MADE EASY

GATE 2023

COMPUTER SCIENCE & IT

Questions &Solutions

GENERAL APTITUDE

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

(a) near (b) nearly

(c) utterly (d) mostly

Ans. **(b)**

Q.2 Kind : ____ : : Often : Frequently

(By word meaning)

(a) Mean (b) Type

(c) Cruel (d) Kindly

Ans. **(b)**

Q.3 A series of natural numbers $F_1, F_2, F_3, F_4, F_5, F_6, F_7, \ldots$ beys $Fn_{+1} = Fn + Fn_{+1}$ for all integers n :c:: 2.

If $F_6 = 37$, and $F_7 = 60$, then what is $F/$

(a) 4 (b) 5

(c) 8 (d) 9

Ans. **(a)**

$Fn_{+1} = Fn + Fn_{+1}$ V n :c:: 2

$F_{n-1} = F_{n+1} - F_n$

For $n = 6$,

$F_s = F_7 - F_6$

= 60 - 37 (∵ Given that $F_7 =$ 60, $F_6 = 37$)

= 23

For $n = 5$, For $n = 4$, For $n = 3$,

$F4 = F6 - F5$

For $n = 2$,

= 37 - 23 = 14

$F3 = Fs - F4$

= 23 - 14 = 9

$F2 = F4 - F3$

= 14 - 9 = 5

$F1 = F3 - F2$

=9-5=4

$F_1 = 4$

Q.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.

Ans. **(a)**

Q.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.

Ans. **(c)**

Q.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.

Ans. **(d)**

Q.7 Consider two functions of time (t),

$t(t) = o.01t^2$

$g(t) = 4t$

where $O < t < \infty$.

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

Ans. **(c)**

$f(t) = o.01t^2$

$g(t) = 4t$

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

For example if $t = 1$, $g(t) = 4$, $f(t) = 0.01$

$g(t) > f(t)$ for some $t = 1$

(ii) There exist $T = 400$ such that $f(t) > g(t)$ $Vt > 400$ so it is true.

Q.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)

Ans. **(d)**

Q.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

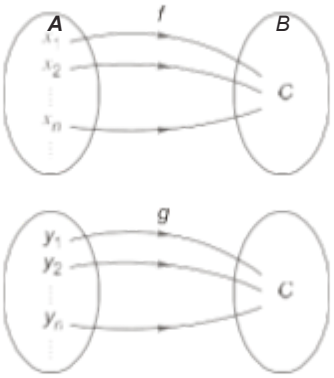
(c) $f(x) \neq$ constant and $g(y) \neq$ constant

(d) $f(x) + g(y) = f(x) - g(y)$

Ans. **(b)**

Given that $f(x) = g(y)$ for all real value of x and y it is necessary that image of 'x' under f is same as image of 'y' is same as image of 'y' using 'g' for all real values of x and y

i.e. $f(x) = g(y) =$ Constant



$f(x) = g(y)\ \forall x, y \in R$

Q.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 go° 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 goQabout an axis perpendicular to the plane of the figure
Operation 2: A reflection along a horizontal line

(c) Operation 1: A clockwise rotation by go° 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 180° about an axis perpendicular to the plane of the figure
Operation 2: A reflection along a vertical line

Ans. **(a)**

■■■■

TECHNICAL

Q.1 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.

Ans. (b)

Front end of a compiler in dependent on programming language and independent on target machine, where as back end is dependent on target machine and independent on programming language.

Hence S1 and S2 are true.

Q.2 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

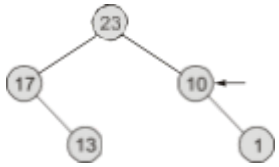
(b) 23, 17, 14, 7, 13, 10, 1, 5, 6, 12

(c) 23, 17, 14, 6, 13, 10, 1, 5, 7, 15

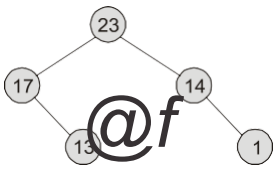
(d) 23, 14, 17, 1, 10, 13, 16, 12, 7, 5

Ans. (b)

(a)

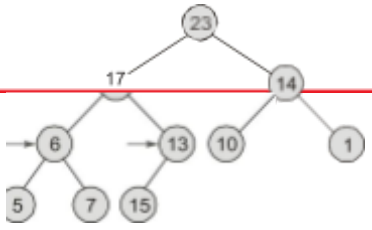


(b)



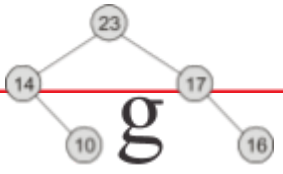
Not max heap

(c)



Max heap

(d)



G)

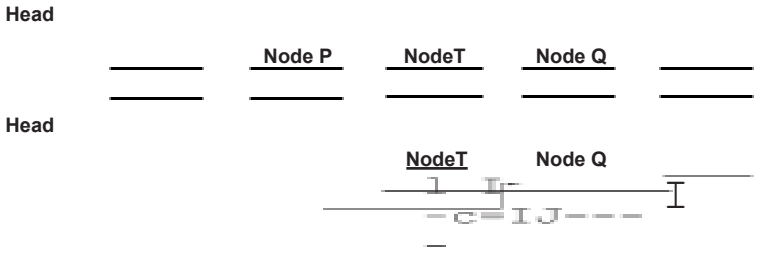
Not max heap

Not max heap

Q.3 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 **0(1)** and DLLdel is ***0(n)***
(b) Both SLLdel and DLLdel are 0(log(n))
(c) Both SLLdel and DLLdel are **0(1)**
(d) SLLdel is ***0(n)*** and DLLdel is **0(1)**

Ans. (d)

For deletion of any node, the pointers are rearranged so that this node is logically removed from the list. To physically remove the node and return and memory occupied by it to the pool of available memory we will use the free( ).
We will take a pointer variable tmp which will point to the node being deleted so that after the pointers have been altered we will still have address of that node in tmp to free it.
So traditionally deletion a node from singly linked list will take *0(n)* and doubly linked list takes 0(1).
Suppose node T is to be deleted and pointer tmp points to it in singly linked list.

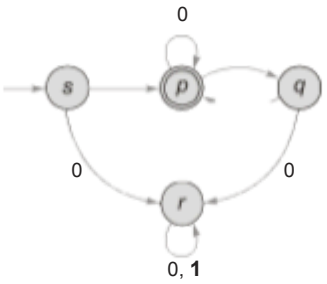



```
    P = head
while (P      link! = NULL)
(
    if (P      link      data =    = tmp      data)
    {
        P      link  = tmp       link;
        ree (tmp)
        eturn head;

    P = P       link;
```

The value to be deleted is in node T, and we need a pointer to its predecessor which is node P, in worst case for traversing list takes in *0(n)* in singly linked list where as in Doubly linked list it takes 0(1) as there is no necessity of traversing list.

Q.4 Consider the Deterministic Finite-state Automaton (DFA) A shown below. The DFA runs on the alphabet I0, 1I, and has the set of states *Is, p, q, rI,* with s being the start state and *p* being the only final state.



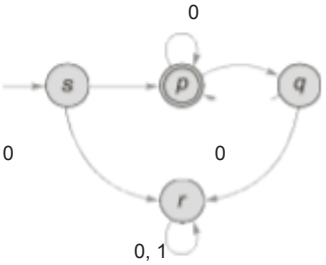
Which one of the following regular expressions correctly describes the language accepted by *A?*

(a) 1(0*11)*
(b) 0(0 + 1)*
(c) 1(0 + 11)*
(d) 1(110*)*

Ans. **(c)**

s is initial state and *p* is final state

From the given transition diagram,



S=E

$p = s1 + p0 + q^1$

$q = p1$

Substituting *s* and *q* in *p*

$p = E\,1 + p0 + p11$

$p = 1 + p(0 + 11)$

$p = 1(0 + 11)^*$ (Using Arden's theorem)

Q.5 The Lucas sequence *Ln* is defined by the recurrence relation:

$Ln = Ln_{-1} + Ln_{-2}$, for $n :::: 3$, with

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

Which one of the options given is TRUE?

(a) *L* =(1+ SY+(1- SY *n\2)* *\2)*

(b) *L* =(1+ SY _(1- SY *n\2)* *\3)*

(c) *L* =(1+ SY+(1- SY *n\2)* *\3)*

(d) *L* =(1+ SY _(1- SY *n\2)* *\2)*

Ans. **(a)**

Given that *Ln* = $Ln_{-1} + Ln_{-2}$ for $n :::: 3$

By replacing *'n'* by *(n* + 2)

we have

Ln+ 2- *Ln*+ 1- *Ln* = O

Characteristics

equation for equation (*) is 12-t-1=0 ...(*)

Characteristics roots are $t = -\frac{1}{2} \pm \frac{\sqrt{3}}{2}j$

Complementary functions $= C_1 t_1^n + C_2 t_2^n$

$$L_n = C\left(1+\frac{\sqrt{3}}{2}j\right)^n + C\left(1-\frac{\sqrt{3}}{2}j\right)^n \quad \ldots(i)$$

Put $n = 1$,

$$1 = C\left(1+\frac{\sqrt{3}}{2}j\right) + C\left(1-\frac{\sqrt{3}}{2}j\right) \quad \ldots(ii)$$

Put $n = 2$,

$$3 = C\left(1+\frac{\sqrt{3}}{2}j\right)^2 + C\left(1-\frac{\sqrt{3}}{2}j\right)^2$$

By solving equation (i) and (ii) we get, $C_1 = 1$, $C_2 = 1$

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

Another approach (Substitution method)

Put $n = 1$, $n = 2$ and eliminate option (b), (c), (d) then correct answer is option (a).

For For $n = 1$, we have $L_1 = 1$

$n = 2$, we have $L_2 = 3$ in option (a)

Q.6 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.

Ans. **(a)**

Arity: Number of attributes of the relational table.

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Q.7 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

Ans. **(a)**

As propagation time is in denominator in expression and it is (1/v). So when length or distance is larger, denominator is more, so overall value will be less transmission

rate I s $\frac{\text{(Data size)}}{t\text{- }t + 2p\cdot t}$.

So when data size is less, transmission rate is less, link utilization is less. Option (a) is answer.

0.8 Let and *A* r:::; Ld *8* ; ;1

I2 3 4 1J 2 3 4 1J

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)

Ans. **(b)**

2 3
1 2
4
3 4

li ;J

3 4

$A=$ 4 1 2 ;1
1 2 3
2 3 4

$B=$

By interchanging R_1, R_3 of A, we get

f3 4 1 21

$A=-$ 4 1 2 3
1 2 3 4
L2 3 4 1J

det(B) = -det(A)

Q.9 Consider the following definition of a lexical token id for an identifier in a programming language, using extended regular expressions:

letter digit id
[A - Za - a]
[0 - 9]
letter (letter I digit)*

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

(a) tt letter digit

E

E ,.,0)1etter

(b) -Q letter

E

digit

E

-Q _letter

(c)

,.,o letter .,.,0 E E

E digit E

E

(d) -Q letter .,.,Q letter .,.0 digit

Ans. **(c)**

Identifier is minimum one letter followed by any combination of letter or digit. Therefore option (c) is correct.

Q.10 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 $h(k) = k \bmod m$.

(b) Multiplication method, i.e., use the hash function $h(k) = Lm(kA - LkAJ)J$, 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.

Ans. **(c)**

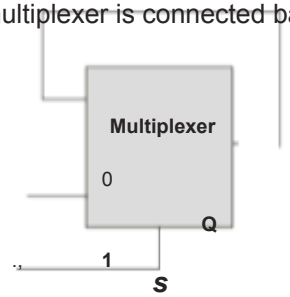
The adversary is malicious who tries to maximize the number of collisions by choosing keys that all hash to the same slot. In such case, consider a finite collection *Hof* hash functions that maps universe *U* of keys into {0, 1, 2, 3, ... *m* - 1}.

His such function called universal if for each pair of keys *k, I,* ∈ *U* where *k* * 1, the

number of hash functions *h* ∈ *H* for which *h(k)* = *h(l)* is less than or equal to $\frac{|H|}{m}$

The otherwords, with a hash function 'h' chosen randomly from *H,* the probability of collision between two different keys is no more than $\frac{1}{m}$. The chance of collision when choosing two slots randomly and independently.

Q.11 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) *0* Flip-flop (b) *0* Latch

(c) Half-adder (d) Demultiplexer

Ans. **(b)**

Output of 2 : 1 MUX O/P = $51_0 + S1_1$

If *S* = 0 O/P = 1_0

No change in the O/P If

S = 1 O/P = ***X***

O/P is same as the input.

Operation is similar to *O* latch.

∴ Answer (b).

Q.12 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

Ans. **(b, c, d)**

Stacks and registers cannot be shared between threads, so they must change. Program counter has to be changed definitely.

Q.13 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

Ans. **(c, d)**

Page fault and system call required to change mode but others may not required.

Q.14 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.

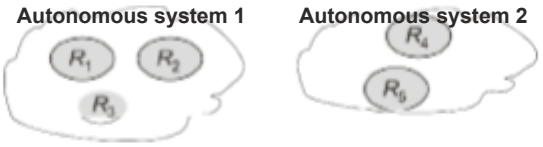
Ans. **(a, c, d)**

Regular, recursive and recursively enumerable languages are closed under intersection but context free languages are not closed under intersection.

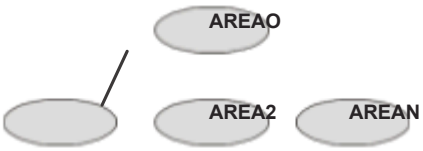
Q.15 Which of the following statements is/are INCORRECT about the OSPF (Open Shortest Path First) routing protocol used in the Internet?

(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.

Ans. **(a, c)**



Router in one autonomous system is transmitting data to router in same autonomous system is known as intra domain routing protocol. Ospf is intra domain protocol.



OSPF supports hierarchical routing.

Q.16 Geetha has a conjecture about integers, which is of the form *Vx(P(x) :lyCXx,y))*, 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) :lx(P(x) A *VyQ(x,y))* (b) *\ix\iyO(x,y)*

(c) *:lyVx(P(x) Q(x,y))* (d) :lx(P(x) A *:lyCXx,y))*

Ans. **(b, c)**

(a) *:lx(P(x) A VyQ(x,y))* *(Vx(P(x) :lyCXx,y)))* is false whenever *:lx(P(x) A VyCXx,y))* is true it does not guarantee that *Vx(P(x) :lyCXx,y))* is true.

(b) *\ix\iyO(x,y)* *(vx(P(x) :lyO(x,y))* is true whenever *\ix\:/yO(x,y)* is true then *Vx(P(x) :lyCXx,y))* is true irrespective of *P(x).*

(c) *:lyVx(P(x) CXx,y))* *Vx(P(x) :lyCXx,y))* is true whenever *:lyVx(P(x)Q(x,y))* is true for some fixed *'y'* then *Vx(P(x) :lyCXx,y))* is also true.

(d) *:lx(P(x) A :lyCXx,y))* *Vx(P(x) :lyCXx,y))* is false for some *'x'* if *:lx(P(x) A :ly Q(x,y))* is true it does not guarantee that *Vx(P(x) :lyCXx,y))* is true.

Q.17 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

Ans. (c)

Priority scheduling and SJF will cause starvation.

PS

[redacted]

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Q.18 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.

Ans. **(b, d)**

$$f(x) = x^3 + 15x^2 - 33x - 36$$
$$f(x) = 3x^2 + 30x - 33$$
$$f''(x) = 6x + 30$$

Let, $f(x) = 0$

$3x^2 + 30x - 33 = 0$ $x^2 + 10x - 11 = 0$ $(x + 11)(x - 1) = 0$

$x=1,\ x=-11$

At $x = 1$, $f''(x) = 36 > 0$

At $x = 11$, $f''(x) = -36 < 0$

$f(x)$ has local maximum

$f(x)$ has local minimum

Q.19 Let f and g be functions of natural numbers given by $f(n) = n$ and $g(n) = n2$.
Which of the following statements is/are TRUE?
(a) $f \in O(g)$ (b) $f \in Q(g)$
(c) $f \in o(g)$ (d) $f \in 0(g)$

Ans. (a, c)

$f(n) \in O(g(n))$ iff $f(n)$ asymptotically smaller or equal to $g(n)$ $f(n) \in o(g(n))$ iff $f(n)$ asymptotically smaller than $g(n)$

Given, $f(n) = n,\ g(n) = n^2$

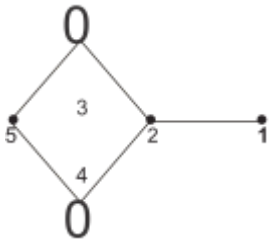
$n \in O(n^2)$

$n \in Q(n^2)$ x

$n \in o(n^2)$

$n \in 0(n^2)$ x

Q.20 Let *A* be the adjacency matrix of the graph with vertices {1, 2, 3, 4, 51.



Let 1,.,1, 1,.,2, 1,.,3, 1,.,4 and 1,.,5 be the five eigenvalues of A Note that these eigenvalues need not be distinct.

The value of A-1 + A-2 + *1,.,3* + 1,.,4 + "'s = ----

Ans. **(2)**

$$A = \begin{array}{c|cccc} & 2 & 3 & 4 & 5 \\ 1 & 1 & & & \\ 2 & & 0 & & \\ 3 & & & 0 & \\ 4 & & & & 0 \\ 5 & & & & & 1 \end{array}$$

Sum of eigen values *(A)*= Trace of *A*

"'1 + A-2 + *1,.,3* + 1,.,4 + 1,.,5 = 1 + 0 + 0 + 0 + 1 = 2

Do not need to consider non-diagonal elements of A

Q.21 The value of the definite integral $\int_{-3}^{3}\int_{2}^{2}\int_{1}^{1} (4x^2y-i3)dzdydx$ is _____ . (Rounded off to the nearest integer)

Ans. **(0)**

$$\int_{-3}^{3}\int_{2}^{2}\int_{1}^{1} (4x^2y-i3)dzdydx$$

$$\int_{x=-3}^{x=3}\int_{y=2}^{y=2}\int_{Z=1}^{Z=1} (4x^2y-z^3)dzdydx$$

$$\int_{-3}^{3}\int_{2}^{2}\{[4x^2yzf \quad 1\, dydx-o\} \qquad {}_3\mathrm{I}8x2y2\mathrm{i}2$$

$$\int_{-3}^{3}\int_{2}^{2} 8x^2ydydx$$

{ *i3* = odd function}

$$\int_{-3L}^{z} f \, dx = O$$

Q.22 A particular number is written as 132 in radix-4 representation. The same number in radix- 5 representation is _ _

Ans. **(110)**

If $(132)_4 = (X)_5$

$(30)_{10} = (110)_5$

$X = 110$

Q.23 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.

Ans. **(2040)**

$k = 3$

$t_P = \max(10, 20, 14)$ ns

$= 20$ ns

$ET_{pipe} = (k + n - 1)\, t_P$

$= (3 + 100 - 1)\, 20$ ns

$= 2040$ ns

Q.24 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)

Ans. **(10.2)**

10 ms — **1 poll**

1 sec — ? **Number of polls generated**

i.e. $\frac{1 \text{ sec}}{10 \text{ ms}} = \frac{1000 \text{ ms}}{10 \text{ ms}} = 100$

polling time = 100 µsec

So, total polling time in 1 sec is

= 100 x 100 µsec = 10000 µsec

Service time if stroke occurred = 200 μsec

Total time to service the keyboard stroke is 10200 μsec

Fraction of time consumed for polling (T_1) = $\left[\frac{10200\ \mu sec}{1000000\ \mu sec}\right] \times 100 = 1.02$

Interrupt:

Interrupt time (CPU time) = 1 sec = 1000 ms

Interrupt processing time 1 ms

Fraction of time consumed for interrupt (T) = $\left[\frac{1\ ms}{1000\ ms}\right] \times 100 = 0.1$

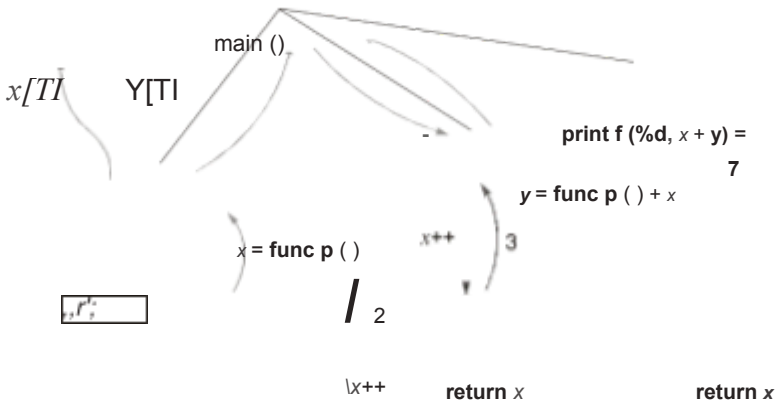
T_1 1.02 10.2

T_2 0.1

Q.25 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;
```

Ans. **(7)**



Whenever funcp called first time then local static variable 'x' of funcp updated to 2 and same value stored in main function variable 'x, hence 'x becomes 2 in main( )

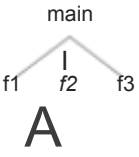
Whenever funcp called second time then local static variable 'x of funcp updated to 3

and y value of main function becomes 5, hence printf statement will point answer is 7.

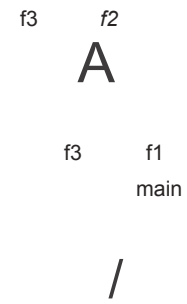
Q.26 Consider the following program:

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

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)

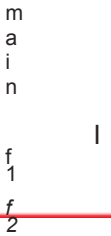


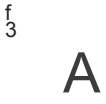
(b)

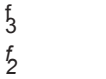
(c)

(d)

Ans. (a)

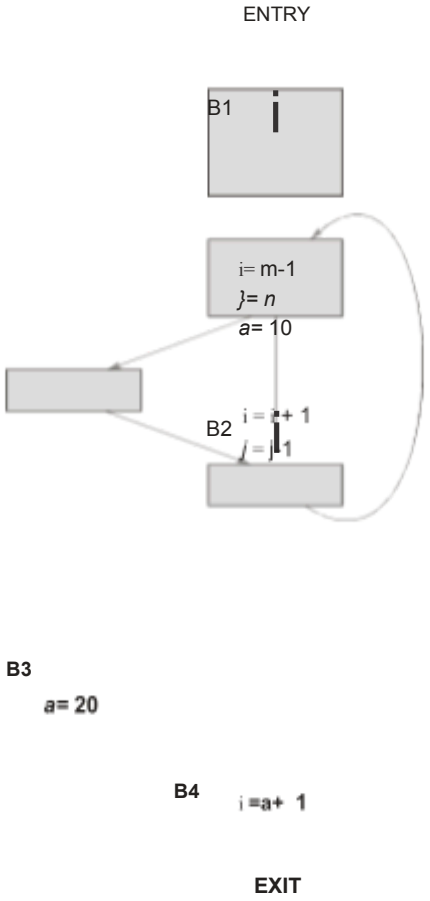






f3 f1

Q.27 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: { I, B2: {al, B3: {a}, B4: {a}

(b) B1: {i, *JI,* B2: {al, B3: (al, B4: (ii

(c) B1: {a, i, *J),* B2: {a, i, *J),* B3: {a, i}, B4: {al

(d) B1: {a, i, *J},* B2: {a, *JI,* B3: {a, *J),* B4: {a, i, *J)*

Ans. **(d)**

IN= USE u (OUT - DEFI

OUT = u IN (successor)

			FIRST GO		SECOND GO		THIRD GO	
Block	**USE**	**DEF**	**IN**	**OUT**	**IN**	**OUT**	**IN**	**OUT**
B1	{m, n}	{a, i, j}	{m, n}	{i, j}	{m, n}	{a, i, j}	{m, n}	{a, i, j}
B2	{i,j}	{i, j}	{i, j}	{a}	{a, i, j}	{a,}}	{a, i, j}	{a,}}
B3	<P	{a}	<P	{a}	<P	{a,}}	U }	{a,}}
B4	{a}	{i}	{a}	{i, j}	{a,}}	{a, i, j}	{a,}}	{a, i, j}

The variables that are live at exit (i.e. live out) of each basic block are B1 = (a, i, *J)*

B2 = (a, *J)*

B3 = {a, *J)*

B4 = (a, i, *J)*

Q.28 Consider the two functions incr and deer shown below:

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

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

There are 5 threads each invoking incr once, and 3 threads each invoking deer 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:

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

1-2 : *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 1-1, 1-2, 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

Ans. **(c)**

Q.29 Consider the context-free grammar G below:

S *aSbIX*

X *aXIXbIalb*

where Sand *X* are non-terminals, and *a* and bare 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

Ans. **(b)**

S *aSblX*

X *aXlXblalb*

S aSb

an bnl n 0

anxbn anaxbn

,; *ana* X bn*

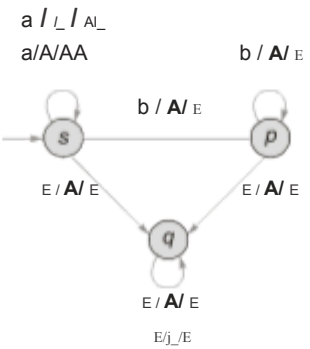
ana X bbn*

,; *ana* X b* bn*

*an a** (a+ b) *b*bn*

which is equal to *a*(a + b)b*.*

Q.30 Consider the pushdown automaton (PDA) Pbelow, which runs on the input alphabet (a, *b),*
has stack alphabet l-1, *A),* and has three states (s, *p, q),* with *s* being the start state. A transition from state *u* to state *v,* labelled *c I XI y,* where *c* is an input symbol or E, *X* is a stack symbol, and *y* 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 *y* on the stack, and go to state *v.* In the initial configuration, the stack has only the symbol -1 in it. The PDA accepts by empty stack.



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

(a) *lambnl* 1 *m* and *n* < m) (b) *lambnlo* *n* m)

(c) *{ambnl* O *m* and O *n)* (d) (aml O *m)* u {bnl O *n)*

Ans. (a)

From the given diagram it is clear that the starting symbol in the input string must be *'a'* and on every *'a'* it pushes *'A'* into the stack. If the input string becomes empty it goes to the state *q* and it empties the stack. This means the PDA accepts the language

$L=!anln211$

If after a's in the input string if b's comes then for every *'b'* it will delete *'A'* from the stack. When the string becomes empty iff the topmost symbol in the stack in *'A'* then the PDA empties the stack. This means the PDA accepts the language

$L = jambn\text{ln}< \text{ ml}$

The language accepted by the PDA is

$L = !\ am\text{l}\ m\ 2\ 11\ \text{u}\ lambn\text{l}\ n < \text{ml}$

or

$L = \{ambn\text{l}\ 1 :<::: m \text{ and } n < \text{ml}$

Hence option (a) is correct.

Q.31 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.

```
/JC-code

int a[10], b[10], i;
// int is 32-bit
for (i=0; i<10; i++) a[i] = b[i] * 8;
```

```
; 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 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
LOB: jmp U4; goto
```

U4 end
L09:

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

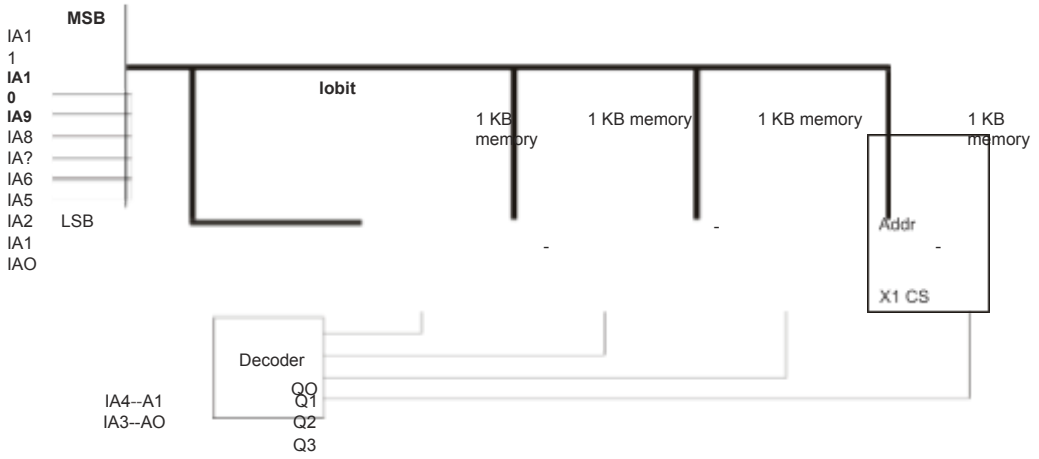
(a) (8, 4, 1, L02) (b) (3, 4, 4, L01)
(c) (8, 1, 1, L02) (d) (3, 1, 1, L01)

Ans. **(b)**

Byte addressable memory so after accessing every element address is incremented by "4".

After every element processing count register' *r/* is incremented and compare with *'r_2'* so jump to 'L01'.

Q.32 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 IA 11 - 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)

Ans. **(c)**

A4 *A3*
0000 ooooh
(0)10: [0000

Chip select (CS)

X1 is enabled
(8)10: [oooo 0000 1oooh
Lr--'

X2 is enabled
(16)10: [oooo ooo1 ooooh
CS

X3 is enabled
(24)10: [oooo ooo1 1 oooh
CS

X4 is enabled

So (0, 8, 16, 24) address enables the starting address of every bank respectively (block).

PRIME

SSC-JE 2023

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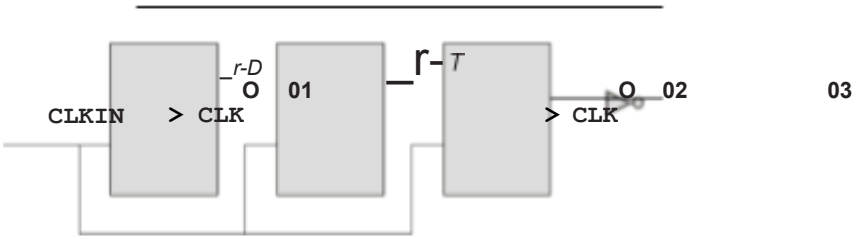
Q.33 Consider a sequential digital circuit consisting of Tflip-flops and *O* flip-flops as shown in the figure. CLKIN is the clock input to the circuit. At the beginning, 01, 02 and 03 have values 0, 1 and 1, respectively.

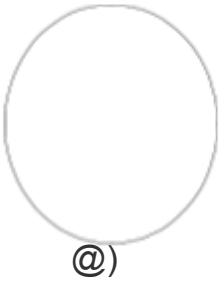


Which one of the given values of (01, 02, 03) can NEVER be obtained with this digital circuit?

(a) (0, 0, 1)
(b) (1,0,0)
(c) (1, 0, 1)
(d) (1, 1, 1)

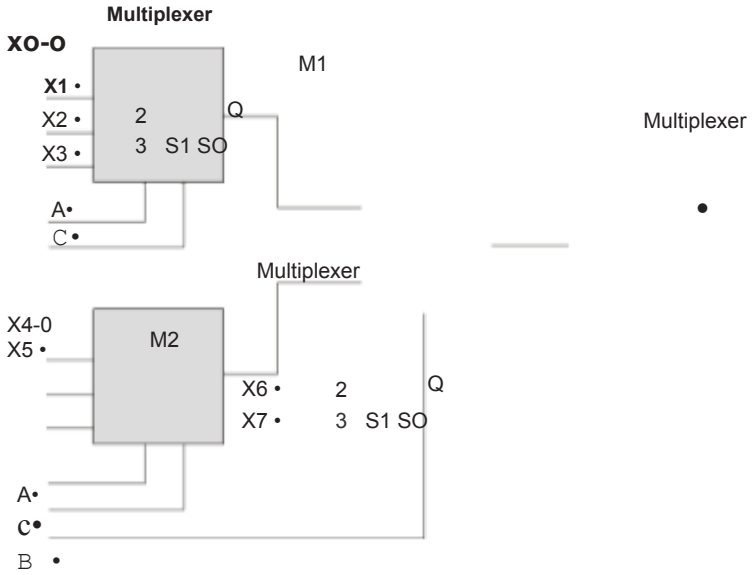
Ans. **(a)**

CLK	Q_1	Q_2	Q_3	$T_1 = \overline{Q}_3$	$D_2 = Q_1$	$T_3 = Q_2$
	0	1	1	0	0	1
1	0	0	0	1	0	0
2	1	0	0	1	1	0
3	0	1	0	1	0	1
4	1	0	1	0	1	0
5	1	1	1	0	1	1
6	1	1	0	1	1	1
7	0	1	1			



State 001 is not produced by given counter.

Q.34 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. XO - X7 are the inputs of the multiplexers M1 and M2 and could be connected to either O 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 (XO, X1, X2, X3, X4, XS, X6, X7) will realise the Boolean function A+ A.C+ A.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, O)
(d) (0, 0, 1, 1, 0, 1, 1, 1)

Ans. (c)

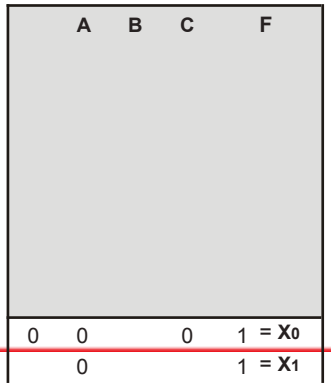
F(A, B, C) =A+ AC + ABC

=A+ABC

(0,1,2,3) 5

= I,m(O, 1, 2, 3, 4)

B is select input of M3 i.e. 2 x 1 MUX.
If B = O; 2 x 1 MUX output is M1 output. If B = 1; 2 x 1 MUX output is M2 output.
A and C are select inputs to both M1 and M2.



2	0		0	1	= **X_4**
3	0			1	= **X_5**
4	1		0	0	= X_2
5				1	= X_3
6	1	Q	0	0	= X_6
7				0	= X_7

$X_0 = 1,\ X_1 = 1,\ X_2 = 0,\ X_3 = 1$
$X_4 = 1,\ X_5 = 1,\quad X_6 = 0,\ X_7 = 0$

Q.35 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 x Q), represented in the IEEE-754 single precision format?
(a) 0x404C2EF4 (b) 0x405C2EF4
(c) 0xC15C2EF4 (d) 0xC14C2EF4

Ans. **(c)**

P = 0xC1800000
Q = 0x3F5C2EF4

P: 1 | 100 00011 | 000 0000 0000 ....
S BE M
[-ve] [131] [0]

Data: $-(1.0) * 2^{131-127}$ [Bias = 127]
$-(1.0) * 2^{+4}$

a: 0 | 01111110 | 10111000010111011110100 S
BE M
[+ve] [126]

Data: $+(1.10111000010111011110100) * 2^{126-127}$
$+(1.10111000010111011110100) * 2^{-1}$

Product: [P * Q]

S = (-ve) * (+ve) = -ve
AE = (+4) + (-1) + 3
M = (1.0)*(1.10111000010111011110100)
= 1.10111000010111011110100

Storage:

1 | 10000010 | 10111000010111011110100
C 5 C 2 E F 4

Answer is (C15C2EF4)H

Q.36 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 0(1).
(b) Both Extract-Max(A) and Insert(A, key) run in O(log(n)).
(c) Extract-Max(A) runs in 0(1) whereas Insert(A, key) runs in *0(n).*
(d) Extract-Max(A) runs in 0(1) whereas Insert(A, key) runs in O(log(n)).

Ans. **(b)**

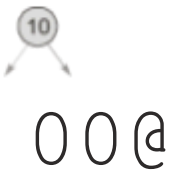
Insert element into max heap: required worst case $\log_2 n$ array shift operations or swaps TC= O(log *n)*

Delete max from max heap: required worst case $\log_2 n$ array shift operations TC= O(log *n)*

Q.37 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 O;
    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?

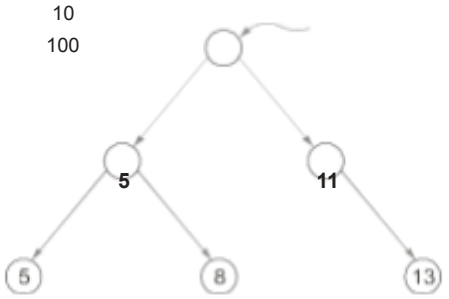
(a) 3 8 5 13 11 10
(b) 3 5 8 10 11 13
(c) 3 8 16 13 24 50
(d) 3 16 8 50 24 13

Ans. (c)

p

[I§§]

10
100



where *P* contain root node address

When foo is called with a pointer to the root node of the given binary tree then we reach the node until that node has left pointer and right pointer both pointing to NULL. Whenever p Left is NULL and p Right is NULL then foo (p left) and foo(p right) both will return 'O' and variable retval contain the following value.

retval = (p val) + foo(p left) + foo (p right)

for node whose value is 3, retval = 3 + 0 + 0 = 3
for node whose value is 8, retval = 8 + 0 + 0 = 8
for node whose value is 5, retval = 5 + 3 + 8 = 16
for node whose value is 13, retval = 13 + 0 + 0 = 3
for node whose value is 11, retval = 11 + 13 + 0 = 24
for node whose value is 10, retval = 10 + 16 + 24 = 50

Q.38 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 $A \cap B = \langle\rangle$. We say that a permutation of U separates A from B if one of the following is true.

(a) n!

(b) $(^{n}_{2k})$ \n-2k)!

(c) (;k}n-2k)! $(k!)^2$

(d) 2(;k}n-2k)! $(k!)^2$

Ans. (c)

$U = \{1, 2, 3, 4, ..., n\}$ where $n > 1000$

A U, B U and $|A| = |B| = k$ and $A \cap B = \langle\rangle$

Case (i): If all elements of A appear before the elements of *'B'* then number of permutations

$= {}^{n}C_{2k} * (n - 2k)!\ k!\ k!$
$= {}^{n}C_{2k}\ (n - 2k)!\ (k!)^2$

Case (ii): If all elements of B appear before the elements of *'A'* then number of permutations

$= {}^{n}C_{2k}\ (n - 2k)!\ (k!)^2$

Total number of permutations = Case (i) + Case (ii)

$= 2 * {}^{n}C_{2k}\ (n - 2k)!\ (k!)^2$

Q.39 Let $f: A \quad B$ be an onto (or surjective) function, where A and Bare non-empty sets. Define an equivalence relation - on the set A as

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

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

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

Which of the following statements is/are TRUE?

(a) Fis NOT well-defined.
(b) Fis an onto (or surjective) function.
(c) Fis a one-to-one (or injective) function.
(d) Fis a bijective function.

Ans. (b, c, d)

Every equivalence class of *'x'* under Fis uniquely mapped with some element *'x'* hence Fis a function and every function is well defined so option (a) is false.

Distinct equivalence *[x], [y]* are having distinct images under *F* hence it is one-one.

Every element of co-domain *'B'* is associated with some element of domain of E under *F* so Fis onto hence Fis bijective.

Q.40 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

Ans. (b, c, d)

Given bandwidth is 100 Mbps, MSL = 120 seconds (2 minutes) 1

$$\text{sec} = 100 \times 2^{20} \text{ bits}$$

$$120 \text{ sec} = 120 \times 100 \times 2^{20} \text{ bits}$$

$$= 15 \times 100 \times 2^{20} \text{ bytes}$$

$$= 1500 \times 2^{20} \text{ bytes}$$

$$\text{logi1500}) + \log_2 2^{20} = 11 + 20 = 31$$

Q.41 Let X be a set and 2^X denote the powerset of X.
Define a binary operation $\circ$ on 2^X as follows:

$$A \circ B = (A - B) \cup (B - A)$$

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

(a) H is a group.
(b) Every element in H has an inverse, but His 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

Ans. (a, **d)**

Let X be a set and 2^X is powerset of X

$$A \circ B = (A - B) \cup (B - A) \text{ for } A, B \in 2^X$$

$$H = (2^X, \circ)$$

H satisfies the following properties:

(i) H satisfies closure property under $\circ$
(ii) H satisfies associative property under $\circ$
(iii) H satisfies identity property under '$\circ$' is identity.
(iv) H is satisfying inverse property for $A \in 2^X$ we have inverse of $A = A$.
(v) H is satisfying commutative property

$$A \circ B = B \circ A \text{ for all } A, B \in 2^X$$

$H = (2^X, \circ)$ is abelian group.

Options (a), (d) are true.

Q.42 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.

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Ans. **(a, d)**

Default mode of http pipelining will take 3 RTTs (one for connection+ one for sending 1O objects + one for closing connection) objects.

And in iterative mode for DNS is 3 RTTs (Root + Top domain + Authoritative). So total 6 RTTs in case of persistent HTTP with pipeline.

For non-persistent with 5 parallel TCP connections.

3 RTTs for iterative + 2 RTT (one for connection + 5 TCP parallel) + 2 RTT (one for connection + 5 TCP parallel)

Q.43 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 Care independent.

(c) Band Care independent. (d) Prob(B IC) = Prob(B)

Ans. **(c, d)**

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 toss = $\frac{3}{4}$

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

$P(A \cap B) = \frac{1}{4}$ -:t $P(A)\cdot P(B)$

A and *B* are not independent.

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

B and C are not independent.

$P(A \cap C) = \frac{1}{4}$ -:t $P(A)\cdot P(C)$

A, C are not independent.

P(B IC) = *P(B)* is true

F\BI C) P(BnC) J¾t_1_ P(B)
P(C) 1_ 2
2

Q.44 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 = Ln/2J; end while
```

Function 2

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

Let *f/n)* and *fin)* 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/n)* ∈ 8(f_2(n))
(b) *f/n)* ∈ *o(fin))*
(c) *f/n)* ∈ *m*(f_2(n))*)*
(d) *f/n)* ∈ *O(n)*

Ans. **(a, d)**

Function 1

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

$f_1(n)$: Number of times $x = x + 1$ executes

$$f1(n) = n + 2^{n} + 22 + {}^{n} + i<$$

where $\frac{n}{2^k} > 1$

$k \approx \log_2 n$

$$f_1(n) = n\left\lceil 1+\frac{1}{2}+\frac{1}{2^2}+....+\frac{1}{2^k}\right\rceil = \theta(n)$$

Function 2

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

$f_2(n)$ Number of times $x = x + 1$ executes

$f_2(n) = 100 * n = 8(n)$
$f_1(n) = 8(f_2(n))$
$f_1(n) = O(n)$ are correct

Q.45 Let G be a simple, finite, undirected graph with vertex set $\{v_1, \ldots, vn\}$. Let 11(G) denote the maximum degree of G and let $N = \{1, 2, \ldots\}$ denote the set of all possible colors. Color the vertices of G using the following greedy strategy:

for i = 1, ..., *n*

color(v) f- mini} E *N:* no neighbour of *vi* 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 **11(** G) + 1.

(c) The number of colors used is at most **11(** G).

(d) The number of colors used is equal to the chromatic number of G.

Ans. (a, **b)**

Let, $V = \{v_1, v_2, \ldots, vn\}$

11(G) = Maximum degree of G

$N = \{1, 2, 3, \ldots.\}$ set of all possible colors

Greedy strategy:

color(*v)* f--- mini} E *N* : no neighbour of *vi* is colored *JI*

By using the above strategy, no two adjacent vertex have same color so it is proper vertex colouring hence option (a) is true.

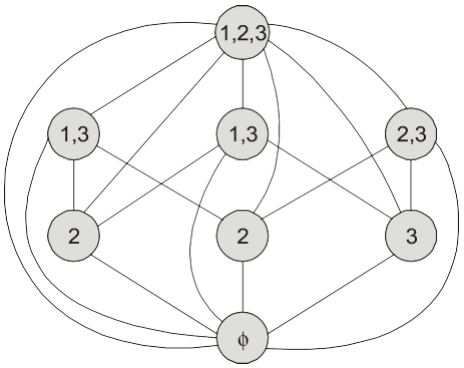
By using Leonard Brooke's theorem, the chromatic number of G is almost 11 + 1 hence option (b) is true.

Q.46 Let $U = \{1, 2, 3\}$. Let *2u* denote the powerset of *U.* Consider an undirected graph G whose vertex set is *2u.* For any *A,* BE *2u,(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 <I> denotes the empty set, then the cardinality of B(<!>) is _ _

Ans. **(5040)**

$U = \{1, 2, 3\}$ graph according to description



Number of BFS sequences from *Q* is B(<!>) are 7! = 5040.

Q.47 Consider the following two-dimensional array *0* in the C programming language, which is stored in row-major order:

int 0[128][128];

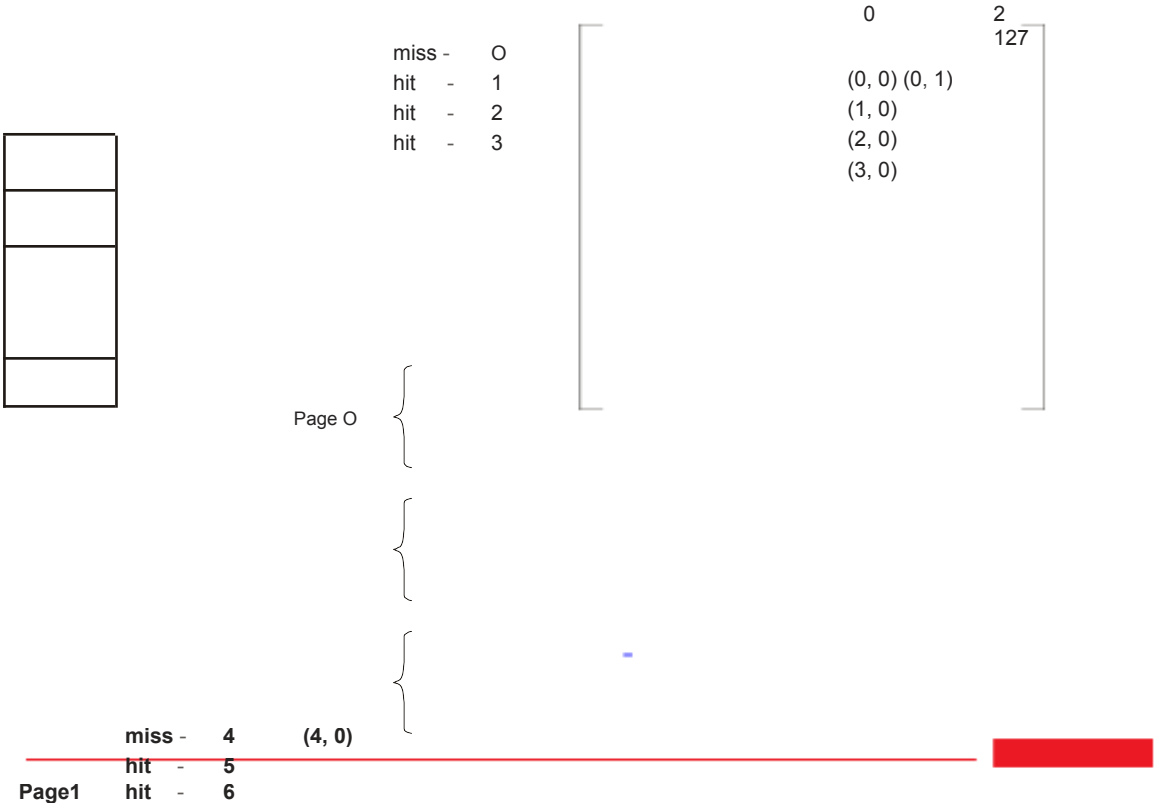
Demand paging is used for allocating memory and each physical page frame holds 512 elements of the array *0.* The Least Recently Used (LRU) page-replacement policy is used by the operating system. A total of 30 physical page frames are allocated to a process which executes the following code snippet:

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

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

Ans. **(4096)**

Given array dimension is 0[128][128] which is stored in row major order. It means that, 128 rows and 128 columns.



Given that, each physical frame holds 512 elements of the array *0.* 30 page frames are allocated to a process. Array access is in column major order [0[j][i] *= 10] As each physical frame holds 512 elements, the 1st 4 rows of the array belongs one page, we

can see that, one page fault 4 elements.
Array contains 32 pages, but memory contains 30 page frames.

$$128x128 = \underline{i}^4 =$$

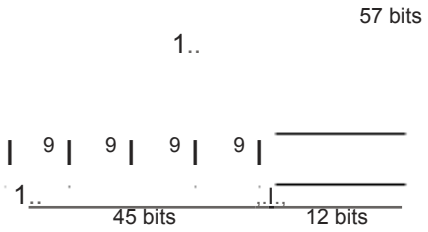
$$\text{nout page faults} = \frac{4}{2^2} \quad 4096$$

Q.48 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 _ _

Ans. **(5)**

$$\text{Offset} = \log_2(\text{Page size})$$
$$= \log_2(4\text{ KB}) = 12 \text{ bits PTE}$$
$$= 8 \text{ bytes}$$

For every level page table should fit into a page.
So, number of entries in a page = KBB =
2^9 Bits for a level = $\log_2(2^9)$ = 9 bits
Following is representation



So, 5 levels required.

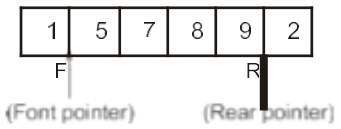
Q.49 Consider a sequence *a* of elements $a_0 = 1$, $a_1 = 5$, $a_2 = 7$, $a_2 = 8$, $a_4 = 9$, and $a_5 = 2$. The following operations are performed on a stack Sand a queue 0, both of which are initially empty.

I: push the elements of a from a0 to a5 in that order into S.
II: enqueue the elements of a from a0 to a5 in that order into 0.
111: pop an element from S.
IV: dequeue an element from 0.
V: pop an element from S.
VI: dequeue an element from 0.
VII: dequeue an element from O and push the same element into S. VI11:
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 _____ _

Ans. (8)

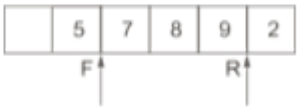
Step I :

Step II :



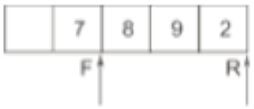
Step III :

Step IV :



Step V :

Step VI :

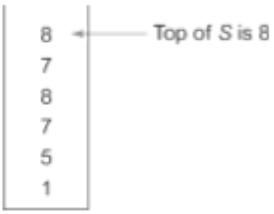


Step VII :

Step VIII :

Step IX :

Step X :



End of Solution

Q.50 Consider the syntax directed translation given by the following grammar and semantic rules. Here N, I, F and Bare 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.

1_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 → I # F N.val = I.val + F.val

I → 1_1 B I.val = (2 1_1.val) + B.val

I → B I.val = B.val

F → BF_1 $F.val = \frac{1}{2^1}(B.val + F_1.val)$

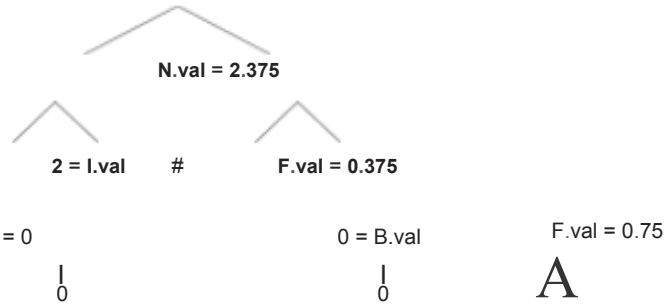
F → B $F.val = \frac{1}{2^1}B.val$

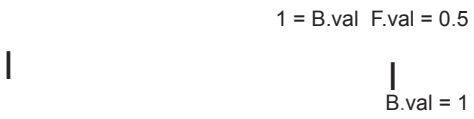
B → 0 B.val = 0.val

B → 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)

Ans. **(2.375)**





Q.51 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 SOL 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 _____

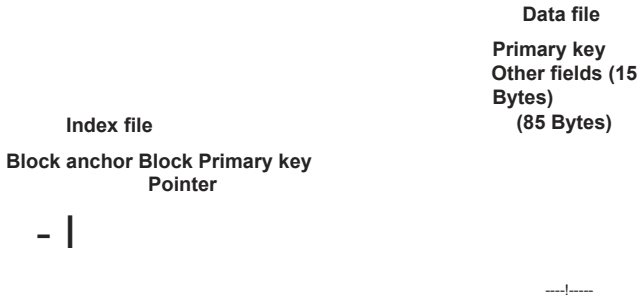
Ans. **(2)**

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

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

2 tuples in result.

Q.52 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_ _

Ans. **(6)**

Number of records	25000
Record size Search key (primary key)	100 byte = 15 bytes
Block size Pointer size	1024 bytes 5 bytes

$$\text{Block factor of DB file} = \frac{\lfloor \text{Block size} - \text{Block header} \rfloor}{\text{Record size}}$$

$$= \frac{102}{10\ R}$$

$$= 4\text{-}0$$

Number of DB blocks =

L 100 J block

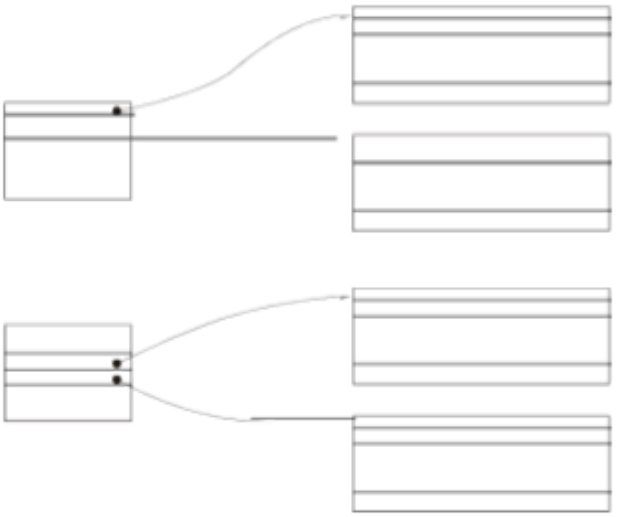
Number of records = 25000 =

br of DB J L 1O J

B-H 1024-0

Block factor of

-- = L---J=50 entries/block
LK+P J 15+5



Sparse index used.

[Number of index entries = Number of block of DB]

Number of index blocks at 1st level = $\lceil 5^{21} / 500 \rceil$ = 49

Number of index block's access required to identify block in DB file

= $\log_2 497 = 6$

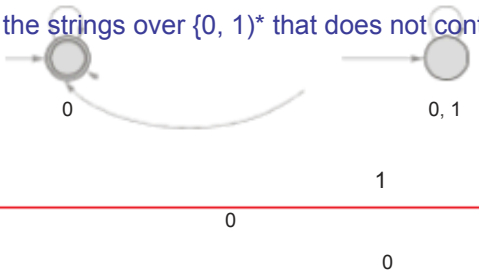
Q.53 Consider the language L over the alphabet $\{0, 1\}$, given below:

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

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

Ans. **(4)**

Lis the language of the strings over {0, 1)* that does not contains '111' as substring. The DFA for L is



Q.54 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 _ _

Ans. **(19)**

8-way set associative cache

CM size = 64 KB MM

Addr = 32 bit Block size

= Not given

So, assume word size

Word size not given so assume word size = Byte

Number of lines in CM (N) = Number of cells in CM only = 64 K

Number of lines in CM = $\frac{N}{\text{P-way}} = \frac{64K}{8} = i^3$

Tag bits= 19

Subnet Number	Subnet mask	Interface ID
[illegible]	255.250.0.0	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
[illegible]	[illegible]	0

Q.55 The forwarding table of a router is shown below:

A packet addressed to a destination address 200.150.68.118 arrives at the router. It will be forwarded to the interface with ID _____ _

Ans. **(3)**

250.150.68.118
255.255.0.0
255.150.0.0 **(matching)**

200.150.68.118
255.255.224.0
200.150.64.0 **(matching)**

250.150.68.118
255.255.255.0
200.150.68.0 (matching)

200.150.68.118
255.255.255.224
200.150.68.96 **(mismatch)**

Inteface 3 is answer according to longest prefix matching.

■■■■