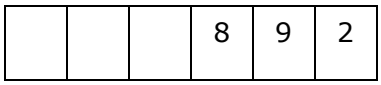
8
7
5
1

VI.

		7	8	9	2

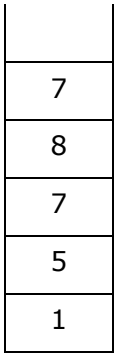
Queue Q Dequeue 5

VII.



Queue Q

Dequeue 7

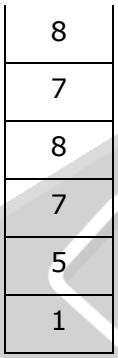


Stack S

VIII.

Queue Q

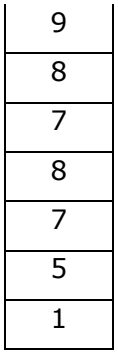
Dequeue 8



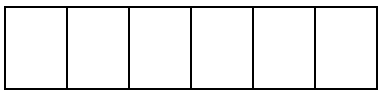
Stack S

Queue Q

Dequeue 9



Stack S



Queue Q

Dequeue 2

2
9
8
7
8
7
5
1

Stack S

IX. Pop 2

9
8
7
8
7
5
1

Stack S

X. Pop 9

8
7
8
7
5
1

So, the top of stack is 8.

60. Consider the syntax directed translation given by the following grammar and semantic rules. Here N, I, F and B are non-terminals. N is the starting non-terminal, and #, **0** and **1** are lexical tokens corresponding to input letters "#", "0" and "1", respectively. X.val denotes the synthesized attribute (a numeric value) associated with a non-terminal X. I_1 and F_1 denote occurrences of I and F on the right hand side of a production, respectively. For the tokens **0** and **1**, **0**.val = 0 and **1**.val = 1.

$N \rightarrow I \ \# \ F$	N.val = I.val + F.val
$I \rightarrow I_1 \ B$	I.val = (2 I_1.val) + B.val
$I \rightarrow B$	I.val = B.val
$F \rightarrow B \ F_1$	F.val = $\frac{1}{2}$(B.val + F_1.val)
$F \rightarrow B$	F.val = $\frac{1}{2}$ B.val
$B \rightarrow 0$	B.val = 0.val
$B \rightarrow 1$	B.val = 1.val

The value computed by the translation scheme for the input string

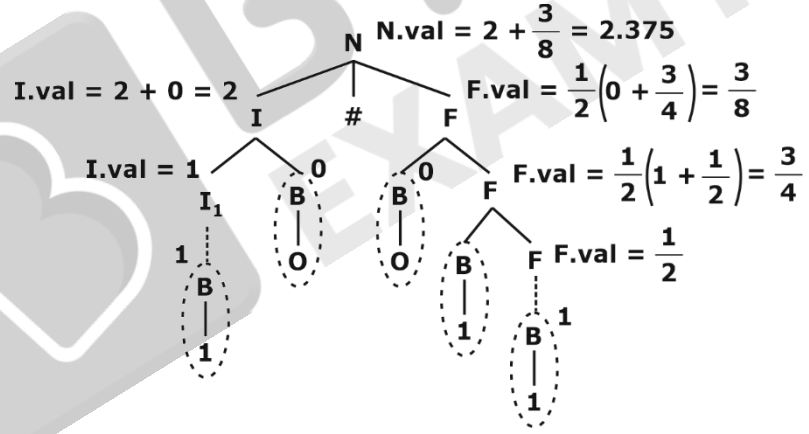
10#011

is _____. (Rounded off to three decimal places)

[NAT - 2 Marks]

Ans. 2.375

Sol. The tree for the following sequence is as follows:



So, the answer is 2.375.

61. Consider the following table named Student in a relational database. The primary key of this table is rollNum.

Student

rollNum	name	gender	marks
1	Naman	M	62
2	Aliya	F	70
3	Aliya	F	80
4	James	M	82
5	Swati	F	65

The SQL query below is executed on this database.

```
SELECT *
FROM Student
WHERE gender = 'F' AND
      marks > 65;
```

The number of rows returned by the query is _____.

[NAT - 2 Marks]

Ans. 2

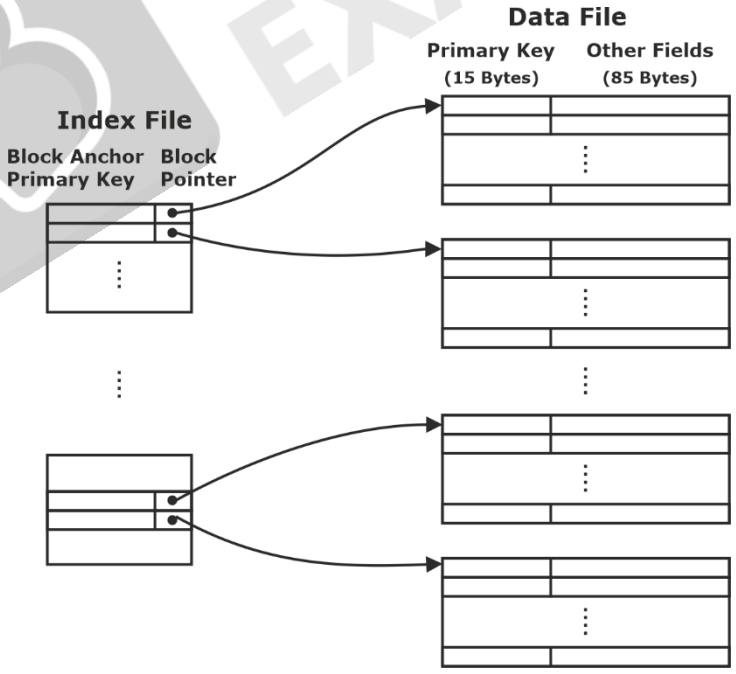
Sol. The above query finds the total tuples (records)of female students who are elder than 65 in age.

Student

rollNum	name	gender	marks	
1	Naman	M	62	✗
2	Aliya	F	70	✓
3	Aliya	F	80	✓
4	James	M	82	✗
5	Swati	F	65	✗

2 Tuples in result.

62. Consider a database of fixed-length records, stored as an ordered file. The database has 25,000 records, with each record being 100 bytes, of which the primary key occupies 15 bytes. The data file is block-aligned in that each data record is fully contained within a block. The database is indexed by a primary index file, which is also stored as a block-aligned ordered file. The figure below depicts this indexing scheme.



Suppose the block size of the file system is 1024 bytes, and a pointer to a block occupies 5 bytes. The system uses binary search on the index file to search for a record with a given key. You may assume that a binary search on an index file of b blocks takes $\lceil \log_2 b \rceil$ block accesses in the worst case.

Given a key, the number of block accesses required to identify the block in the data file that may contain a record with the key, in the worst case, is _____.

[NAT - 2 Marks]

Ans. 7

Sol. Given,

Number of records = 25000

Block size = 1024 Byte

Key size = 15 Byte

Block pointer size = 5 Byte

Record size = 100 Byte

Index entry size = 15 + 5 = 20 Byte

Number of records per block $= \left\lfloor \frac{1024}{100} \right\rfloor$

$\lfloor 10.24 \rfloor = 10$

Total data blocks required $= \left\lceil \frac{25000}{10} \right\rceil$

= 2500

Number of index entries per block $= \left\lfloor \frac{1024}{20} \right\rfloor = \lfloor 51.2 \rfloor$

= 51

Total index blocks required $= \left\lceil \frac{\text{Total data blocks}}{\text{Total index entries}} \right\rceil = \left\lceil \frac{2500}{51} \right\rceil = \lceil 49.01 \rceil$

= 50

Total blocks required to access for searching a record using primary key $\lceil \log_2 50 \rceil + 1$

(∴ Records are sequential so binary search is used)

= 6 + 1

= 7

63. Consider the language L over the alphabet {0, 1}, given below:

$$L = \{w \in \{0, 1\}^* \mid w \text{ does not contain three or more consecutive 1's}\}.$$

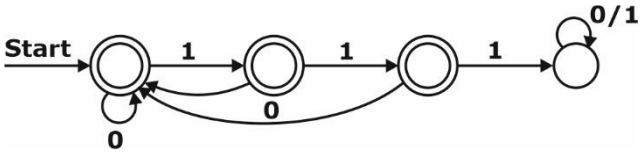
The minimum number of states in a Deterministic Finite-State Automaton (DFA) for L is _____.

[NAT - 2 Marks]

Ans. 4

Sol. Assume S = {0, 1}

String do not contain 111 sequence,



Total states = 4 maximum

64. An 8-way set associative cache of size 64 KB (1 KB = 1024 bytes) is used in a system with 32-bit address. The address is sub-divided into TAG, INDEX, and BLOCK OFFSET.

The number of bits in the TAG is _____.

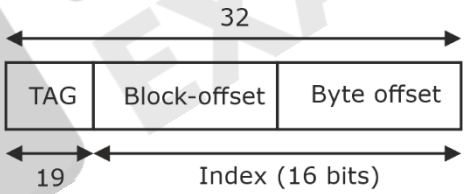
[NAT - 2 Marks]

Ans. 19

Sol. Cache size = 64 KB = 2^{16} bytes

8-way set associative memory contains eight blocks per set.

Let us assume direct mapping is considered then,



Number of bits of TAG is set-associative mapping is more than direct mapping. For 2^n-way set associative, it is n-bits more. So for 8-way set associative, it is 3-bits more.

Total = 16 + 3 = 19 bits

65. The forwarding table of a router is shown below.

Subnet Number	Subnet Mask	Interface ID
200.150.0.0	255.255.0.0	1
200.150.64.0	255.255.224.0	2
200.150.68.0	255.255.255.0	3
200.150.68.64	255.255.255.224	4
Default		0

A packet addressed to a destination address 200.150.68.118 arrives at the router.

It will be forwarded to the interface with ID _____.

[NAT - 2 Marks]

Ans. 3

Sol.

200 • 150 • 68 • 118

1. 225 • 255 • 0 • 0
   200 • 150 • 0 • 0 (Matched)

200 • 150 • 68 • 118

2. 225 • 255 • 224 • 0
   200 • 150 • 64 • 0 (Matched)

200 • 150 • 68 • 118

3. 225 • 255 • 255 • 0
   200 • 150 • 68 • 0 (Matched)

4th entry is not matched with the subnet number. So Interface 3 is used as it is more specific subnet.

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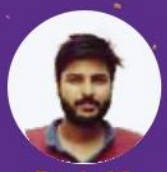

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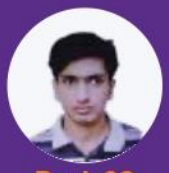
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