Detailed Analysis of GATE 2018 Papers

GATE CSIT Solved Paper 2018 Detailed Analysis

Subject	1 Mark Questions	2 Mark Questions	Total Marks
General Aptitude	5	5	15
Engineering Mathematics	6	5	16
Theory of Computation	2	3	8
Digital Logic	2	1	4
Computer Organization and Architecture	3	4	11
Programming and Data Structures	3	3	9
Algorithm	1	5	11
Compiler Design	1	2	5
Operating System	2	3	8
Database	2	2	6
Computer Networks	3	2	7
Software Engineering	0	0	0
Web Technology	0	0	0
Total			**100**

GATE 2018 Solved Paper
CS: Computer Science and Information Technology
Set – I

Number of Questions: 65 **Total Marks:100.0**

Wrong answer for MCQ will result in negative marks, (–1/3) for 1 Mark Questions and (–2/3) for 2 Marks Questions.

General Aptitude

Number of Questions: 10 **Section Marks: 15.0**

Q.1 to Q.5 carry 1 mark each and Q.6 to Q.10 carry 2 marks each.

Question Number: 1 **Question Type: MCQ**

What would be the smallest natural number which when divided either by 20 or by 42 or by 76 leaves a remainder of 7 in each case?

(A) 3047 (B) 6047
(C) 7987 (D) 63847

Solution: The LCM of 20, 42, 76 = 20 (3) (7) (19)
= 7980.

The required number is 7987.

Hence, the correct option is (C).

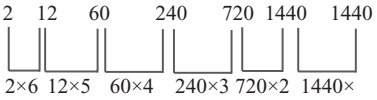
Question Number: 2 **Question Type: MCQ**

What is the number missing in the following sequence?

2, 12, 60, 240, 720, 1440, ___, 0

(A) 2880 (B) 1440
(C) 720 (D) 0

Solution: 2, 12, 60, 240, 720, 1440, _____, 0



The blank value will be 1440.

Hence, the correct option is (B).

Question Number: 3 **Question Type: MCQ**

"From where are they bringing their books? _____ bringing _____ books from _____."

The words that best fill the blanks in the above sentence are

(A) Their, they're, there (B) They're, their, there
(C) There, their, they're (D) They're, there, there

Solution: The words that are apt for the three blanks are "they're" (which is a contraction of "they are"), "their" (which means "belonging to the people previously mentioned) and "there" (which means in that place).

Hence, the correct option is (B).

Question Number: 4 **Question Type: MCQ**

"A ___ investigation can sometimes yield new facts, but typically organized ones are more successful."

The word best fills the blank in the above sentence is

(A) meandering (B) timely
(C) consistent (D) systematic

Solution: A process or activity that does not seem to have a clear purpose or direction is said to meander. Thus, "meandering" is the apt word; the sentence suggests that a meandering investigation might yield new facts, but organized ones are more successful.

Hence, the correct option is (A).

Question Number: 5 **Question Type: MCQ**

The area of a square is d. What is the area of the circle which has the diagonal of the square as its diameter?

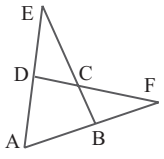
(A) πd (B) πd^2
(C) $\frac{1}{4}d^2$ (D) $\frac{1}{2}d$

Solution: The area of the square is d. Its side is $\sqrt{d}$. Its diagonal is $\sqrt{2d}$. This is the diameter of the circle. Therefore, the area of the circle $= \frac{\pi(2d)}{4} = \frac{\pi d}{2}$.

Hence, the correct option is (D).

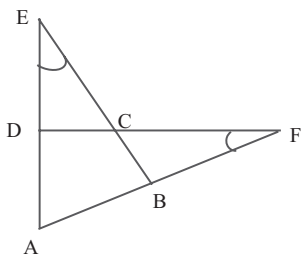
Question Number: 6 **Question Type: MCQ**

In the figure below, $\angle DEC + \angle BFC$ is equal to ____.



(A) $\angle BCD - \angle BAD$
(B) $\angle BAD + \angle BCF$
(C) $\angle BAD + \angle BCD$
(D) $\angle CBA + \angle ADC$

Solution:



$$\angle E + \angle F + \angle A = \angle ECF = \angle BCD$$

$$\therefore \angle E + \angle F = \angle BCD - \angle A = \angle BCD - \angle BAD$$

Hence, the correct option is (A).

Question Number: 7 **Question Type: MCQ**

A six sided unbiased die with four green faces and two red faces is rolled seven times. Which of the following combinations is the most likely outcome of the experiment?

(A) Three green faces and four red faces.
(B) Four green faces and three red faces.
(C) Five green faces and two red faces.
(D) Six green faces and one red face.

Solution: The most likely outcome in the one where the ratio of the number of green and red faces in closest to 2:1. This is 5*g*, 2*r*. We may want to consider 4*g*, 3*r*.

$$P(5g, 2r) = {}^7C_5\left(\frac{2}{3}\right)^5\left(\frac{1}{3}\right)^2 = 32(21)/3^7$$

$$= 16(42)/3^7$$

$$P(4g, 3r) = {}^7C_4\left(\frac{2}{3}\right)^4\left(\frac{1}{3}\right)^3 = 16(35)/3^7$$

We see that 5*g*, 2*r* is more probable.

Hence, the correct option is (C).

Question Number: 8 **Question Type: MCQ**

In appreciation of the social improvements completed in a town, a wealthy philanthropist decided to gift ₹750 to each male senior citizen in the town and ₹1000 to each female senior citizen. Altogether, there were 300 senior citizens eligible for this gift. However, only 8/9th of the eligible men and 2/3rd of the eligible women claimed the gift. How much money (in Rupees) did the philanthropist give away in total?

(A) 1,50,000 (B) 2,00,000
(C) 1,75,000 (D) 1,51,000

Solution: Let the number of men be 9*x* and the number of women be 3*y*. (8/9 of the number of men and 2/3 of the number of women are integers)

$$\therefore \quad 9x + 3y = 300 \Rightarrow 3x + y = 100 \qquad (1)$$

8*x* men and 2*y* women claimed the gift.

Amount given

$$= 750(8x) + 1000(2y) = 6000x + 2000y \qquad (2)$$
$$= 6000x + 2000(100 - 3x) = 200{,}000x$$

If *x* is an integer, among the options only *B* satisfies the condition.

Hence, the correct option is (B).

Question Number: 9 **Question Type: MCQ**

If $pqr \neq 0$ and $p^{-x} = \frac{1}{q}$, $q^{-y} = \frac{1}{r}$, $r^{-z} = \frac{1}{p}$, what is the value of the product *xyz*?

(A) –1 (B) $\frac{1}{pqr}$
(C) 1 (D) *pqr*

Solution: $p^{-x} = \frac{1}{q}, q^{-y} = \frac{1}{r}, r^{-z} = \frac{1}{p}$

$$\therefore \quad p^x = q, q^y = r, r^z = p$$

$$p = r^z = (q^y)^z = p^{xyz}$$

If $p \neq -1$, 0 or 1, then $xyz = 1$

The condition that $p = -1$ or 1 is not given, only with this condition we can conclude that $xyz = 1$. But as cannot be determined is not an option, we select 1.

Hence, the correct option is (C).

Question Number: 10 **Question Type: MCQ**

In a party, 60% of the invited guests are male and 40% are female. If 80% of the invited guests attended the party and if all the invited female guests attended, what would be the ratio of males to females among the attendees in the party?

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

Solution: Let the number of invited men and women be 6 and 4. All the women attended. Overall 80 % attended. Therefore, 4 men and 4 women attended. The required ratio is 1 : 1.

Hence, the correct option is (B).

Computer Science and Information Technology

Number of Questions: 55 **Section Marks: 85.0**

Q.11 to Q.25 carry 1 mark each and Q.26 to Q.65 carry 2 marks each.

Question Number: 11 **Question Type: MCQ**

Let N be an NFA with n states. Let k be the number of states of a minimal DFA which is equivalent to N. Which one of the following is necessarily true?

(A) $k \geq 2^n$ (B) $k \geq n$
(C) $k \leq n^2$ (D) $k \leq 2^n$

Solution:

Hence, the correct option is (D).

Question Number: 12 **Question Type: MCQ**

The set of all recursively enumerable languages is

(A) Closed under complementation.
(B) Closed under intersection.
(C) A subset of the set of all recursive languages.
(D) An uncountable set.

Solution:

Hence, the correct option is (B).

Question Number: 13 **Question Type: MCQ**

Which one of the following statements is FALSE?

(A) Context-free grammar can be used to specify both lexical and syntax rules.
(B) Type checking is done before parsing.
(C) High-level language programs can be translated to different Intermediate Representations.
(D) Arguments to a function can be passed using the program stack.

Solution:

Type checking is done after parsing, as syntax analysis is done before semantic analysis.

Hence, the correct option is (B).

Question Number: 14 **Question Type: MCQ**

The following are some events that occur after a device controller issues an interrupt while process L is under execution.

(P) The processor pushes the process status of L onto the control stack.
(Q) The processor finishes the execution of the current instruction.
(R) The processor executes the interrupt service routine.
(S) The processor pops the process status of L from the control stack.
(T) The processor loads the new PC value based on the interrupt.

Which one of the following is the correct order in which the events above occur?

(A) QPTRS (B) PTRSQ
(C) TRPQS (D) QTPRS

Solution:

Hence, the correct option is (A).

Question Number: 15 **Question Type: MCQ**

Consider a process executing on an operating system that uses demand paging. The average time for a memory access in the system is M units if the corresponding memory page is available in memory and D units if the memory access causes a page fault. It has been experimentally measured that the average time taken for a memory access in the process is X units.

Which one of the following is the correct expression for the page fault rate experienced by the process?

(A) $(D - M)/(X - M)$ (B) $(X - M/(D - M)$
(C) $(D - X/(D - M)$ (D) $(X - M/(D - X)$

Solution: Effective memory access time

$= (1 - \alpha) *$ memory access time $+ \alpha$ (page fault overhead)

$\alpha =$ page fault rate

From given data,

$$X = (1 - \alpha) \times M + \alpha \times D$$
$$X = M - \alpha M + \alpha D$$
$$\alpha = \frac{X - M}{D - M}$$

Hence, the correct option is (B).

Question Number: 16 **Question Type: MCQ**

Which one of the following is a closed form expression for the generating function of the sequence $\{a_n\}$, where $a_n = 2n + 3$ for all $n = 0, 1, 2, \ldots$?

(A) $\frac{3}{(1-x)^2}$ (B) $\frac{3x}{(1-x)^2}$
(C) $\frac{2-x}{(1-x)^2}$ (D) $\frac{3-x}{(1-x)^2}$

Solution:

For $a_n = 2n + 3$ for all $n = 0, 1, 2, \ldots.$ generating function of the given sequence $\{a_n\}$, will be

$$F(x) = \sum_{n=0}^{\infty} (2n + 3) x^n$$
$$= 3 + 5x + 7x^2 + 9x^3 + 11x^4 + \ldots\ldots$$
$$= (3 + 6x + 9x^2 + 12x^3 + 15x^4 + \ldots..)$$
$$- (x + 2x^2 + 3x^3 + 4x^4 + \ldots..)$$

$$= 3(1 + 2x + 3x^2 + 4x^3 + \ldots\ldots)$$
$$- x(1 + 2x + 3x^2 + 4x^3 + \ldots.)$$
$$= 3 \cdot \frac{1}{(1-x)^2} - x\frac{1}{(1-x)^2} = \frac{3-x}{(1-x)^2}$$

Hence, the correct option is (D).

Question Number: 17 **Question Type: NAT**

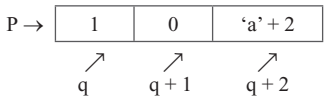
Consider the following C program.

```
struct Ournode p = {'1', '0', 'a'+2};
struct Ournode *q = &p;
printf ("%c, %c", *( (char*)q+1),
                    * ( (char*)q+2) );
return 0;
}
```

The output of this program is:

(A) 0, c
(B) 0, a+2
(C) '0', 'a+2'
(D) '0', 'c'

Solution:




```
*((char*) q + 1)⇒0
*((char*) q + 2)⇒'a'+2
                ⇒ c
```

The output of program is 0, c

Hence, the correct option is (A).

Question Number: 18 **Question Type: MCQ**

A queue is implemented using a non-circular singly linked list. The queue has a head pointer and a tail pointer, as shown in the figure. Let n denote the number of nodes in the queue. Let enqueue be implemented by inserting a new node at the head, and dequeue be implemented by deletion of a node from the tail.

Which one of the following is the time complexity of the most time-efficient implementation of enqueue and dequeue, respectively, for this data structure?

(A) $\theta(1), \theta(1)$ (B) $\theta(1), \theta(n)$
(C) $\theta(n), \theta(1)$ (D) $\theta(n), \theta(n)$

Solution: We know that enqueue operation is done at header of linked list, if will take $\theta(1)$ time.

Also we know that dequeue() takes θ(n) time because after deletion it takes 'n' computations to reach last node, as tail points last node of linked list.

Hence, the correct option is (B).

Question Number: 19 **Question Type: MCQ**

Let $\oplus$ and $\odot$ denote the Exclusive OR and Exclusive NOR operations, respectively. Which one of the following is NOT CORRECT?

(A) $\overline{P \oplus Q} = P \odot Q$
(B) $\bar{P} \oplus Q = P \odot Q$
(C) $\bar{P} \oplus \bar{Q} = P \oplus Q$
(D) $\left(P \oplus \bar{P}\right) \oplus Q = \left(P \odot \bar{P}\right) \odot \bar{Q}$

Solution:

If we consider the last option given in problem, then we have

$$\left(P \oplus \bar{P}\right) \oplus Q = \left(P \odot \bar{P}\right) \odot Q$$
$$1 \oplus Q \neq 0 \odot Q$$
$$\bar{Q} \neq Q$$

Hence, the correct option is (D).

Question Number: 20 **Question Type: MCQ**

Consider the following processor design characteristics.

I. Register-to-register arithmetic operations only
II. Fixed-length instruction format
III. Hardwired control unit

Which of the characteristics above are used in the design of a RISC processor?

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

Solution:

Hence, the correct option is (D).

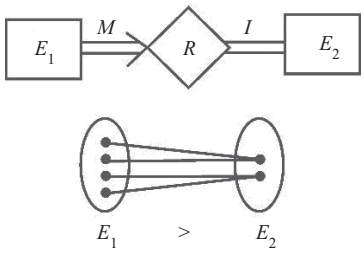
Question Number: 21 **Question Type: MCQ**

In an Entity-Relationship (ER) model, suppose R is a many-to-one relationship from entity set E_1 to entity set E_2. Assume that E_1 and E_2 participate totally in R and that the cardinality of E_1 is greater than the cardinality of E_2.

Which one of the following is true about R?

(A) Every entity in E_1 is associated with exactly one entity in E_2.
(B) Some entity in E_1 is associated with more than one entity in E_2.
(C) Every entity in E_2 is associated with exactly one entity in E_1.
(D) Every entity in E_2 is associated with at most one entity in E_1.

Solution: Consider figure given below



From above figure we conclude that every entity in E_1 is associated with

exactly one entity in E_2

Hence, the correct option is (A).

Question Number: 22 **Question Type: MCQ**

Consider the following two tables and four queries in SQL.

Book (isbn, bname), Stock (isbn, copies)

Query 1: SELECT B.isbn, S.copies
FROM Book B INNER JOIN Stock S
ON B.isbn = S.isbn;

Query 2: SELECT B.isbn, S.copies
FROM Book B LEFT OUTER JOIN Stock S
ON B.isbn = S.isbn;

Query 3: SELECT B.isbn, S.copies
FROM Book B RIGHT OUTER JOIN Stock S
ON B.isbn = S.isbn;

Query 4: SELECT B.isbn, S.copies
FROM Book B FULL OUTER JOIN Stock S
ON B.isbn = S.isbn;

Which one of the queries above is certain to have an output that is a superset of the outputs of the other three queries?

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

Solution:

1. The natural join will return only those values which are common in both the tables.
2. The left outer join will gives all rows from left table with null values, if right side table is not having match.
3. The right outer join will gives all rows from table on right hand side with null values, if left hand side table is not having the match.
4. Full outer join will gives all rows in output which are common in both tables, present in left table only or right table only.

Hence, the correct option is (D).

Question Number: 23 **Question Type: MCQ**

Match the following:

	Field		Length in bits
P.	UDP Header's Port Number	I.	48
Q.	Ethernet MAC Address	II.	8
R.	IPv6 Next Header	III.	32
S.	TCP Header's Sequence Number	IV.	16

(A) P-III, Q-IV, R-II, S-I
(B) P-II, Q-I, R-IV, S-III
(C) P-IV, Q-I, R-II, S-III
(D) P-IV, Q-I, R-III, S-II

Solution:

The correct mapping is given in option C.

Hence, the correct option is (C).

Question Number: 24 **Question Type: MCQ**

Consider the following statements regarding the slow start phase of the TCP congestion control algorithm. Note that cwnd stands for the TCP congestion window and MSS denotes the Maximum Segment Size.

(i) The cwnd increases by 2 MSS on every successful acknowledgment.
(ii) The cwnd approximately doubles on every successful acknowledgement.
(iii) The cwnd increases by 1 MSS every round trip time.
(iv) The cwnd approximately doubles every round trip time.

Which one of the following is correct?

(A) Only (ii) and (iii) are true
(B) Only (i) and (iii) are true
(C) Only (iv) is true
(D) Only (i) and (iv) are true

Solution: Slow start phase of TCP congestion control algorithm:

- Each time an ACK is received the congestion window is increased by one segment.
- If ack acknowledges 2 segment, cwnd is still increased by only one segment.
- If ack acknowledges a segment smaller than MSS bytes long, cwnd is increased by MSS bytes.
- If cwnd is 3, and if there is still outstanding ack, sender can only send two segments.

Hence, the correct option is (C).

Question Number: 25 **Question Type: NAT**

Two people, P and Q, decide to independently roll two identical dice, each with 6 faces, numbered 1 to 6. The

person with the lower number wins. In case of a tie, they roll the dice repeatedly until there is no tie. Define a trial as a throw of the dice by P and Q. Assume that all 6 numbers on each dice are equi-probable and that all trials are independent. The probability (rounded to 3 decimal places) that one of them wins on the third trial is _____.

Solution: Let A be the event of both P and Q getting same number on the dice in one trial.

and B be the event of P and Q getting different numbers on the dice in one trial.

$$\therefore \quad P(A) = \frac{6}{36} = \frac{1}{6}$$

$$P(B) = \frac{30}{36} = \frac{5}{6}$$

$\therefore$ The probability that one of them wins on the third trial

$$= P(A \cap A \cap B)$$

$$= P(A)\,P(A)\,P(B)$$

($\therefore$ A and B are independent)

$$= \frac{1}{6} \times \frac{1}{6} \times \frac{5}{6}$$

$$= \frac{5}{216} = 0.023$$

Hence, the correct answer is 0.021 to 0.024.

Question Number: 26 **Question Type: NAT**

The value of $\int_0^{\pi/4} x\cos\left(x^2\right)dx$ correct to three decimal places (assuming that $\pi = 3.14$) is _____.

Solution: Let $I = \int_0^{\pi/4} x\cos(x^2)\,dx$ (1)

Put $x^2 = t \Rightarrow 2x\,dx = dt$

$$\Rightarrow \quad xdx = \frac{1}{2}dt$$

At $x = 0$; $t = 0^2 = 0$

and at $x = \frac{\pi}{4}$; $\quad t = \left(\frac{\pi}{4}\right)^2 = \frac{\pi^2}{16}$

$\therefore$ (1) becomes,

$$I = \int_0^{\pi/4} x\cos(x^2)\,dx$$

$$= \int_0^{\pi/4} (\cos(x^2))(x\,dx)$$

$$= \int_{t=0}^{\pi^2/16} (\cos(t))\frac{1}{2}dt$$

$$= \frac{1}{2}\sin t\Big]_0^{\pi^2/16}$$

$$= \frac{1}{2}\left[\sin\left(\frac{\pi^2}{16}\right) - \sin 0\right]$$

$$= 0.289$$

Hence, the correct answer is 0.27 to 0.30.

Question Number: 27 **Question Type: NAT**

Consider a matrix $A = uv^T$ where $u = \begin{pmatrix}1\\2\end{pmatrix}$, $v = \begin{pmatrix}1\\1\end{pmatrix}$. Note that v^T denotes the transpose of v. The largest eigenvalue of A is _____.

Solution: Given $\quad u = \begin{pmatrix}1\\2\end{pmatrix}$ and $v = \begin{pmatrix}1\\1\end{pmatrix}$

$$\therefore \quad A = uv^T = \begin{pmatrix}1\\2\end{pmatrix}(1\ \ 1) = \begin{bmatrix}1 & 1\\2 & 2\end{bmatrix}$$

As $\det(A) = 0$, one of the eigen values of A is 0.

Let λ be the other eigne value of A

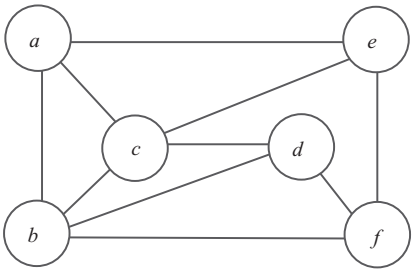
$\therefore \quad 0 + \lambda = \text{Trace}(A) \Rightarrow \lambda = 1 + 2 = 3$

So the largest eigen value of A is 3.

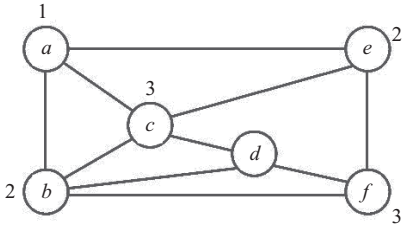
Hence, the correct answer is 3.

Question Number: 28 **Question Type: NAT**

The chromatic number of the following graph is _____.



Solution: The chromatic number of the given graph is 3.



Hence, the correct answer is 3.

Question Number: 29 **Question Type: NAT**

Let G be a finite group on 84 elements. The size of a largest possible proper subgroup of G is _____.

Solution: Given order of $G = O(G) = 84$

Any proper subgroup of G will have order less than 84. Also, we know that the order of a subgroup of a finite group divides the order of the group.

$\therefore$ The size of a largest possible proper subgroup of G.

= The largest divisor of 84 that is less than 84 = 42

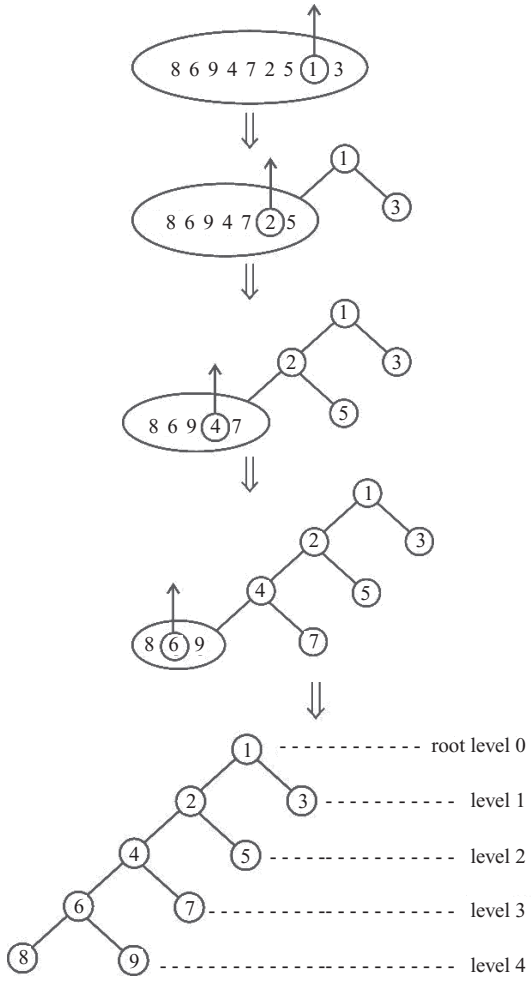
Hence, the correct answer is 42.

Question Number: 30 **Question Type: NAT**

The postorder traversal of a binary tree is 8, 9, 6, 7, 4, 5, 2, 3, 1. The inorder traversal of the same tree is 8, 6, 9, 4, 7, 2, 5, 1, 3. The height of a tree is the length of the longest path from the root to any leaf. The height of the binary tree above is _____.

Solution: Postorder: 8,9,6,7,4,5,2,3,1

In order: 8,6,9,4,7,2,5,1,3



Hence, the correct answer is 4.

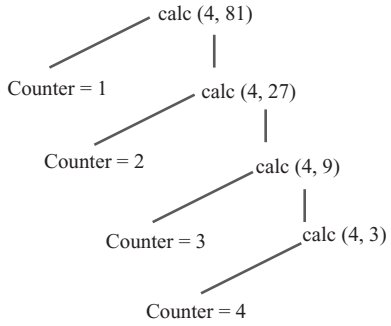
Question Number: 31 **Question Type: NAT**

Consider the following C program:

```
#include <stdio.h>
int counter = 0;
int calc (int a, int b) {
    int c;
    counter++;
    if (b==3) return (a*a*a);
    else {
        c = calc (a, b/3);
        return (c*c*c);
     }
 }
 int main () {
     calc (4, 81);
     printf ("%d", counter);
 }
```

The output of this program is _____.

Solution:



The output of this program is 4.

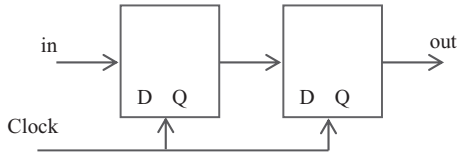
Hence, the correct answer is 4.

Question Number: 32 **Question Type: NAT**

Consider the sequential circuit shown in the figure, where both flip-flops used are positive edge-triggered D flip-flops.

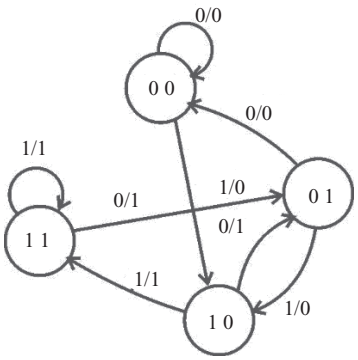
The number of states in the state transition diagram of this circuit that have a transition back to the same state on some value of "in" is _____.

Solution:



p.s		x	D_A	D_B	n.s		Out
A	B				A	B	B
0	0	0	0	0	0	0	0
0	0	1	1	0	1	0	0
0	1	0	0	0	0	0	0
0	1	1	1	0	1	0	0
1	0	0	0	1	0	1	1
1	0	1	1	1	1	1	1
1	1	0	0	1	0	1	1
1	1	1	1	1	1	1	1

States transition diagram of the above sequential circuit is as shown below



$\therefore$ the number of states in the state transition diagram of this circuit that have a transition back to the same states on some value of "in" is 2.

Hence, the correct answer is 2.

Question Number: 33 **Question Type: NAT**

A 32-bit wide main memory unit with a capacity of 1 GB is built using 256M × 4-bit DRAM chips. The number of rows of memory cells in the DRAM chip is 2^{14}. The time taken to perform one refresh operation is 50 nanoseconds. The refresh period is 2 milliseconds. The percentage (rounded to the closest integer) of the time available for performing the memory read write operations in the main memory unit is _____.

Solution:

Number of memory cells rows in DRAM chip is 2^{14} = 16K

Total time for refreshing, if one refreshing takes 50 nanoseconds

$$= 16\text{ K} \times 50\text{ ns}$$

$$= 800\ \mu\text{sec} = 0.8\text{ m sec.}$$

We know that refresh period is 2 msec.

Out of 2 m sec, 0.8 m sec is used for refreshing and remaining 1.2 msec is used for RD/WR operation.

Percentage of time available for Read/Write operation

$$= \frac{1.2\text{ m sec}}{2\text{ m sec}} \times 100$$

$$= 60\%.$$

Hence, the correct answer is 59 to 60.

Question Number: 34 **Question Type: NAT**

Consider a system with 3 processes that share 4 instances of the same resource type. Each process can request a maximum of *K* instances. Resource instances can be requested and released only one at a time. The largest value of *K* that will always avoid deadlock is _____.

Solution: There are 3 processes and 4 resources, one process can be able to obtain two resources.

Maximum number of instances a process can request will be 2.

$$\left.\begin{matrix} P_{1\to1} \\ P_{2\to1} \\ P_{3\to1} \end{matrix}\right\} + 1$$

Hence, the correct answer is 2.

Question Number: 35 **Question Type: NAT**

Consider a long-lived TCP session with an end-to-end bandwidth of 1Gbps (= 10^9 bits-per-second). The session starts with a sequence number of 1234. The minimum time (in seconds, rounded to the closest integer) before this sequence number can be used again is _____.

Solution:

Amount of time required to lapse sequence numbers are

$$\frac{2^{32} \times 8}{10^9} = 34.35\text{ sec.}$$

Hence, the correct answer is 34.

Question Number: 36 **Question Type: MCQ**

Consider a matrix P whose only eigenvectors are the multiples of $\begin{bmatrix} 1 \\ 4 \end{bmatrix}$.

Consider the following statements.

(I) P does not have an inverse

(II) P has a repeated eigenvalue

(III) P cannot be diagonalized

Which one of the following options is correct?

(A) Only I and III are necessarily true

(B) Only II is necessarily true

(C) Only I and II are necessarily true

(D) Only II and III are necessarily true

Solution: We know that any eigen vector of a matrix P is a multiple of $\begin{bmatrix}1\\4\end{bmatrix}$.

As every eigen vector of P is a multiple of $\begin{bmatrix}1\\4\end{bmatrix}$,

P has only one linearly independent eigen vector

As P is a 2×2 matrix, if the two eigen values of P are distinct, then P should have two linearly independent eigen vectors.

So, P has a repeated eigen value

Hence (II) is correct.

A 2×2 matrix is diagonalizable if and only if it has two linearly independent eigen vectors.

But P has only one linearly independent eigen vector.

Hence P is not diagonalizable.

So (III) is correct.

P need not be a singular matrix.

So, (I) is not correct.

$\therefore$ Only (II) and (III) are necessarily correct.

Hence, the correct option is (D).

Question Number: 37 Question Type: MCQ

Let N be the set of natural numbers. Consider the following sets.

P: Set of Rational numbers (positive and negative)

Q: Set of functions from {0,1} to N

R: Set of functions from N to {0,1}

S: Set of finite subsets of N.

Which of the sets above are countable?

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

Solution: We know that the set of rational numbers is countable. So P is countable

Q: set of functions from {0, 1} to N.

As 0 can be mapped to a number in N ways and 1 can be mapped to a number in N ways,

The number of elements in the set of functions from {0, 1} to N

= The number of elements in the cartesian product $N \times N$

We know that the cartesian product of two countable sets is countable.

As N is countable, $N \times N$ is countable

So Q is countable.

R: Set of functions from N to { 0,1}

In a function from N to {0, 1},

Every element of N is mapped to 0 or 1

So, the number of ways of mapping any element of N is 2.

$\therefore$ The number or elements in the set of functions from N to {0,1}

= The number of elements in the power set of N

But the power set of N is uncountable because the power set of a infinite countable set is uncountable.

So R is uncountable.

S: Set of finite subsets of N.

As we are considering only the finite subsets of N, S is a countably infinite set.

So only P, Q and S are countable.

Hence, the correct option is (D).

Question Number: 38 Question Type: MCQ

Consider the first-order logic sentence

$$\phi = \exists s \exists t \exists u \forall v \forall w \forall x \forall y \ \ \psi(s,t,u,v,w,x,y)$$

where $\psi(s,t,u,v,w,x,y)$ is a quantifier-free first-order logic formula using only predicate symbols, and possibly equality, but no function symbols. Suppose ϕ has a model with a universe containing 7 elements.

Which one of the following statements is necessarily true?

(A) There exists at least one model of ϕ with universe of size less than or equal to 3.
(B) There exists no model of ϕ with universe of size less than or equal to 3.
(C) There exists no model of ϕ with universe of size greater than 7.
(D) Every model of ϕ has a universe of size equal to 7.

Solution:

Hence, the correct option is (A).

Question Number: 39 Question Type: MCQ

Consider the following C program:

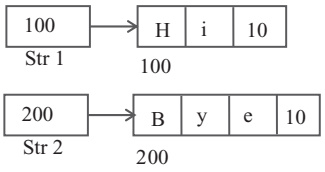
```
#include<stdio.h>
void fun1 (char *s1, char * s2) {
char *tmp;
tmp = s1;
s1 = s2
s2 = tmp;
}
void fun2 (char **s1, char **s2) {
char *tmp;
tmp = *s1;
```

```
*s1 = *s2;
*s2 = tmp;
}
int main () {
char *str1 = "Hi", *str2 = "Bye";
fun1 (str1, str2);
printf ("%s %s ", str1, str2);
fun2 (&str1, &str2);
printf ("%s %s", str1, str2);
return 0;
}
```

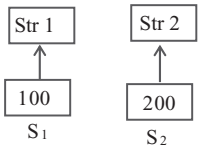
The output of the program above is

(A) Hi Bye Bye Hi (B) Hi Bye Hi Bye
(C) Bye Hi Hi Bye (D) Bye Hi Bye Hi

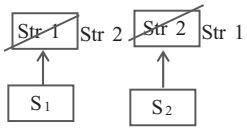
Solution:




```
main ( )
fun 1 ( )
```




```
fun 2 ( )
```



The output of the program is Hi Bye Bye Hi

Hence, the correct option is (A)

Question Number: 40 Question Type: MCQ

Let G be a simple undirected graph. Let T_D be a depth first search tree of G. Let T_B be a breadth first search tree of G.

Consider the following statements.

(I) No edge of G is a cross edge with respect to T_D. (A cross edge in G is between two nodes neither of which is an ancestor of the other in T_D.)

(II) For every edge (u,v) of G, if u is at depth i and v is at depth j in T_B, then $|i - j| = 1$.

Which of the statements above must necessarily be true?

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

Solution: We know that in DFS of an undirected graph, we will not get cross edge because all edges that are incident on a vertex are explored.

Hence, the correct option is (A).

Question Number: 41 Question Type: MCQ

Assume that multiplying a matrix G_1 of dimension $p \times q$ with another matrix G_2 of dimension $q \times r$ requires pqr scalar multiplications. Computing the product of n matrices $G_1G_2G_3 \ldots G_n$ can be done by parenthesizing in different ways. Define $G_i\ G_{i+1}$ as an explicitly computed pair for a given paranthesization if they are directly multiplied. For example, in the matrix multiplication chain $G_1G_2G_3G_4G_5G_6$ using parenthesization $(G_1(G_2G_3))(G_4(G_5G_6))$, G_2G_3 and G_5G_6 are the only explicitly computed pairs.

Consider a matrix multiplication chain $F_1F_2F_3F_4F_5$, where matrices F_1, F_2, F_3, F_4, and F_5 are of dimensions 2×25, 25×3, 3×16, 16×1 and 1×1000, respectively. In the parenthesization of $F_1F_2F_3F_4F_5$ that minimizes the total number of scalar multiplications, the explicitly computed pairs is/are

(A) F_1F_2 and F_3F_4 only (B) F_2F_3 only
(C) F_3F_4 only (D) F_1F_2 and F_4F_5 only

Solution: Use Parenthesization $((F_1(F_2(F_3F_4)))F_5)$

$$F_3F_4 = 48\ [16 \times 3 \times 1]$$
$$(F_2(F_3F_4)) = 75\ [25 \times 3 \times 1]$$
$$(F_1(F_2(F_3F_4))) = 50\ [2 \times 25 \times 1]$$
$$((F_1(F_2(F_3F_4)))F_5) = 2000\ [2 \times 1 \times 1000]$$

$\therefore$ Total no. of multiplication required

$= 2000 + 50 + 75 + 48$

$= 2173$ (minimum number of multiplications).

Hence, the correct option is (C).

Question Number: 42 Question Type: MCQ

Consider the following C code. Assume that unsigned long int type length is 64 bits.

```
unsigned long int fun (unsigned long int n) {
unsigned long int i, j = 0, sum = 0;
for (i = n; i > 1. i = i/2) j++;
for (; j > 1; j = j/2) sum++;
return (sum);
}
```

The value returned when we call fun with the input 2^{40} is

(A) 4 (B) 5
(C) 6 (D) 40

Solution: For input 2^{40}, j get incremented to '40'

j = 40 sum=1	j = 20 sum=2	j = 10 sum=3	j = 5 sum=4	j = 2 sum=5

Hence, the correct option is (B).

Question Number: 43 **Question Type: MCQ**

Consider the unsigned 8-bit fixed point binary number representation below,

$$b_7\, b_6 b_5 b_4\, b_3 \cdot b_2\, b_1\, b_0$$

Where the position of the binary point is between b_3 and b_2. Assume b_7 is the most significant bit. Some of the decimal numbers listed below cannot be represented exactly in the above representation:

(i) 31.500 (ii) 0.875
(iii) 12.100 (iv) 3.001

Which one of the following statements is true?

(A) None of (i), (ii), (iii), (iv) can be exactly represented
(B) Only (ii) cannot be exactly represented
(C) Only (iii) and (iv) cannot be exactly represented
(D) Only (i) and (ii) cannot be exactly represented

Solution:

$$(31.500)_{10} = (11111.100)_2$$
$$(0.875)_{10} = (00000.111)_2$$
$$(12.100)_{10} = (01100.000110011\ldots..)_2$$
$$(3.001)_{10} = (00011.0000000001\ldots.)_2$$

Fraction part in the given representation is of only 3 - bits, (iii) and (iv) can't be represented accurately due to lack of storage.

Hence, the correct option is (C).

Question Number: 44 **Question Type: MCQ**

The size of the physical address space of a processor is 2^P bytes. The word length is 2^W bytes. The capacity of cache memory is 2^N bytes. The size of each cache block is 2^M words. For a K-way set-associative cache memory, the length (in number of bits) of the tag field is

(A) $P - N - \log_2 K$
(B) $P - N + \log_2 K$
(C) $P - N - M - W - \log_2 K$
(D) $P - N - M - W + \log_2 K$

Solution: Given main memory space = 2^M bytes

Physical address size = 'P' bits

Cache memory size = 2^N bytes

Then size of the block $= (2^{M+W})\ B$ (2^M words × 2^W bytes/word)

Number of lines $= 2^{N-M-W}$

Number of sets $= \dfrac{\text{Number of Cache memory}}{P\text{-way}}$

$$= \frac{2^{N-M-W}}{\log_2 K}$$

$\therefore$ The Tage size will be

$$= P - (M + W - \log_2 k + M + W)$$
$$= P - N + \log_2 K.$$

Hence, the correct option is (B).

Question Number: 45 **Question Type: MCQ**

Consider the following languages:

I. $\{a^m b^n c^p d^q \mid m + p = n + q$, where $m, n, p, q \geq 0\}$
II. $\{a^m b^n c^p d^q \mid m = n$ and $p = q$, where $m, n, p, q \geq 0\}$
III. $\{a^m b^n c^p d^q \mid m = n = p$ and $p \neq q$, where $m, n, p, q \geq 0\}$
IV. $\{a^m b^n c^p d^q \mid mn = p + q$, where $m, n, p, q \geq 0\}$

Which of the languages above are context-free?

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

Solution:

I. $\{a^m\, b^n\, c^p\, d^q \mid m + p = n + q\}$

The given language is context free language, as it can be implemented by using stack

II. $\{a^m\, b^n\, c^p\, d^q \mid m = n$ and $p = q\}$

The given language is CFL, as it can be implemented by using stack.

Hence, the correct option is (B).

Question Number: 46 **Question Type: MCQ**

Consider the following problems. $L(G)$ denotes the language generated by a grammer G. $L(M)$ denotes the language accepted by a machine M.

(I) For an unrestricted grammer G and a string w, whether $w \in L(G)$
(II) Given a Turing machine M, whether $L(M)$ is regular
(III) Given two grammars G_1 and G_2, whether $L(G_1) = L(G_2)$
(IV) Given and NFA N, whether there is a deterministic PDA P such that N and P accept the same language.

Which one of the following statements is correct?

(A) Only I and II are undecidable
(B) Only III is undecidable

(C) Only II and IV are undecidable
(D) Only I, II and III are undecidable

Solution:

I. Membership problem of unrestricted grammar (i.e. REL) is undecidable as there is a possibility of entering into infinite loop.
II. Every regular language is REL, but REL may or may not be regular. (undecidable)
III. As the type of grammar is not given, the equivalence problem is undecidable in REL.
IV. Every regular language is Deterministic CFL. (decidable)

Hence, the correct option is (D)

Question Number: 47 Question Type: MCQ

A lexical analyzer uses the following patterns to recognize three tokens T_1, T_2, and T_3 over the alphabet $\{a, b, c\}$.

T_1: $a?(b|c)^*a$

T_2: $b?(a|c)^*b$

T_3: $c?(b|a)^*c$

Note that 'x?' means 0 or 1 occurrence of the symbol x. Note also that the analyzer outputs the token that matches the longest possible prefix.

If the string bbaacabc is processed by the analyzer, which one of the following is the sequence of tokens it outputs?

(A) $T_1T_2T_3$ (B) $T_1T_1T_3$
(C) $T_2T_1T_3$ (D) T_3T_3

Solution: Given string is given below

$b\ b\ a\ a\ c\ a\ b\ c$

The longest possible prefix will be bbaac that can be obtained from T_3. $a\ b\ c$ is the another possible prefix obtained from T_3.

bbaac a b c
↓ ↓
T_3 T_3

Hence, the correct option is (D).

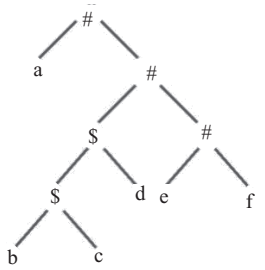
Question Number: 48 Question Type: MCQ

Consider the following parse tree for the expression $a\#b\$c\$d\#e\#f$, involving two binary operators \$ and #.

Which one of the following is correct for the given parse tree?

(A) \$ has higher precedence and is left associative; # is right associative
(B) # has higher precedence and is left associative; \$ is right associative
(C) \$ has higher precedence and is left associative; # is left associative
(D) # has higher precedence and is right associative; \$ is left associative

Solution:



The operator which appears at lower level of tree has higher precedence. Therefore '\$' has higher precedence.

operator is right associative, as right subtree is extended.

Hence, the correct option is (A).

Question Number: 49 Question Type: MCQ

In a system, there are three types of resources: E, F and G. Four processes P_0, P_1, P_2 and P_3 execute concurrently. At the outset, the processes have declared their maximum resource requirements using a matrix named Max as given below. For example, Max[P_2,F] is the maximum number of instances of F that P_2 would require. The number of instances of the resources allocated to the various processes at any given state is given by a matrix named Allocation.

Consider a state of the system with the Allocation matrix as shown below, and in which 3 instances of E and 3 instances of F are the only resources available.

Allocation			
	E	F	G
P_0	1	0	1
P_1	1	1	2
P_2	1	0	3
P_3	2	0	0

Max			
	E	F	G
P_0	4	3	1
P_1	2	1	4
P_2	1	3	3
P_3	5	4	1

From the perspective of deadlock avoidance, which one of the following is true?

(A) The system is in safe state.
(B) The system is not in safe state, but would be safe if one more instance of E were available
(C) The system is not in safe state, but would be safe if one more instance of F were available
(D) The system is not in safe state, but would be safe if one more instance of G were available

Solution:

	Max			Allocation			Need			Available			
	E	*F*	*G*	*E*	*F*	*G*	*E*	*F*	*G*	*E*(3)	*F*(3)	*G*(0)	
P_0	4	3	1	1	0	1	3	3	0	3 ↓	3 ↓	0 ↓	(On 'P_1' execution)
P_1	2	1	4	1	1	2	1	0	2	4 ↓	3 ↓	1 ↓	(On 'P_2' execution)
P_2	1	3	3	1	0	3	0	3	0	5 ↓	3 ↓	4 ↓	(On 'P_1' execution)
P_3	5	4	1	2	0	0	3	4	1	6 ↓	4 ↓	6 ↓	(On 'P_3' execution)
										8	4	6	

The system is in safe state, with safe sequence P_0, P_2, P_1, P_3.

Hence, the correct option is (A).

Question Number: 50 **Question Type: MCQ**

Consider the following solution to the producer-consumer synchronization problem. The shared buffer size is N. Three semaphores empty, full and mutex are defined with respective initial values of 0, N and 1. Semaphore empty denotes the number of available slots in the buffer, for the consumer to read from. Semaphore full denotes the number of available slots in the buffer, for the producer to write to. The placeholder variables, denoted by P, Q, R, and S, in the code below can be assigned either empty or full. The valid semaphore operations are: wait () and signal ().

Producer	Consumer

`do {`
`  wait(P);`
`  wait (mutex);`
`  //Add item to`
`  buffer`
`  signal (mutex);`
`  signal (Q);`
`} while (1);`
	`do {`
	`  wait(R);`
	`  wait (mutex);`
	`  //Consume item`
	`  from buffer`
	`  signal (mutex);`
	`  signal (S);`
	`} while (1);`

Which one of the following assignments to *P*, *Q*, *R* and *S* will yield the correct solution?

(A) *P*: full, *Q*: full, *R*: empty, *S*: empty
(B) *P*: empty, *Q*: empty, *R*: full, *S*: full
(C) *P*: full, *Q*: empty, *R*: empty, *S*: full
(D) *P*: empty, *Q*: full, R: full, S: empty

Solution: In the producer - consumer problem, producer keeps the item in buffer when the slots on the buffer are empty. While, it has to wait when the buffer is full. In the given problem, full denotes number of available slots in buffer, i.e. full will be 0, when there are no empty slots in buffer. So *P*: full.

When producer places an item in buffer, it implies there is increase in the number of available slots in the buffer, for the consumer to read from. This can be done by signal (empty). So, *Q*:empty

Similarly, consumer has to wait when there are no items to consume in buffer, which can be shown by wait (empty). So, *R*: empty

Once the consumer consumes item, it implies, there is increase in-the available slots in the buffer, for the producer to write to. So, *S*:full

Hence, the correct option is (C).

Question Number: 51 **Question Type: MCQ**

Consider the relations $r(A, B)$ and $s(B, C)$, where $s \cdot B$ is a primary key and $r \cdot B$ is a foreign key referencing $s \cdot B$. Consider the query

$$Q: r \triangleright\triangleleft (\sigma_{B<5}(S))$$

Let LOJ denote the natural left outer-join operation. Assume that r and s contain no null values.

Which one of the following queries is NOT equivalent to *Q*?

(A) $\sigma_{B<5}(r \triangleright\triangleleft s)$
(B) $\sigma_{B<5}(r \text{ LOJ } s)$
(C) $r \text{ LOJ } (\sigma_{B<5}(s))$
(D) $\sigma_{B<5}(r) \text{ LOJ } s$

Solution: Consider a data set

r

A	B
12	2
13	6
15	4
12	6
13	4
16	7

s

B	C
2	A
3	B
4	C
5	A
6	C

Q: $x \bowtie (\sigma_{B<5}(s))$

A	B	C
12	2	A
15	4	C
13	4	C

(A) $\sigma_{B<5}(r \bowtie s)$

A	B	C
12	2	A
15	4	C
13	4	C
13	6	C
12	6	C

(B) $\sigma_{B<5}(x$ LOJS)

A	B	C
12	2	A
13	6	C
15	4	C
12	6	C
13	4	C
16	7	–

(C) x LOJ $(\sigma_{B<5}(s))$

r LOJ

B	C
2	A
3	B
4	C

A	B	C
12	2	A
13	6	–
15	4	C
12	6	–
13	4	C
16	7	–

(D) $\sigma_{B<5}(x)$ LOJS

A	B
12	2
15	4
13	4

LOJS

A	B	C
12	2	A
15	4	C
13	4	C

Hence, the correct option is (C).

Question Number: 52 **Question Type: MCQ**

Consider the following four relational schemas. For each schema, all non-trivial functional dependencies are listed. The underlined attributes are the respective primary keys.

Schema I:

Registration (rollno, courses)

Field 'courses' is a set-valued attribute containing the set of courses a student has registered for.

Non-trivial functional dependency:

Rollno → courses

Schema II:

Registration (rollno, courseid, email)

Non-trivial functional dependencies:

Rollno, courseid → email

email → rollno

Schema III:

Registration (rollno, courseid, marks, grade)

Non-trivial functional dependencies:

Rollno, courseid → marks, grade

Marks → grade

Schema IV:

Registration (rollno, courseid, credit)

Non-trivial functional dependencies:

Rollno, courseid → credit

Courseid → credit

Which one of the relational schemas above is in 3NF but not in BCNF?

(A) Schema I (B) Schema II
(C) Schema III (D) Schema IV

Solution:

I. The given relation is not having transitivity dependency therefore it is in 3NF. For BCNF, every determinant should be candidate key as email is determinant but not candidate key, the given schema is not in BCNF.

Hence, the correct option is (B).

Question Number: 53 **Question Type: NAT**

Let G be a graph with 100! vertices, with each vertex labeled by a distinct permutation of the numbers 1, 2, …, 100. There is an edge between vertices u and v if and only if the label of u can be obtained by swapping two adjacent numbers in the label of v. Let y denote the degree of a vertex in G, and z denote the number of connected components in G.

Then, $y + 10z =$ _____.

Solution: As the label of a vertex in the graph G is a permutation of the numbers 1,2,3,….,100 and two vertices u and v of G are adjacent if and only if the label of one vertex can be obtained from the other by swapping two adjacent numbers,

If the label of a vertex u of G is 1,2,3,….,100

$\deg(u)$ = Number of ways of swapping two adjacent numbers in 1,2,3,…,100 = 99

Similarly, we can observe that every vertex will have the same degree.

$$\therefore \quad y = 99$$

Also, from any permutation consisting of the numbers 1,2,3,…,and 100, we can obtain any other permutation of the 100! permutations of 1,2,3,….,100 by a finite number of swaps with swapping two adjacent numbers at a time.

This means there exists a path from any vertex of G to any other vertex of G.

So G is a connected graph.

Hence, the number of connected components in

$$G = z = 1$$

So, $$y + 10z = 99 + 10 \times 1 = 109.$$

Hence, the correct answer is 109.

Question Number: 54 **Question Type: NAT**

Consider Guwahati (G) and Delhi (D) whose temperatures can be classified as high (H), medium (M) and low (L). Let $P(H_G)$ denote the probability that Guwahati has high temperature. Similarly, $P(M_G)$ and $P(L_G)$ denotes the probability of Guwahati having medium and low temperatures respectively. Similarly, we use $P(H_D)$, $P(M_D)$ and $P(L_D)$ for Delhi.

The following table gives the conditional probabilities for Delhi's temperature given Guwahati's temperature.

	H_D	M_D	L_D
H_G	0.40	0.48	0.12
M_G	0.10	0.65	0.25
L_G	0.01	0.50	0.49

Consider the first row in the table above. The first entry denotes that if Guwahati has high temperature (H_G) then the probability of Delhi also having a high temperature (H_D) is 0.40; i.e., $P(H_D|H_G) = 0.40$. Similarly, the next two entries are

$$P(M_D|H_G) = 0.48 \text{ and } P(L_D|H_G) = 0.12.$$

Similarly for the other rows.

If it is known that $P(H_G) = 0.2$, $P(M_G) = 0.5$, and $P(L_G) = 0.3$, then the probability (correct to two decimal places) that Guwahati has high temperature given that Delhi has high temperature is _____.

Solution: Probability that Guwahati has high temperature given that Delhi has high temperature

$$P(H_G/H_D) = \frac{P(H_G)P(H_D/H_G)}{P(H_G)P(H_D/H_G) + P(M_G)P(H_D/M_G) + P(L_G)P(H_D/L_G)}$$

(By Baye's theorem)

Substituting these in the above, we have

$$P(H_G/H_D) = \frac{0.2 \times 0.40}{0.2 \times 0.40 + 0.5 \times 0.1 + 0.3 \times 0.01}$$

$$= 0.601$$

Hence, the correct answer is 0.60 to 0.62.

Question Number: 55 **Question Type: NAT**

Consider the following program written in pseudo-code. Assume that x and y are integers.

```
Count (x,y) {
if (y ! = 1) {
    if (x ! = 1) {
        print ("*");
        Count (x/2, y);
    }
    else {
        y = y-1;

        Count (1024, y);
        }
    }
}
```

The number of times that the print statement is executed by the call count (1024, 1024) is _____.

Solution: The number of times that the print statement is executed = (1023 * 10)

$$= 10230$$

Hence, the correct answer is 10230.

Question Number: 56 **Question Type: NAT**

The number of possible min-heaps containing each value from {1, 2, 3, 4, 5, 6, 7} exactly once is _____.

Solution: For min - heap, only root possible is '1'.

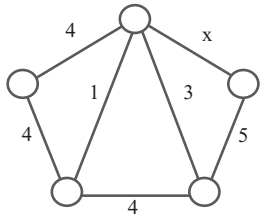
The total ways to design a min heap

$$f(N) = ({}^{N-1}C_L) \times f(L) \times f(R)$$
$$L = 2^{K-1} - 1 + \min(2^{K-1}, m)$$
$$R = 2^{K-1} - 1 + \max(0, m - 2^{K-1})$$
$$M = 1 + N - 2K$$
$$N = 7, M = 4 \text{ (no. of leaf nodes)}$$
$$4 = 1 + 7 - 2K$$
$$2K = 1 + 7 - 4$$
$$2K = 4$$
$$K = 2$$
$$f(7) = {}^{6}C_3 \times f(3) \times f(3)$$
$$L = 2^1 - 1 + \min(2^1, 4)$$
$$= 2 - 1 + 2 = 3$$
$$R = 2^1 - 1 + \max(0, 4 - 2^1)$$
$$= 2 - 1 + 2 = 3$$
$$f(3) = {}^{2}C_1 \times f(1) \times f(1) = 2 \times 1 \times 1 = 2$$
$$f(7) = \frac{6!}{3!3!} \times 2 \times 2 = \frac{6 \times 5 \times 4 \times 3!}{3 \times 2 \times 3!} \times 2 \times 2$$
$$= 80.$$

Hence, the correct answer is 80.

Question Number: 57 **Question Type: NAT**

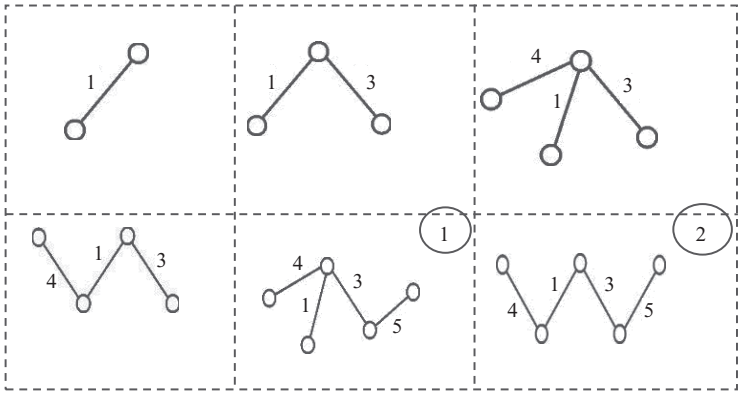
Consider the following undirected graph G:



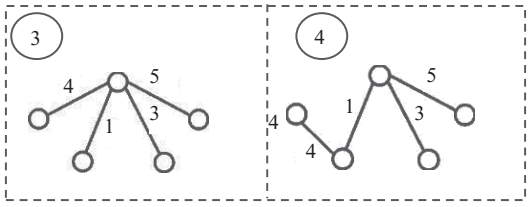
Choose a value for x that will maximize the number of minimum weight spanning trees (MWSTs) of G. The number of MWSTs of G for this value of x is _____.

Solution: Consider Kruskal's algorithm to find Minimum Weight Spanning Tree (MWST).

Arrange the edges in ascending order 1, 3, 4, 4, 4, 5, ssx



If $x = 5$



if x < = 4, then vertex with weight '4' will be considered every time, and If $x > 5$, then vertex with weight '5' will be considered everytime - which gives total of 2-spanning trees. When $x = 5$, there will be two choices, which gives total of 4 spanning trees.

Hence, the correct answer is 4.

Question Number: 58 **Question Type: NAT**

Consider the weights and values of items listed below. Note that there is only one unit of each item.

Item no.	Weight (in Kgs)	Value (in Rupees)
1	10	60
2	7	28
3	4	20
4	2	24

The task is to pick a subset of these items such that their total weight is no more than 11 Kgs and their total value is maximized. Moreover, no item may be split. The total value of items picked by an optimal algorithm is denoted by V_{opt}. A greedy algorithm sorts the items by their value-to-weight ratios in descending order and packs them greedily, starting from the first item in the ordered list. The total value of items picked by the greedy algorithm is denoted by V_{greedy}. The value of $V_{opt} - V_{greedy}$ is _____.

Solution: It is 0/1 knapsack problem max $\sum_{i=1}^{n} p_i x_i$.

Subject to $= \sum_{1}^{n} w_i x_i \le m$

$x_i = 0$ or 1

$1 \le i \le n$

$M = 11$ kgs

Item no.	Weight (in kgs)	value (in rupees)	v/w
1	10	60	6
2	7	28	4
3	4	20	5
4	2	24	12

v/w in descending order:

12	6	5	4
x_4	x_1	x_3	x_2
✓		✓	

$(2 + 4 \le 11$

$6 \le 11$

$\therefore \quad V_{greedy} = \sum p_i x_i$

$= 24 + 20$

$= 44$

$S^0 = \{(0, 0)\}$, $S_1^0 = \{(60, 10)\}$ $\Big\rangle S^1 = \{(0, 0), (60, 10)\}$

$S_1^1 = \{(28, 7), (88, 17)\}$

$\{\because 17 > 11$ overflow$\}$

$S^2 = \{(0, 0), (60, 10), (28, 7)\}$

$S_1^2 = \{(20, 4), (80, 14), (48, 11)\}$

$\{\because 14 > 11$ overflow$\}$

$S^3 = \{(0, 0), (60, 10), (28, 7), (20, 4), (48, 11)\}$

$S_1^3 = \{(24, 2), (84, 12), (52, 9), (44, 6), (72, 13)\}$

$\{\because 12 > 11, 13 > 11$ overflow$\}$

$S^4 = \{(0, 0), (60, 10), (28, 7), (20, 4), (48, 11), (24, 2), (52, 9), (44, 6)\}$

Optimal solution is (60, 10) after back tracking $x_1 = 1$,

$\therefore \quad V_{opt} = \sum p_i x_i = 60$

The value

$V_{opt} - V_{greedy} = 60 - 44$

$= 16$

Hence, the correct answer is 16.

Question Number: 59 **Question Type: NAT**

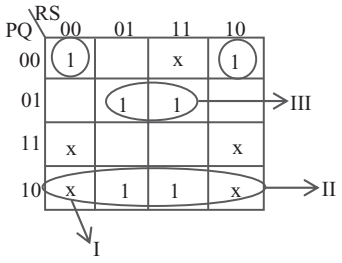
Consider the minterm list form of a Boolean function F given below.

$$F(P, Q, R, S) = \sum m(0,2,5,7,9,11) + d(3,8,10,12,14)$$

Here, m denotes a minterm and d denotes a don't care term. The number of essential prime implicants of the function F is _____.

Solution:

$F(P, Q, R, S) = \Sigma\, m(0, 2, 5, 7, 9, 11) + d(3, 8, 10, 12, 14)$



I, II,III all are essential prime implicants

$\therefore$ 3 essential prime implicants

Hence, the correct answer is 3.

Question Number: 60 **Question Type: NAT**

The instruction pipeline of a RISC processor has the following stages: Instruction Fetch (IF), Instruction Decode (ID), Operand Fetch (OF), Perform Operation (PO) and Writeback (WB). The IF, ID, OF and WB stages take 1 clock cycle each for every instruction. Consider a sequence of 100 instructions. In the PO stage, 40 instructions take 3 clock cycles each, 35 instructions take 2 clock cycles each, and the remaining 25 instructions take 1 clock cycle each. Assume that there are no data hazards and no control hazards.

The number of clock cycles required for completion of execution of the sequence of instructions is _____.

Solution: From the given question, there are three types of questions, based on number cycles required by PO stage, and remaining stages in instruction takes one cycle each.

	Number of instructions	Number of cycles required by PO stage	Number of cycles required for Instruction execution
Type 1	40	3	7
Type 2	35	2	6
Type 3	25	1	5

Type 1 instruction executions ends on 124^{th} cycle.

Similarly, Type 2 Instruction execution ends on 194^{th} cycle and Type 3 Instructions execution ends on 219^{th} cycle.

In other words, Number of clock cycles required are

$$= 1 + 1 + 1 + [(40 \times 3) + (35 \times 2) + (25 \times 1)] + 1$$

$$= 219$$

Hence, the correct answer is 219.

Question Number: 61 **Question Type: NAT**

A processor has 16 integer registers ($R0$, $R1$, .., $R15$) and 64 floating point registers ($F0$, $F1$…., $F63$). It uses a 2-byte instruction format. There are four categories of instructions: Type-1, Type-2, Type-3, and Type-4. Type-1 category consists of four instructions, each with 3 integer register operands (3Rs). Type-2 category consists of eight instructions, each with 2 floating point register operands (2Fs). Type-3 category consists of fourteen instructions, each with one integer register operand and one floating point register operand ($1R + 1F$). Type-4 category consists of N instructions, each with a floating point register operand ($1F$).

The maximum value of N is _____.

Solution: Instruction size = 16 bits

Integer register requires 4 bits

Floating point register requires 6 bits

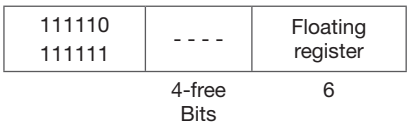
- Both Type1 and Type2 opcode sizes will be 4-bits in which max number of instructions to be formulated are 16, but it uses 12 instructions out of 16, other 4 combinations are reserved for tpe-3.
- Similarly for Type-3, Number of instruction produced are maximum 16 bit instructions, it uses 14 instructions out of 16.

  from 110000 to 111101

  and

  111110 and 111111 are combinations used for Type-4 instructions.

Type-4:



For each, there will be free combination of first 6-bit opcode and 4-bits are used for Type-4 instructions.

$\therefore$ Maximum number of instructions to be formed = $2 \times 2^4 = 32$

Hence, the correct answer is 32.

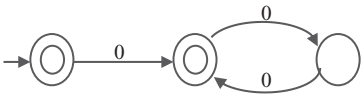
Question Number: 62 **Question Type: NAT**

Given a language L, define L^i as follows:

$$L^0 = \{\varepsilon\}$$

$$L^i = L^{i-1} \text{ . L for all } i > 0$$

The order of a language L is defined as the smallest k such that $L^k = L^{k+1}$. Consider the language L_1 (over alphabet 0) accepted by the following automaton.



The order of L_1 is _____ .

Solution:

$$L_1 = \{\varepsilon, 0, 000, 00000, ...\}$$

$$L^0 = \{\varepsilon\}$$

$$L^1 = L^0 \cdot L_1$$

$$L^1 = \{\varepsilon, 0, 000, 00000, ...\}$$

$$L^2 = L^1 \cdot L_1$$

$$L^2 = \{\varepsilon, 0, 000, 0000, ...\}$$

$$L^3 = L^2 \cdot L_1$$

$$L^3 = \{\varepsilon, 0, 00, 0000, 00000, ...\}$$

$\therefore$ $L^2 = L^3$

So, $K = 2$.

Hence, the correct answer is 2.

Question Number: 63 **Question Type: NAT**

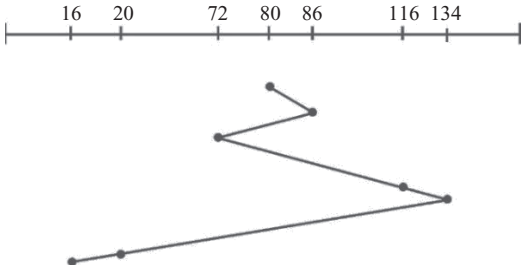
Consider a storage disk with 4 platters (numbered as 0, 1, 2 and 3), 200 cylinders (numbered as 0, 1, ….., 199), and 256 sectors per track (numbered as 0, 1, …., 255). The following 6 disk requests of the form [sector number, cylinder number, platter number] are received by the disk controller at the same time:

[120, 72, 2], [180, 134, 1], [60, 20, 0], [212, 86, 3], [56, 116, 2], [118, 16, 1]

Currently the head is positioned at sector number 100 of cylinder 80, and is moving towards higher cylinder numbers.The average power dissipation in moving the head over 100 cylinders is 20 milliwatts and for reversing the direction of the head movement once is 15 milliwatts. Power dissipation associated with rotational latency and switching of head between different platters is negligible.

The total power consumption in milliwatts to satisfy all of the above disk requests using the Shortest Seek Time First disk scheduling algorithm is _____.

Solution: Disk requests in cylinders are 72, 134, 2.0, 8.6, 116, 16 currently it is at 80.



Number of head movements

$$= |86 - 80| + |72 - 86| + |116 - 72| + |134 - 116| + |20 - 134| + |20 - 16|$$

$$= 200$$

Average power dissipation for 200 cylinders = 40 milliwatt and there are 3 reversals of head movement direction which takes 45 milliwatt.

Total power consumption

$$= 40 + 45 \Rightarrow 85 \text{ milliwatt.}$$

Hence, the correct answer is 85.

Question Number: 64 **Question Type: NAT**

Consider an IP packet with a length of 4,500 bytes that includes a 20-byte IPv4 header and a 40-byte TCP header. The packet is forwarded to an IPv4 router that supports a Maximum Transmission Unit (MTU) of 600 bytes. Assume that the length of the IP header in all the outgoing fragments of this packet is 20 bytes. Assume that the fragmentation offset value stored in the first fragment is 0.

The fragmentation offset value stored in the third fragment is _____ .

Solution: Data packet length = 4.500B

TCP header = 40 bytes

IP header = 20 bites

Given maximum transmission unit of 600 Bytes

Data packet will be

Data	Header
580	20

The fragmented Bytes and its offset are

	1st fragment	2nd fragment	3rd fragment
	576	576	576
	+	+	+
	20	20	20
Fragment offset	0	72	144

Hence, the correct answer is 144.

Question Number: 65 **Question Type: NAT**

Consider a simple communication system where multiple nodes are connected by a shared broadcast medium (like Ethernet or wireless). The nodes in the system use the following carrier-sense based medium access protocol. A node that receives a packet to transmit will carrier-sense the medium for 5 units of time. If the node does not detect any other transmission in this duration, it starts transmitting its packet in the next time unit. If the node detects another transmission, it waits until this other transmission finishes, and then begins to carrier-sense for 5 time units again. Once they start to transmit, nodes do not perform any collision detection and continue transmission even if a collision occurs. All transmissions last for 20 units of time. Assume that the transmission signal travels at the speed of 10 meters per unit time in the medium.

Assume that the system has two nodes P and Q, located at a distance d meters from each other. P starts transmitting a packet at time $t = 0$ after successfully completing its carrier-sense phase. Node Q has a packet to transmit at time $t = 0$ and begins to carrier-sense medium.

The maximum distance d (in meters, rounded to the closest integer) that allows Q to successfully avoid a collision between its proposed transmission and P's ongoing transmission is _____.

Solution: Given channel sensing time = 5 units time.

As a packet travel time = 10 meters/sec

For avoiding collision for Q, the distance should be 50 meters.

Hence, the correct answer is 50.