

GATE 2015 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 Question.

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**

Didn't you buy _____ when you went shopping?
(A) any paper (B) much paper
(C) no paper (D) a few paper

Solution: The use of 'any paper' is correct. The use of 'a few' would have been correct had it been followed by 'papers' and 'not paper'. The rest of the choices render the sentence incorrect.

Hence, the correct option is (A).

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

Which of the following options is the closest in meaning to the sentence below?

She enjoyed herself immensely at the party.

- (A) She had a terrible time at the party
- (B) She had a horrible time at the party
- (C) She had a terrific time at the party
- (D) She had a terrifying time at the party

Solution: The question statement means that the girl had a very good time at the party. Choice (C) brings this out. 'Terrific' means extremely good and is used in a positive connotation. The other choices have negative contexts.

Hence, the correct option is (C).

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

Which one of the following combinations is incorrect?

- (A) Acquiescence–Submission
- (B) Wheedle–Roundabout
- (C) Flippancy–Lightness
- (D) Profligate–Extravagant

Solution: 'Acquiescence' means 'submission' 'Wheedle' is to persuade someone to do something for you. 'Roundabout' means indirect. 'Flippancy' means a lack of seriousness in grave matters. 'Lightness' means the same. 'Profligate' means 'extravagant'. Thus, choice (B) is the incorrect option.

Hence, the correct option is (B).

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

Based on the given statements, select the most appropriate option to solve the given question.

If two floors in a certain building are 9 feet apart, how many steps are there in a set of stairs that extends from the first floor to the second floor of the building?

Statements:

- (I) Each step is $\frac{3}{4}$ foot high.
- (II) Each step is 1 foot wide.
- (A) Statement I alone is sufficient but statement II alone is not sufficient.
- (B) Statement II alone is sufficient, but statement I alone is not sufficient.
- (C) Both statements together are sufficient, but neither statement alone is sufficient.
- (D) Statement I and II together are not sufficient.

Solution: The distance between the 2 floors of the building is 9 feet. And we are asked to find the number steps from first floor to second floor.

From I:

If each step is $\frac{3}{4}$ th foot.

Let there be a total of n steps from first floor to record floor.

$$\frac{3}{4} \times n = 9 \Rightarrow n = \frac{4 \times 9}{3} = 12$$

So, I alone gives this answer

II speaks about the width of each step. From width we cannot get the number; of steps between 1st and 2nd floors.

Hence, the correct option is (A).

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

Given Set A = {2, 3, 4, 5} and Set B = {11, 12, 13, 14, 15}, two numbers are randomly selected, one from each set. What is the probability that the sum of the two numbers equals 16?

- (A) 0.20 (B) 0.25
- (C) 0.30 (D) 0.33

Solution: Let the numbers randomly selected from set A and set B be a and b respectively.

The number of (a, b) that can be formed taking a from A and b from B is $4 \times 5 = 20$. And the (a, b) for which $a + b = 16$ are $(2, 14), (3, 13), (4, 12), (5, 11)$.

Number of favourable selections = 4

$$\text{Required probability} = \frac{4}{20} = 0.2$$

Hence, the correct option is (A).

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

Select the alternative meaning of the underlined part of the sentence.

The chain snatchers took to their heels when the police party arrived.

- (A) took shelter in a thick jungle
- (B) open indiscriminate fire
- (C) took to flight
- (D) unconditionally surrendered

Solution: 'Took to their heels' means to run away. This supports choice (C). The other answer choices are incorrect. Hence, the correct option is (C).

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

The given statement is followed by some courses of action. Assuming the statement to be true, decide the correct option.

Statement:

There has been significant drop in the water level in the lakes supplying water to the city.

Course of action:

- (I) The water supply authority should impose a partial cut in supply to tackle the situation.
 - (II) The government should appeal to all the residents through mass media for minimal use of water.
 - (III) The government should ban the water supply in lower areas.
- (A) Statements I and II follow.
 - (B) Statements I and III follow.
 - (C) Statements II and III follow.
 - (D) All statements follow.

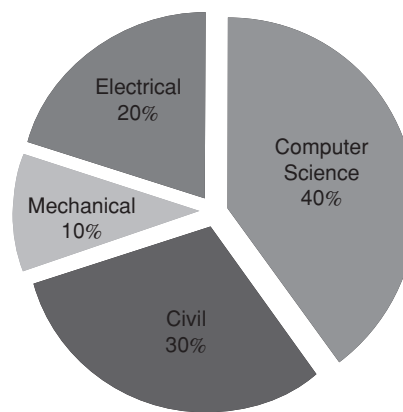
Solution: When there is a significant drop in the water level in the lakes supplying water in the city. The plausible course of action has to be the ones which are practically possible. Among the three given courses of action. only I and II are practically possible. III speaks about banning the water supply in lower areas.

This is not an appropriate solution to the existing problem. And stopping or banning water in the lower areas for proper supply in the city is unethical as well.

Hence, the correct option is (A).

Question Number: 8 **Question Type: NAT**

The pie chart below has the breakup of the number of students from different departments in an engineering college for the year 2012. The proportion of male to female students in each department is 5:4. There are 40 males in Electrical Engineering. What is the difference between the numbers of female students in the Civil department and the female students in the Mechanical department?



Solution: Number of students in the Electrical Engineering department = $40 \left(\frac{9}{5} \right) = 72$

Number of students in the Civil department = $\frac{30}{20} (72) = 108$

Number of students in the Mechanical department = $\frac{10}{20} (72) = 36$

Number of female students in the Civil and the Mechanical departments are $108 \left(\frac{4}{9} \right)$ and $36 \left(\frac{4}{9} \right)$ respectively i.e., 48 and 16 respectively. Difference is $48 - 16$ i.e., 32.

Hence, the correct option is (32).

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

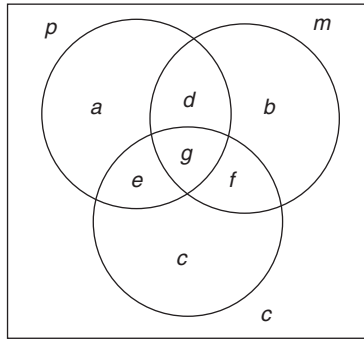
The probabilities that a student passes in Mathematics, Physics and Chemistry are m, p and c respectively. Of these subjects, the student has 75% chance of passing in at least one, a 50% chance of passing in at least two and a 40% chance of passing in exactly two. Following relations are drawn in m, p, c :

- (I) $p + m + c = 27/20$
- (II) $p + m + c = 13/20$
- (III) $(p) \times (m) \times (c) = 1/10$

- (A) Only relation I is true.
- (B) Only relation II is true.
- (C) Relations II and III are true.
- (D) Relations I and III are true.

Solution: VD for probabilities

Total = 1



$$p + m + c = a + b + c + 2(d + e + f) + 3g = (a + b + c + d + e + f + g) + (d + e + f + 2g)$$

$$= \frac{75}{100} + \frac{40}{100} + \frac{20}{100} = \frac{27}{20} \Rightarrow \text{I is true and II is not true.}$$

(p) (m) (c) = probability (The student passing in all the three

$$\text{subjects}) = \frac{50}{100} - \frac{40}{100} = \frac{10}{100} = \frac{1}{10}$$

Hence, I and III are true.

Hence, the correct option is (D).

Question Number: 10

Question Type: MCQ

The number of students in a class who have answered correctly, wrongly, or not attempted each question in an exam, are listed in the table below. The marks for each question are also listed. There is no negative or partial marking.

| Q.No. | Marks | Answered Correctly | Answered Wrongly | Not Attempted |
|-------|-------|--------------------|------------------|---------------|
| 1 | 2 | 21 | 17 | 6 |
| 2 | 3 | 15 | 27 | 2 |
| 3 | 1 | 11 | 29 | 4 |
| 4 | 2 | 23 | 18 | 3 |
| 5 | 5 | 31 | 12 | 1 |

What is the average of the marks obtained by the class in the examination?

- (A) 2.290 (B) 2.970
(C) 6.795 (D) 8.795

Solution: Average of the marks obtained by the class

$$= \frac{2(21) + 3(15) + 1(11) + 2(23) + 5(31)}{\text{Total number of students}} = \frac{299}{44} = 6.795$$

Hence, the correct option is (C).

COMPUTER SCIENCE AND INFORMATION TECHNOLOGY

Number of Questions: 55

Section marks: 85.0

Q.11 to Q.35 carry 1 mark each and Q.36 to Q.65 carry 2 marks each.

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

If $g(x) = 1 - x$ and $h(x) = \frac{x}{x-1}$, then $\frac{g(h(x))}{h(g(x))}$ is

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

Solution: Given $g(x) = 1 - x$ and $h(x) = \frac{x}{x-1}$

Consider $\frac{g(h(x))}{h(g(x))} = \frac{g\left(\frac{x}{x-1}\right)}{h(1-x)}$

$$= \frac{\left[1 - \left(\frac{x}{x-1}\right)\right]}{\left[\frac{(1-x)}{(1-x)-1}\right]} \Rightarrow \frac{\left[\frac{-1}{(x-1)}\right]}{\left[\frac{(1-x)}{-x}\right]}$$

$$= \frac{\left[\frac{x}{(x-1)}\right]}{[1-x]} = \frac{h(x)}{g(x)}$$

Hence, the correct option is (A).

Question Number: 12

Question Type: MCQ

$\lim_{x \rightarrow \infty} x^{1/x}$ is

- (A) ∞ (B) 0
(C) 1 (D) Not defined

Solution: Let $y = \lim_{x \rightarrow \infty} x^{1/x}$

$$\Rightarrow \ln y = \ln \left(\lim_{x \rightarrow \infty} x^{1/x} \right) \Rightarrow = \lim_{x \rightarrow \infty} [\ln(x^{1/x})]$$

$$= \lim_{x \rightarrow \infty} \left[\frac{1}{x} \ln(x) \right] \Rightarrow = \lim_{x \rightarrow \infty} \left[\frac{\ln x}{x} \right]$$

$$= \lim_{x \rightarrow \infty} \left[\frac{1}{x} \right] \text{ [By L' Hospital's Rule]}$$

$$\therefore \ln y = 0 \Rightarrow y = 1$$

$$\Rightarrow \lim_{x \rightarrow \infty} x^{1/x} = 1$$

Hence, the correct option is (C).

Question Number: 13

Question Type: MCQ

Match the following

| | |
|---|---------------------------|
| (P) prim's algorithm for minimum spanning tree | (i) Backtracking |
| (Q) Floyd-Warshall algorithm for all pairs shortest paths | (ii) Greedy method |
| (R) Mergesort | (iii) Dynamic programming |
| (S) Hamiltonian circuit | (iv) Divide and conquer |

- (A) P-iii, Q-ii, R-iv, S-i
- (B) P-i, Q-ii, R-iv, S-iii
- (C) P-ii, Q-iii, R-iv, S-i
- (D) P-ii, Q-i, R-iii, S-iv

Solution: Prim's algorithm for minimum spanning tree

- Greedy Method.
- Floyd-Warshall algorithm for all pairs shortest paths-Dynamic programming.
- Merge sort-Divide and conquer
- Hamiltonian circuit-Back tracking.

Hence, the correct option is (C).

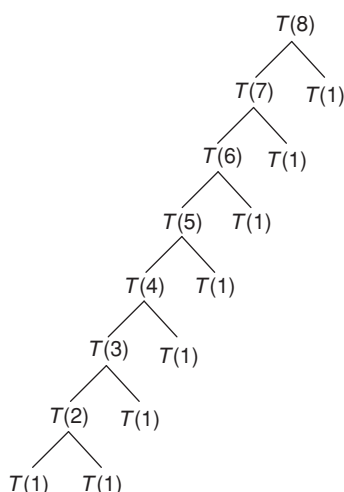
Question Number: 14 **Question Type: MCQ**

Which one of the following is the recurrence equation for the worst case time complexity of the Quicksort algorithm for sorting $n(\geq 2)$ numbers? In the recurrence equations given in the options below, c is a constant.

- (A) $T(n) = 2T(n/2) + cn$
- (B) $T(n) = T(n-1) + T(1) + cn$
- (C) $T(n) = 2T(n-1) + cn$
- (D) $T(n) = T(n/2) + cn$

Solution: The Worst Quick sort Recurrence Tree:

Example: Suppose $n = 8$



The Recurrence equation is $T(n) = T(n-1) + T(1) + cn$.

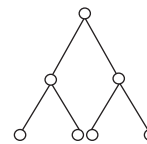
Hence, the correct option is (B).

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

The height of a tree is the length of the longest root-to-leaf path in it. The maximum and minimum number of nodes in a binary tree of height 5 are

- (A) 63 and 6, respectively
- (B) 64 and 5, respectively
- (C) 32 and 6, respectively
- (D) 31 and 5, respectively

Solution: Height = 2(max nodes = 7)



Maximum number of nodes $2^{h+1} - 1$

\therefore Height = 5(max nodes 63)



Height = 2(min nodes = 3)

\therefore Height = 5(min nodes = 6)

\therefore minimum number of nodes = $h + 1$

\therefore 63 and 6

Hence, the correct option is (A).

Question Number: 16

Question Type: MCQ

Match the following:

| | |
|------------------------------------|--------------------------|
| (P) Condition coverage | (i) Black-box testing |
| (Q) Equivalence class partitioning | (ii) System testing |
| (R) Volume testing | (iii) White-box testing |
| (S) Alpha testing | (iv) Performance testing |

(A) P-ii, Q-iii, R-i, S-iv

(B) P-iii, Q-iv, R-ii, S-i

(C) P-iii, Q-i, R-iv, S-ii

(D) P-iii, Q-i, R-ii, S-iv

Solution: Condition coverage-White-Box testing

Equivalence class partitioning-Black-Box testing

Volume testing-Performance testing

Alpha testing-System testing

Hence, the correct option is (C).

Question Number: 17

Question Type: MCQ

Which of the following is/are correct inorder traversal sequence(s) of binary search tree(s)?

- I. 3, 5, 7, 8, 15, 19, 25
- II. 5, 8, 9, 12, 10, 15, 25
- III. 2, 7, 10, 8, 14, 16, 20
- IV. 4, 6, 7, 9, 18, 20, 25

(A) I and IV only

(B) II and III only

(C) II and IV only

(D) II only

Solution: The in order traversal of Binary search tree results in ascending order of the node elements.

In given question option (I) and (IV) are sorted in ascending order.

\therefore I and IV are correct in-order traversal.

Hence, the correct option is (A).

Question Number: 18

Question Type: MCQ

Which one of the following is TRUE at any valid state in shift-reduce parsing?

- (A) Viable prefixes appear only at the bottom of the stack and not inside.

- (B) Viable prefixes appear only at the top of the stack and not inside.
- (C) The stack contains only a set of viable prefixes.
- (D) The stack never contains viable prefixes.

Solution: The prefixes of right sentential forms that can appear on the stack of a shift-reduce parser are called viable prefixes.

The stack will contain only a set of viable prefixes.

Hence, the correct option is (C).

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

Which one of the following is NOT equivalent to $p \leftrightarrow q$?

- (A) $(\neg p \vee q) \wedge (p \vee \neg q)$
- (B) $(\neg p \vee q) \wedge (q \rightarrow p)$
- (C) $(\neg p \wedge q) \vee (p \wedge \neg q)$
- (D) $(\neg p \wedge q) \vee (p \wedge q)$

Solution: $p \leftrightarrow q$ biconditional or xnor

$$\begin{aligned} (p \leftrightarrow q) &= (\neg p \vee q) \wedge (p \vee \neg q) = (p \wedge q) \vee (\neg p \wedge \neg q) \\ &= (\neg p \vee q) \wedge (q \rightarrow p) \\ &\because q \rightarrow p = (\neg q \vee p) \end{aligned}$$

Hence, the correct option is (C).

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

For a set A, the power set of A is denoted by 2^A . If $A = \{5, \{6\}, \{7\}\}$, which of the following options are TRUE?

- I. $\emptyset \in 2^A$
- II. $\emptyset \subseteq 2^A$
- III. $\{5, \{6\}\} \in 2^A$
- IV. $\{5, \{6\}\} \subseteq 2^A$
- (A) I and III only
- (B) II and III only
- (C) I, II and III only
- (D) I, II and IV only

Solution: Given $A = \{5, \{6\}, \{7\}\}$

\Rightarrow The power set of $A = 2^A = \{\emptyset, \{5\}, \{\{6\}\}, \{\{7\}\}, \{5, \{6\}\}, \{\{6\}, \{7\}\}, \{\{7\}, 5\}, \{5, \{6\}, \{7\}\}\}$

Clearly $\emptyset \in 2^A$

\therefore I is TRUE

Because the null set \emptyset is a subset of every set,

$\emptyset \subseteq 2^A$

\therefore II is TRUE

As $\{5, \{6\}\}$ is an element of 2^A $\{5, \{6\}\} \in 2^A$

\therefore III is TRUE

An element of a set cannot be subset of that set.

$\therefore \{5, \{6\}\} \not\subseteq 2^A$

\therefore IV is NOT TRUE.

Note that $\{5, \{6\}\} \notin 2^A$, but $\{\{5, \{6\}\}\} \in 2^A$

Hence, I, II and III are only TRUE.

Hence, the correct option is (C).

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

Consider a 4-bit Johnson counter with an initial value of 0000. The counting sequence of this counter is

- (A) 0, 1, 3, 7, 15, 14, 12, 8, 0
- (B) 0, 1, 3, 5, 7, 9, 11, 13, 15, 0
- (C) 0, 2, 4, 6, 8, 10, 12, 14, 0
- (D) 0, 8, 12, 14, 15, 7, 3, 1, 0

Solution: 4-bit Johnson counter (or) twisted ring counter

| Clk | Q ₃ | Q ₂ | Q ₁ | Q ₀ | Value |
|-----|----------------|----------------|----------------|----------------|-------|
| 0 | 0 | 0 | 0 | 0 | 0 |
| 1 | 1 | 0 | 0 | 0 | 8 |
| 2 | 1 | 1 | 0 | 0 | 12 |
| 3 | 1 | 1 | 1 | 0 | 14 |
| 4 | 1 | 1 | 1 | 1 | 15 |
| 5 | 0 | 1 | 1 | 1 | 7 |
| 6 | 0 | 0 | 1 | 1 | 3 |
| 7 | 0 | 0 | 0 | 1 | 1 |
| 8 | 0 | 0 | 0 | 0 | 0 |

Hence, the correct option is (D).

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

For computers based on three-address instruction formats, each address field can be used to specify which of the following:

- (S₁) A memory operand
- (S₂) A processor register
- (S₃) An implied accumulator register

- (A) Either S₁ or S₂
- (B) Either S₂ or S₃
- (C) Only S₂ and S₃
- (D) All of S₁, S₂ and S₃

Solution: Computer with 3 address instruction format can use each address field to specify either processor register (or) memory operand.

Example:

$$\begin{aligned} \text{ADD } R_1, A, B & \quad R_1 \leftarrow M[A] + M[B] \\ \text{ADD } R_2, C, D & \quad R_2 \leftarrow M[C] + M[D] \\ \text{MUL } X, R_1, R_2 & \quad M[X] \leftarrow R_1 * R_2 \end{aligned}$$

Hence, the correct option is (A).

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

Suppose two hosts use a TCP connection to transfer a large file. Which of the following statements is/are FALSE with respect to the TCP connection?

- I. If the sequence number of a segment is m , then the sequence number of the sub sequent segment is always $m + 1$.
 - II. If the estimated round trip time at any given point of time is t sec, the value of the retransmission timeout is always set to greater than or equal to t sec.
 - III. The size of the advertised window never changes during the course of the TCP connection.
 - IV. The number of unacknowledged bytes at the sender is always less than or equal to the advertised window.
- (A) III only
 - (B) I and III only
 - (C) I and IV only
 - (D) II and IV only

Solution: I. The sequence number of the subsequent segment depends on the number of 8 byte characters of the current segment (False)

II. Window will keep changing depending on network traffic and processing capability.

Hence, the correct option is (B).

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

Suppose that everyone in a group of N people wants to communicate secretly with the $N - 1$ others, using symmetric key cryptographic system. The communication between any two persons should not be decodable by the others in the group. The number of keys required in the system as a whole to satisfy the confidentiality requirement is

- (A) $2N$ (B) $N(N - 1)$
 (C) $N(N - 1)/2$ (D) $(N - 1)^2$

Solution: In symmetric key cryptography, If there are ' n ' number of users, then we need $\frac{n(n-1)}{2}$ keys.

Hence, the correct option is (C).

Question Number: 25 **Question Type: MCQ**

Which of the following statements is/are FALSE?

- I. XML overcomes the limitations in HTML to support a structured way of organizing content.
- II. XML specification is not case sensitive while HTML specification is case sensitive.
- III. XML supports user defined tags while HTML uses pre-defined tags.
- IV. XML tags need not be closed while HTML tags must be closed.

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

Solution:

- XML over comes the limitations in HTML (TRUE)
- HTML is not case sensitive
- XML is case sensitive
- XML supports user defined tags (TRUE)
- XML tags must be closed.

Hence, the correct option is (C).

Question Number: 26 **Question Type: MCQ**

Which one of the following fields of an IP header is NOT modified by a typical IP router?

- (A) Checksum (B) Source address
 (C) Time to Live (TTL) (D) Length

Solution:

Checksum: Checksum is calculated at each Router, because the value of TTL will be decremented at each Router.

TTL: (Time-to-Live)

The value of TTL will be decremented at each router, once the value of TTL becomes '0', the packet will be discarded.

Length: The maximum header length is 15 words (i.e., 60 bytes) minimum is 20 bytes, but the options may make it bigger.

Example: When a packet is fragmented at a Router, having the Router put in a IP address of a router and a time stamp so the final destination knows how long it took to get to each hop.

∴ The source and destination in the IP header is the original source and the final destination.

Hence, the correct option is (B).

Question Number: 27 **Question Type: MCQ**

In one of the pairs of protocols given below, both the protocols can use multiple TCP connections between the same client and the server. Which one is that?

- (A) HTTP, FTP (B) HTTP, TELNET
 (C) FTP, SMTP (D) HTTP, SMTP

Solution:

HTTP, FTP:

Both protocols are used to transfer files from one host to another.

- HTTP transfers files from web server to web user agent (The browser)
- FTP can send multiple files over the same TCP connection.
- HTTP is a "pull protocol" (users use HTTP to pull the information off the server.

Hence, the correct option is (A).

Question Number: 28 **Question Type: MCQ**

For any two languages L_1 and L_2 such that L_1 is context-free and L_2 is recursively enumerable but not recursive, which of the following is/are necessarily true?

- I. $\overline{L_1}$ (complement of L_1) is recursive
- II. $\overline{L_2}$ (complement of L_2) is recursive
- III. $\overline{L_1}$ is context-free
- IV. $\overline{L_1} \cup L_2$ is recursively enumerable

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

Solution: Context free language (CFL) is not closed under complement.

If Language ' L ' is Recursive enumerable but not recursive, then \overline{L} is not Recursive Enumerable.

Option-I is true

If L_1 is CFL then $\overline{L_1}$ is not CFL, but the language $\overline{L_1}$ is recursive, so this is True.

Option-II is false

L_2 is Recursive Enumerable but not recursive, i.e., $\overline{L_2}$ is not Recursive Enumerable. So, it is not recursive.

Option–III is false

$\overline{L_1}$ is not context free.

Option–IV is true

$\overline{L_1}$ is recursive and L_2 is Recursive Enumerable.

Union of Recursive and Recursive Enumerable is Recursive Enumerable.

Hence, the correct option is (D).

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

Consider a system with byte-addressable memory, 32-bit logical addresses, 4 kilobyte page size and page table entries of 4 bytes each. The size of the page table in the system in megabytes is _____.

Solution:

Logical address = 32-bits

Page size = 4 K byte (4 KB)

Page table entry = 4 bytes each

Logical address space = $2^{32} = 4 \text{ GB}$

$$\text{Number of pages} = \frac{\text{Logical address space}}{\text{page size}}$$

$$= \frac{4 \text{ GB}}{4 \text{ KB}} = 1 \text{ MB}$$

$$\begin{aligned} \text{Page table size} &= 1 \text{ MB} \times \text{page table Entry} \\ &= 1 \text{ MB} \times 4 \text{ B} = 4 \text{ MB} \end{aligned}$$

Hence, the correct Answer is (4).

Question Number: 30 **QuestionsType: NAT**

The following two function $P1$ and $P2$ that share a variable B with an initial value of 2 execute concurrently.

```

P1 ( ) {
    C = B - 1;
    B = 2 * C;
}
P2 ( ) {
    D = 2 * B;
    B = D - 1;
}
    
```

The number of distinct values that B can possibly take after the execution is _____

Solution: The functions $P1$ and $P2$

```

P1 ( )          P2 ( )
{
C = B - 1 ; → 1  D = 2 * B ; → 3
B = 2 * C ; → 2  B = D - 1 ; → 4
}
    
```

Let us number the instructions in $P1()$ and $P2()$ as 1, 2, 3, 4. The possible execution sequence of instructions and the value of B is

- (I) 1, 2, 3, 4 $\Rightarrow B = 3$
- (II) 1, 3, 2, 4 $\Rightarrow B = 3$
- (III) 1, 3, 4, 2 $\Rightarrow B = 2$
- (IV) 3, 1, 2, 4 $\Rightarrow B = 2$
- (V) 3, 1, 4, 2 $\Rightarrow B = 2$
- (VI) 3, 4, 1, 2 $\Rightarrow B = 4$

The value of B can be 2, 3, 4.

Hence, the correct Answer is (3).

Question Number: 31 **Question Type: MCQ**

SELECT operation in SQL is equivalent to

- (A) The selection operation in relational algebra
- (B) The selection operation in relational algebra, except that SELECT in SQL retains duplicates.
- (C) The projection operation in relational algebra.
- (D) The projection operation in relational algebra, except that SELECT in SQL retains duplicates.

Solution: Let us consider the following

```

SELECT      NAME
FROM        Student
WHERE       Grade = 'A'
    
```

$$\pi_{NAME} (\sigma_{Grade='A'}^{(student)})$$

$\therefore \pi$ – eliminates duplicates from the result.

\therefore To eliminate duplicates in SQL query, we have to use DISTINCT keyword in SELECT clause.

Hence, the correct option is (D).

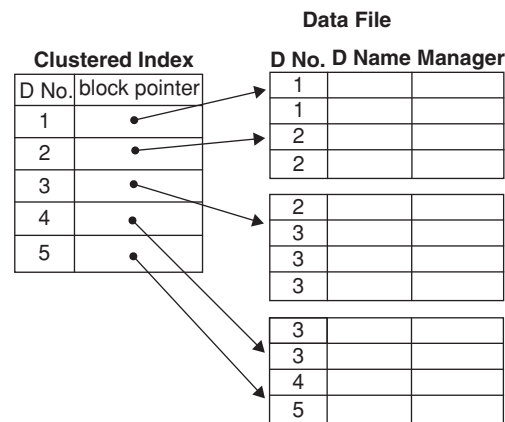
Question Number: 32 **Question Type: MCQ**

A file is organized so that the ordering of data records is the same as or close to the ordering of data entries in some index. Then that index is called

- (A) Dense
- (B) Sparse
- (C) Clustered
- (D) Unclustered

Solution: Clustered Index is constructed on a non-key field which is ordered.

Example:



Hence, the correct option is (C).

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

If the LU decomposition of the matrix $\begin{bmatrix} 2 & 2 \\ 4 & 9 \end{bmatrix}$, if the diagonal elements of U are both 1, then the lower diagonal entry l_{22} of L is _____

Solution:

$$\text{Let } A = \begin{bmatrix} 2 & 2 \\ 4 & 9 \end{bmatrix}$$

Let the LU decomposition of A be

$$A = LU$$

$$\text{Where } L = \begin{bmatrix} l_{11} & 0 \\ l_{21} & l_{22} \end{bmatrix} \text{ and } U = \begin{bmatrix} 1 & u_{12} \\ 0 & 1 \end{bmatrix}$$

$$A = LU$$

$$\Rightarrow \begin{bmatrix} 2 & 2 \\ 4 & 9 \end{bmatrix} = \begin{bmatrix} l_{11} & 0 \\ l_{21} & l_{22} \end{bmatrix} \begin{bmatrix} 1 & u_{12} \\ 0 & 1 \end{bmatrix}$$

$$\Rightarrow \begin{bmatrix} l_{11} & l_{11}u_{12} \\ l_{21} & l_{21}u_{12} + l_{22} \end{bmatrix} = \begin{bmatrix} 2 & 2 \\ 4 & 9 \end{bmatrix}$$

Comparing the corresponding elements on both sides, we have $l_{11} = 2, l_{21} = 4$

$$l_{11} u_{12} = 2 \Rightarrow u_{12} = \frac{2}{l_{11}} = \frac{2}{2} = 1$$

$$\Rightarrow u_{12} = 1$$

$$l_{21} u_{12} + l_{22} = 9 \Rightarrow 4 \times 1 + l_{22} = 9$$

$$\Rightarrow l_{22} = 9 - 4 = 5$$

$$\therefore l_{22} = 5$$

Hence, the correct answer is (5).

Question Number: 34

Question Type: NAT

The output of the following C program is _____

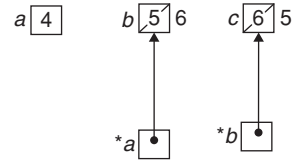
```
void f1 (int a, int b) {
    int c;
    c=a; a=b; b=c;
}
void f2(int *a, int *b) {
    int c;
    c=*a; *a=*b; *b=c;
}
int main ( ) {
    int a=4, b=5, c=6;
    f1 (a, b);
    f2 (&b, &c);
    printf ("%d", c-a-b);
}
```

Solution: The values of a, b, c are 4, 5, 6

$$a \quad \boxed{4} \quad b \quad \boxed{5} \quad c \quad \boxed{6}$$

$f1(a, b)$ doesn't affect the a, b, c values, because parameters are passed by call by value.

$f2(&b, &c)$ reflects the values of b and c (it swaps the b, c values)



the value of $(c - a - b)$ is $(5 - 4 - 6)$

$\therefore -5$

It prints -5

Hence, the correct answer is (-5) .

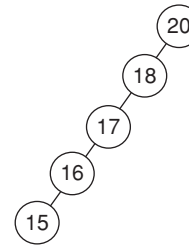
Question Number: 35

Question Type: MCQ

What are the worst-case complexities of insertion and deletion of a key in a binary search tree?

- (A) $\theta(\log n)$ for both insertion and deletion
- (B) $\theta(n)$ for both insertion and deletion
- (C) $\theta(n)$ for insertion and $\theta(\log n)$ for deletion
- (D) $\theta(\log n)$ for insertion and $\theta(n)$ for deletion

Solution: Worst case binary search tree, consider the following:



$n = 5$ elements

To insert an element '14' (Worst case)

We need to compare with First 5 elements

$\therefore \theta(n)$

To delete an element, First we have to search for that element.

Assume that, element to be deleted is 15(Worst case), To search for 15, we need 5 comparisons.

$\therefore \theta(n)$

Hence, the correct option is (B)

Question Number: 36

Question Type: NAT

Suppose that the stop-and-wait protocol is used on a link with a bit rate of 64 kilobits per second and 20 milliseconds propagation delay. Assume that the transmission time for the acknowledgement and the processing time at nodes are negligible. Then the minimum frame size in bytes to achieve a link utilization of at least 50% is _____

Solution: Propagation delay $T_p = 20$ m sec

(B) Bit rate = 64 K bits/sec

To achieve 50% link utilization

The minimum frame size in bytes should be

$$\begin{aligned}
 L &\geq BR(R = 2T_p) \\
 L &= 64 \times 10^3 \times 2 \times 20 \times 10^{-3} \\
 &= 2560 \text{ bits} \\
 &= 320 \text{ bytes} \\
 &= \frac{320}{2} = 160
 \end{aligned}$$

Hence, the correct answer is (160).

Question Number: 37 **Question Type: MCQ**

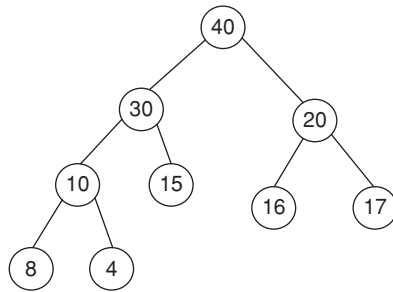
Consider a max heap, represented by the array: 40, 30, 20, 10, 15, 16, 17, 8, 4

| Array Index | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|-------------|----|----|----|----|----|----|----|---|---|
| Value | 40 | 30 | 20 | 10 | 15 | 16 | 17 | 8 | 4 |

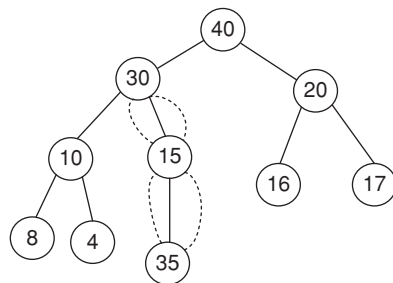
Now consider that a value 35 is inserted into this heap. After insertion, the new heap is

- (A) 40, 30, 20, 10, 15, 16, 17, 8, 4, 35
- (B) 40, 35, 20, 10, 30, 16, 17, 8, 4, 15
- (C) 40, 30, 20, 10, 35, 16, 17, 8, 4, 15
- (D) 40, 35, 20, 10, 15, 16, 17, 8, 4, 30

Solution: The given heap is

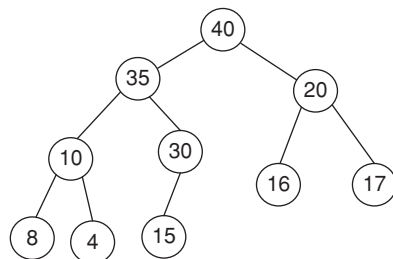


When 35 is inserted into the heap



It is not following ordering property, requires swaps. There are 2 swaps i.e., swap (15, 35) and swap (30, 35)

The resultant heap is



The new heap is

40, 35, 20, 10, 30, 16, 17, 8, 4, 15

Hence, the correct option is (B).

Question Number: 38 **Question Type: NAT**

Consider the following C program segment.

```

while (first <= last)
{
    if (array[middle] < search)
        first = middle + 1;
    else if (array[middle] == search)
        found = TRUE;
    else last = middle - 1;
    middle = (first + last) / 2;
}
if (first > last) notPresent = TRUE;
    
```

The cyclomatic complexity of the program segment is _____.

Solution: Cyclomatic complexity of the program is, (number of conditions in the program) + 1

$$4 + 1 = 5$$

In the program, there is 1 while condition and 3 if conditions.

Hence, the correct answer is (5).

Question Number: 39 **Question Type: NAT**

Consider a LAN with four nodes S_1, S_2, S_3 and S_4 . Time is divided into fixed-size slots, and a node can begin its transmission only at the beginning of a slot. A collision is said to have occurred if more than one node transmit in the same slot. The probabilities of generation of a frame in a time slot by S_1, S_2, S_3 and S_4 are 0.1, 0.2, 0.3 and 0.4, respectively. The probability of sending a frame in the first slot without any collision by any of these four stations is _____

Solution: When S_1 is sending remaining nodes have to listen.

The probability for S_1 is $(0.1)(1 - 0.2)(1 - 0.3)(1 - 0.4) = 0.0336$

$$\text{For } S_2 \Rightarrow (1 - 0.1)(0.2)(1 - 0.3)(1 - 0.4) = 0.0756$$

$$\text{For } S_3 \Rightarrow (1 - 0.1)(1 - 0.2)(0.3)(1 - 0.4) = 0.1296$$

$$\text{For } S_4 \Rightarrow (1 - 0.1)(1 - 0.2)(1 - 0.3)(0.4) = 0.2016$$

The probability of sending a frame in the first slot without any collision by any of these 4 stations is

$$\therefore 0.0336 + 0.0756 + 0.1296 + 0.2016 = 0.4404$$

Hence, the correct answer is (0.40) to (0.46).

Question Number: 40 **Question Type: MCQ**

The binary operator \neq is defined by the following truth table

| p | q | $p \neq q$ |
|---|---|------------|
| 0 | 0 | 0 |
| 0 | 1 | 1 |
| 1 | 0 | 1 |
| 1 | 1 | 0 |

Which one of the following is true about the binary operator \oplus ?

- (A) Both commutative and associative
- (B) Commutative but not associative
- (C) Not commutative but associative
- (D) Neither commutative nor associative

Solution:

$p \neq q \Rightarrow x$ or operation

$p \oplus q = q \oplus p$, so commutative

$p \oplus (q \oplus r) = (p \oplus q) \oplus r$, so associative.

Hence, the correct option is (A).

Question Number: 41

Question Type: NAT

$$\sum_{x=1}^{99} \frac{1}{x(x+1)} = \underline{\hspace{2cm}}$$

Solution:

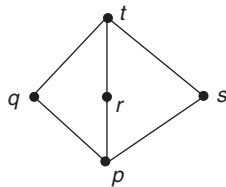
$$\begin{aligned} \text{We have } \sum_{x=1}^{99} \frac{1}{x(x+1)} &= \sum_{x=1}^{99} \left(\frac{1}{x} - \frac{1}{x+1} \right) \\ &= \left(\frac{1}{1} - \frac{1}{1+1} \right) + \left(\frac{1}{2} - \frac{1}{2+1} \right) + \left(\frac{1}{3} - \frac{1}{3+1} \right) + \dots \\ &\quad \dots + \left(\frac{1}{98} - \frac{1}{98+1} \right) + \left(\frac{1}{99} - \frac{1}{99+1} \right) \\ &= 1 - \frac{1}{100} \\ &= \frac{99}{100} = 0.99 \end{aligned}$$

Hence, the correct answer is (0.99).

Question Number: 42

Question Type: MCQ

Suppose $\mathcal{L} = \{p, q, r, s, t\}$ is a lattice represented by the following Hasse diagram:



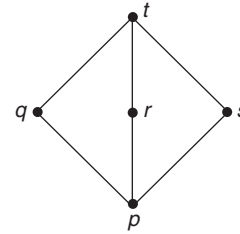
For any $x, y \in \mathcal{L}$, not necessarily distinct, $x \vee y$ and $x \wedge y$ are join and meet of x, y , respectively.

Let $\mathcal{L}^3 = \{(x, y, z) : x, y, z \in \mathcal{L}\}$ be the set of all ordered triplets of the elements of \mathcal{L} . Let p_r be the probability that an element $(x, y, z) \in \mathcal{L}^3$ chosen equiprobably satisfies $x \vee (y \wedge z) = (x \vee y) \wedge (x \vee z)$. Then

- (A) $p_r = 0$
- (B) $p_r = 1$
- (C) $0 < p_r \leq \frac{1}{5}$
- (D) $\frac{1}{5} < p_r < 1$

Solution:

Given that $L = \{p, q, r, s, t\}$ is a lattice with Hasse diagram as shown below.



Given $L^3 = \{(x, y, z) / x, y, z \in L\}$

\therefore The total number elements of $L^3 =$ The number of ordered triples that can be formed using 5 elements $= 5^3 = 125$.

Of all these ordered triples, all ordered triples satisfy the condition.

$$x \vee (y \wedge z) = (x \vee y) \wedge (x \vee z)$$

except those in which all the three elements q, r and s are present in any order.

For, take $x = q, y = r$ and $z = s$

$\therefore x \vee (y \wedge z) = q \vee (r \wedge s) = q \vee p = q \rightarrow (1)$ and

$(x \vee y) \wedge (x \vee z) = (q \vee r) \wedge (q \vee s) = t \wedge t = t \rightarrow (2)$

From (1) and (2),

$$x \vee (y \wedge z) \neq (x \vee y) \wedge (x \vee z)$$

The number. of ordered triples involving all the three elements in any order $= 3! = 6$

\therefore Probability that an element $(x, y, z) \in L^3$ chosen equiprobably satisfies $x \vee (y \wedge z)$

$$= (x \vee y) \wedge (x \vee z) \text{ is}$$

$$P_r = \frac{125 - 6}{125} = \frac{119}{125}$$

Hence $\frac{1}{5} < P_r < 1$

Alternative Solution: The total number of elements (ordered triples) of

$$L^3 = 125.$$

Of these, the ordered triples, which start p , or t is definitely is satisfy the given condition. The are 50 elements in L^3 that starts either with p or t . Also the ordered triples consisting of the three elements, q, r, s does not satisfy the condition.

$\therefore \frac{1}{5} < P_r < 1$

Hence, the correct option is (D).

Question Number: 43

Question Type: MCQ

Consider the operations

$$f(X, Y, Z) = X^1 YZ + XY^1 + Y^1 Z^1 \text{ and}$$

$$g(X, Y, Z) = X^1 YZ + X^1 YZ^1 + XY.$$

Which one of the following is correct?

- (A) Both $\{f\}$ and $\{g\}$ are functionally complete
- (B) Only $\{f\}$ is functionally complete
- (C) Only $\{g\}$ is functionally complete
- (D) Neither $\{f\}$ nor $\{g\}$ is functionally complete

Solution:

$$\begin{aligned}
 f(X, Y, Z) &= X^1 YZ + XY^1 + Y^1 Z^1 \\
 g(X, Y, Z) &= X^1 YZ + X^1 YZ^1 + XY \\
 &= Y(X^1 Z + X^1 Z^1 + X) = Y \\
 f(X, Y, Z) &= X^1 YZ + XY^1 Z + XY^1 Z^1 + Y^1 Z^1 \\
 &= (X^1 Y + XY^1)Z + Y^1 Z^1
 \end{aligned}$$

by using $\{f\}$, we can implement the functions AND, OR, NOT, so only $\{f\}$ is functionally complete.

Hence, the correct option is (B).

Question Number: 44 **Question Type: NAT**

Let G be a connected planar graph with 10 vertices. If the number of edges on each face is three then the number of edges in G is _____.

Solution:

We have, the no. of vertices of $G = |V| = 10$

Let $|E|$ and $|R|$ denote the no. of edges and the no. of regions of the connected planar graph G respectively.

By Euler's formula, we have

$$|V| + |R| - |E| = 2 \rightarrow \tag{1}$$

Given the number of edges on each face (region) is 3.

We know that the sum of the degrees of all faces of a planar graph = $2 \times$ The no. of edges.

i.e., $3 |R| = 2 |E|$

$$\Rightarrow |R| = \frac{2}{3} |E|$$

\therefore (1) becomes,

$$|V| + \frac{2}{3} |E| - |E| = 2$$

$$\Rightarrow 10 - \frac{1}{3} |E| = 2$$

$$\Rightarrow \frac{1}{3} |E| = 8$$

$$\Rightarrow |E| = 24$$

Hence, the correct answer is (24).

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

Let a_n represent the number of bit strings of length n containing two consecutive 1s. What is the recurrence relation for a_n ?

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

Solution:

$$a_1 = 0$$

$$a_2 = 11 \text{ (1)}$$

$$a_3 = 110, 011, 111 \text{ (3)}$$

$$a_4 = 1100, 1101, 0110, 0011, 1110, 1111, 0111, 1011 \text{ (8)}$$

Hence, the correct option is (A).

If we take $n = 4$

$$\begin{aligned}
 \Rightarrow a_{n-2} + a_{n-1} + 2^{n-2} \\
 a_4 = a_2 + a_3 + 2^{4-2} \\
 = 1 + 3 + 2^2 \\
 a_4 = 8
 \end{aligned}$$

If we take $n = 3$

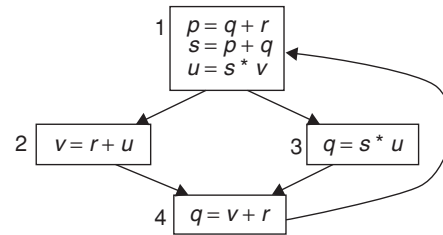
$$\begin{aligned}
 a_3 &= 3 \\
 a_3 &= a_{n-2} + a_{n-1} + 2^{n-2} \\
 &= a_1 + a_2 + 2^{3-2} \\
 &= 0 + 1 + 2 \\
 &= 3 \\
 a_3 &= 3
 \end{aligned}$$

Hence, the correct option is (A)

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

A variable x is said to be live at a statement S_i in a program if the following three conditions hold simultaneously:

1. There exists a statement S_j that uses x
2. There is a path from S_i to S_j in the flow graph corresponding to the program.
3. The path has no intervening assignment to x including at S_i and S_j .



The variables which are live both at the statement in basic block 2 and at the statement in basic block 3 of the above control flow graph are

- (A) p, s, u
- (B) r, s, u
- (C) r, u
- (D) q, v

Solution: Initially the variables which are live on entry to block 1 are $\{q, r, u\}$ as these variables are required to get the values defined in that block

- On exit from Block 1 live variables are $\{r, u, v\}$ as p, q and s values are not required by other blocks.
- Live variables on entry to Block 2 are $\{r, u\}$ as these variables are required to get V , and V is not live as it is defined in block 2
- On exit from block 2 live variables are $\{r, v\}$ as 4 is no where used and v is used in block 4
- On entry to block 3, live variables are $\{r, u, v\}$ and on exit live variables are $\{r, q, v\}$ as U is no where used and q is used in Block 4

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- On entry to block 4 live variables are $\{r, v\}$ and q is not live as q is defined inside block 4
- On exit from block 4 live variables are $\{q, r, v\}$ as q is defined in block 4.

Hence $\{r, U\}$ both are live at block 2 and block 3

Hence, the correct option is (C).

Question Number: 47 **Question Type: NAT**

The least number of temporary variables required to create a three-address code in static single assignment form for the expression $q + r/3 + s - t * 5 + u * v/w$ is _____

Solution:

$$q + r/3 + s - t * 5 + u * v/w$$

The 3-address code for above expression is

$$\begin{aligned} t_1 &= r/3 \\ t_2 &= t * 5 \\ t_3 &= u * v \\ t_4 &= t_3/w \\ t_5 &= q + t_1 \\ t_6 &= t_5 + s \\ t_7 &= t_6 - t_2 \\ t_8 &= t_7 + t_4 \end{aligned}$$

The temporary variables required = 8

Hence, the correct answer is (8).

Question Number: 48 **Question Type: NAT**

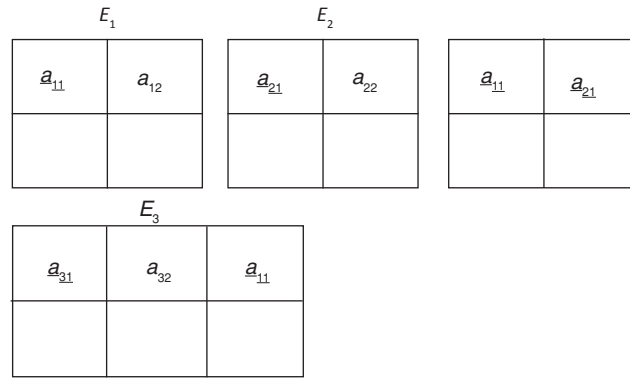
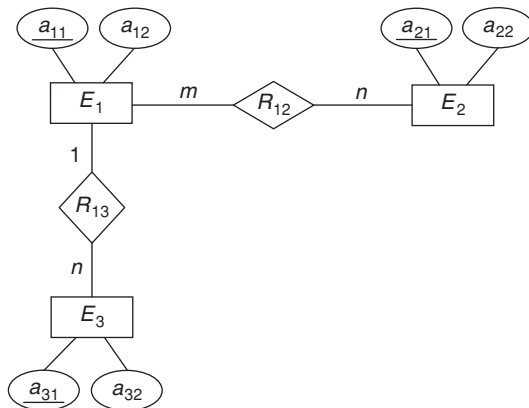
Consider an entity-Relationship (ER) model in which entity sets E_1 and E_2 are connected by an m:n relationship R_{12} . E_1 and E_3 are connected by a 1:n (1 on the side of E_1 and n on the side of E_3) relationship R_{13} .

E_1 has two single-valued attributes a_{11} and a_{12} of which a_{11} is the key attribute. E_2 has two single-valued attributes a_{21} and a_{22} of which a_{21} is the key attribute. E_3 has two single-valued attributes a_{31} and a_{32} of which a_{31} is the key attribute. The relationships do not have any attributes.

If a relational model is derived from the above ER model, then the minimum number of relations that would be generated if all the relations are in 3 NF is _____.

Solution: R_{12} has m: n Relation

Extra table is needed to store all the primary keys of participating Entities in R_{12} .



R_{13} has 1:n relation, place 1's side primary key into n's side table.

Hence, the correct answer is (4).

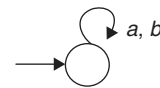
Question Number: 49 **Question Type: NAT**

Consider the DFAs M and N given above. The number of states in a minimal DFA that accepts the language $L(M) \cap L(N)$ is _____



Solution: M is a DFA which accepts language with strings ends with 'a' over $\Sigma = \{a, b\}$ i.e., $M = \{a, aa, ba, baa, aaa, \dots\}$

N is a DFA which accepts a language with strings ends with 'b' over $\Sigma = \{a, b\}$, i.e., $N = \{b, bb, ab, bbb, \dots\}$ then $L(M) \cap L(N)$ is an empty language i.e., $L(M) \cap L(N) = \emptyset$. The automata for $L(M) \cap L(N)$

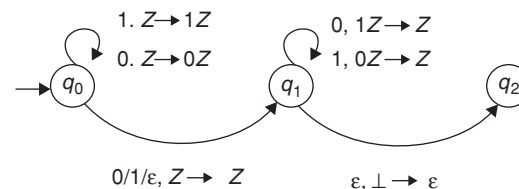


Number. of states = 1

Hence, the correct answer is (1).

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

Consider the NPDA $\langle Q = \{q_0, q_1, q_2\}, \Sigma = \{0, 1\}, \Gamma = \{0, 1, \perp\}, \delta, q_0, \perp, F = \{q_2\} \rangle$, where (as per usual convention) Q is the set of states, Σ is the input alphabet, Γ is the stack alphabet, δ is the state transition function, q_0 is the initial state, \perp is the initial stack symbol, and F is the set of accepting states. The state transition is as follows:



Which one of the following sequences must follow the string 1011 00 so that the overall string is accepted by the automation?

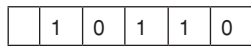
- (A) 10110
- (B) 10010
- (C) 01010
- (D) 01001

Solution: In the questions, on information given about 'z'. If we assume z as any stack symbol (either 0 or 1) then we can able to solve the problem.

Given input is 101100

Push till last but one is zero.

The PDA will be q_0 state till this input then, the stack will have



With last zero it will move to q_1 , without pushing or popping anything

Hence, the correct option is (A).

1 0 1 1 0

- With input 1, it checks 0 as top of stack, As 0 is in top, it pops that symbol, with next input 0, it will check 1 as top. As 1 is top, pop that 1.
- With next input 1 as input, it checks for 0 as top of the stack but top is 1

∴ Choice (A) is not the answer

Hence, the correct option is (A).

1 0 0 1 0

- With input 1, it checks 0 as top of stack. As 0 is top of stack, it pops that symbol
- With next input 0, it will check 1 as top As 1 is top, pop that 1
- With next input 0 as input, it checks for 1 as top of the stack as top is 1 pop it similarly with the next inputs 1 and 0 it pops 0 and 1 respectively
- With left-out initial stack symbol on epsilon-input it reaches final state

Hence choice (B) is the answer

Hence, the correct option is (B).

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

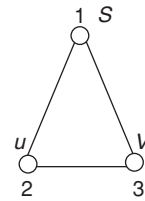
Let $G = (V, E)$ be a simple undirected graph, and s be a particular vertex in it called the source. For $x \in V$, let $d(x)$ denote the shortest distance in G from s to x . A breadth first search (BFS) is performed starting at s . Let T be the resultant BFS tree. If (u, v) is an edge of G that is not in T , then which one of the following CANNOT be the value of $d(u) - d(v)$?

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

Solution:

Example:

Case 1:



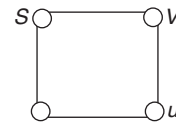
From source (S)

The distance to $u = D(u) = 1$

The distance to $v = D(v) = 1$

$$D(u) - D(v) = 0$$

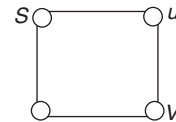
Case 2:



$$D(u) = 2, D(v) = 1$$

$$D(u) - D(v) = 2 - 1 = 1$$

Case 3:



$$D(u) = 1, D(v) = 2$$

$$D(u) - D(v) = 1 - 2 = -1$$

∴ $D(u) - D(v) = 2$ is not possible.

Hence, the correct option is (D).

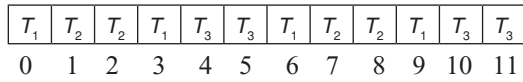
Question Number: 52 **Question Type: NAT**

Consider a uniprocessor system executing three tasks T_1, T_2 and T_3 , each of which is composed of an infinite sequence of jobs (or instances) which arrive periodically at intervals of 3, 7 and 20 milliseconds, respectively. The priority of each task is the inverse of its period, and the available tasks are scheduled in order of priority, with the highest priority task schedule first. Each instance of T_1, T_2 and T_3 requires an execution time of 1, 2 and 4 milliseconds, respectively. Given that all tasks initially arrive at the beginning of the 1st millisecond and task preemptions are allowed, the first instance of T_3 completes its execution at the end of _____ milliseconds.

Solution:

| | | Arrival times | Burst time | Priority |
|-------|---|-------------------|------------|----------|
| T_1 | - | 0, 3, 6, 9, 12... | 1 | 1 |
| T_2 | - | 0, 7, 14, 21... | 2 | 0.5 |
| T_3 | - | 0, 20, 40, ... | 4 | 0.25 |

The Gantt chart with above Tasks is



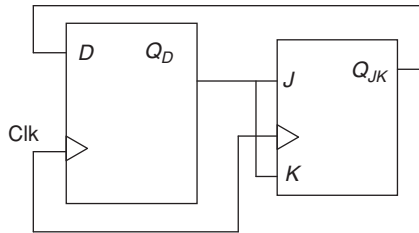
The first instance of task (T_3) completes at 12th millisecond. Hence, the correct answer is (12).

Question Number: 53 **Question Type: MCQ**

A positive edge-triggered D-flip-flop is connected to a positive edge-triggered JK flip-flop as follows. The Q output of the D flip-flop is connected to both the J and K inputs of the JK flip-flop, while the Q output of the JK flip-flop is connected to the input of the D flip-flop. Initially, the output of the D flip-flop is set to logic one and the output of the JK flip-flop is cleared. Which one of the following is the bit sequence (including the initial state) generated at the Q output of the JK flip-flop when the flip-flops are connected to a free-running common clock? Assume that $J = K = 1$ is the toggle mode and $J = K = 0$ is the state-holding mode of the JK flip-flop. Both the flip-flops have non-zero propagation delays.

- (A) 0110110... (B) 0100100...
 (C) 011101110... (D) 011001100...

Solution:



The given problem is shown in the above figure initially $Q_D = 1, Q_{JK} = 0$

| Clk | Q_D Q_{JK} | D J K Q_{JK} Q_D Q_D |
|-----|----------------|-------------------------------------|
| 0 | 1 0 | 0 1 1 |
| 1 | 0 1 | 1 0 0 |
| 2 | 1 1 | 1 1 1 |
| 3 | 1 0 | |

After 3 Clk pulses, the circuit came back to original state, mod-3 counter.

Sequence at $Q_{JK} = 011011011...$

Hence, the correct option is (A).

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

Consider a disk pack with a seek time of 4 milliseconds and rotational speed of 10000 rotations per minute (RPM). It has 600 sectors per track and each sector can store 512 bytes of data. Consider a file stored in the disk. The file contains 2000 sectors. Assume that every sector access necessitates a seek, and the average rotational latency for accessing each

sector is half of the time for one complete rotation. The total time (in milliseconds) needed to read the entire file is _____.

Solution:

Given seek time = 4 m sec

Given rotational speed = 10000 rotations/minute

Number of rotations in one second = $\frac{60}{10000} = 6$ ms

Rotational latency = $\frac{1}{2} \times 6$ ms = 3 ms

Given that there are 600 sectors/track

So, to access 600 sectors it takes 6 ms.

To access 1 sector = $\frac{6 \text{ ms}}{600} = 0.01$ ms

For accessing 2000 sectors it takes 2000 (0.01) = 20 ms

\therefore total time needed to read the entire file
 = (2000(4 + 3) + 20)ms
 = 14020 ms

Hence, the correct answer is (14020).

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

Consider a non-pipelined processor with a clock rate of 2.5 gigahertz and average cycles per instruction of four. The same processor is upgraded to a pipelined processor with five stages; but due to the internal pipeline delay, the clock speed is reduced to 2 gigahertz. Assume that there are no stalls in the pipeline. The speed up achieved in this pipelined processor is _____.

Solution:

$$\text{Speed-up} = \frac{nk}{(K + n - 1)}$$

Assume that $n = 16$

$k = 5$ (stages)

$$S(\text{For 5 stages}) = \frac{16 * 5}{(5 + 16 - 1)} = \frac{80}{20} = 4$$

The frequency is reduced in pipe lined processor by a factor

$$\text{of } \frac{2}{2.5} = 0.8$$

$$\therefore 4 * 0.8 = 3.2$$

Hence, the correct answer is (3.2).

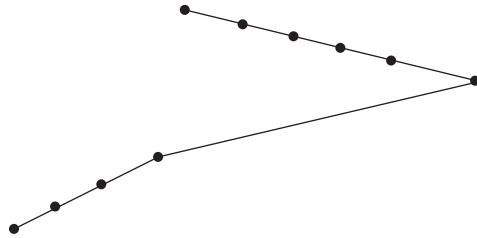
Question Number: 56 **Question Type: NAT**

Suppose the following disk request sequence (track numbers) for a disk with 100 tracks is given: 45, 20, 90, 10, 50, 60, 80, 25, 70. Assume that the initial position of the R/W head is on track 50. The additional distance that will be traversed by the R/W head when the Shortest Seek Time First (SSTF) algorithm is used compared to the SCAN (Elevator) algorithm (assuming that SCAN algorithm moves towards 100 when it starts execution) is _____ tracks.

Solution:

SCAN

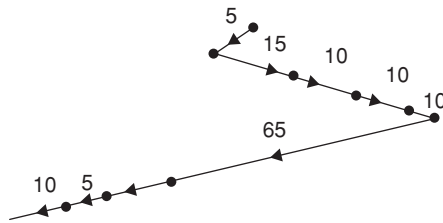
10 20 25 45 50 60 70 80 90 100



Total head movements = 10 + 10 + 10 + 10 + 10 + 55 + 20 + 5 + 10 ⇒ 140.

SSTF

1 10 20 25 45 50 60 70 80 90 100



∴ total head movements = 5 + 15 + 10 + 10 + 10 + 65 + 5 + 10 ⇒ 130

⇒ 130

∴ The extra distance that is traversed = 140 – 130 = 10

Hence, the correct answer is (10).

Question Number: 57

Question Type: MCQ

Consider a main memory with five page frames and the following sequence of page references: 3, 8, 2, 3, 9, 1, 6, 3, 8, 9, 3, 6, 2, 1, 3. Which one of the following is true with respect to page replacement policies First In First Out (FIFO) and Least Recently Used (LRU)?

- (A) Both incur the same number of page faults
- (B) FIFO incurs 2 more page faults than LRU
- (C) LRU incurs 2 more pages faults than FIFO
- (D) FIFO incurs 1 more page faults than LRU

Solution: The page references are 3, 8, 2, 3, 9, 1, 6, 3, 8, 9, 3, 6, 2, 1, 3
No. of page faults using FIFO

| |
|---|
| 3 |
| 8 |
| 2 |
| 3 |
| 9 |
| 1 |

✓✓✓✓✓ ✓ ✓✓✓

3, 8, 2, 3, 9, 1, 6, 3, 8, 9, 3, 6, 2, 1, 3
= 9 page faults

LRU

| |
|---|
| 3 |
| 8 |
| 2 |
| 3 |
| 9 |
| 1 |
| 6 |
| 3 |
| 8 |
| 9 |
| 3 |
| 6 |
| 2 |
| 1 |
| 3 |

✓✓✓ ✓✓✓ ✓ ✓✓

3, 8, 2, 3, 9, 1, 6, 3, 8, 9, 3, 6, 2, 1, 3
= 9 page faults

Both LRU and FIFO incur same number of page faults.

Hence, the correct option is (A).

Question Number: 58

Question Type: NAT

$$\int_{1/\pi}^{2/\pi} \frac{\cos\left(\frac{1}{x}\right)}{x^2} dx = \underline{\hspace{2cm}}$$

Solution: Consider the integral

$$\int_{1/\pi}^{2/\pi} \frac{\cos\left(\frac{1}{x}\right)}{x^2} dx = \int_{1/\pi}^{2/\pi} \left[\cos\left(\frac{1}{x}\right) \right] \frac{1}{x^2} dx \quad (1)$$

put $\frac{1}{x} = t \Rightarrow \frac{-1}{x^2} dx = dt$

$\Rightarrow \frac{1}{x^2} dx = -dt$

$x = \frac{1}{\pi} \Rightarrow t = \pi$ and $x = \frac{2}{\pi} \Rightarrow t = \frac{\pi}{2}$

∴ (1) becomes,

$$\begin{aligned} \int_{1/\pi}^{\pi/2} \frac{\cos\left(\frac{1}{x}\right)}{x^2} dx &= \int_{\pi}^{\pi/2} \cos t(-dt) \\ &= -\int_{\pi}^{\pi/2} \cos t dt \\ &= \int_{\pi/2}^{\pi} \cos t dt \\ &= [\sin t]_{\pi/2}^{\pi} \\ &= \sin \pi - \sin \frac{\pi}{2} = -1 \end{aligned}$$

Hence, the correct answer is (-1).

Question Number: 59

Question Type: MCQ

Consider the following 2×2 matrix A, where two elements are unknown and are marked by a and b. The eigenvalues of this matrix are -1 and 7. What are the values of a and b?

$$A = \begin{bmatrix} 1 & 4 \\ b & a \end{bmatrix}$$

(A) a = 6, b = 4

(B) a = 4, b = 6

(C) a = 3, b = 5

(D) a = 5, b = 3

Solution:

Given matrix is $A = \begin{bmatrix} 1 & 4 \\ b & a \end{bmatrix}$

Given the eigen values of A are -1 and 7 . We know that the sum of the eigen values of A .

= Trace of A
 $\Rightarrow -1 + 7 = 1 + a$
 $\Rightarrow a = 5$

The product of the eigen values of A = The determinant of A .

$\Rightarrow (-1)(7) = \begin{vmatrix} 1 & 4 \\ b & a \end{vmatrix}$
 $\Rightarrow -7 = -a - 4b$
 $\Rightarrow 5 - 4b = -7$
 $\Rightarrow 4b = 12 \Rightarrow b = 3$
 $\therefore a = 5$ and $b = 3$

Hence, the correct option is (D).

Question Number: 60 **Question Type: MCQ**

An algorithm performs $(\log N)^{1/2}$ find operations, N insert operations, $(\log N)^{1/2}$ delete operations, and $(\log N)^{1/2}$ decrease-key operations on a set of data items with keys drawn from a linearly ordered set. For a delete operation, a pointer is provided to the record that must be deleted For the decrease – key operation, a pointer is provided to the record that has its key decreased Which one of the following data structures is the most suited for the algorithm to use, if the goal is to achieve the best total asymptotic complexity considering all the operations?

- (A) Unsorted array
- (B) Min-heap
- (C) Sorted array
- (D) Sorted doubly linked list

Solution:

MIN-HEAP:

- To insert ' N ' elements it takes $(N \log N)$ time
- To delete $(\log N)^{1/2}$ elements, it takes $((\log N)^{1/2} * \log N)$
- To find $(\log N)^{1/2}$ elements it takes $((\log N)^{1/2} * \theta(N \log N))$ time

Because, when we apply heap property, position of elements change.

Sorted array: Takes same asymptotic times mentioned above.

Unsorted array:

- $(\log N)^{1/2}$ find operations will take $(\log N)^{1/2} * \theta(N) \Rightarrow \theta(N(\log N)^{1/2})$
- N insertions will take $N * \theta(1) = \theta(N)$ (element is inserted at last place)
- $(\log N)^{1/2}$ delete operations will take, (pointer is provided to particular element) $(\log N)^{1/2} * \theta(1) = \theta(\log N)^{1/2}$
- $(\log N)^{1/2}$ decrease key operations will take $\theta(\log N)^{1/2}$

\therefore The best total asymptotic complexity is achieved through unsorted array.

Hence, the correct option is (A).

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

Consider the following relations:

Student

| Roll No | Student Name |
|---------|--------------|
| 1 | Raj |
| 2 | Rohit |
| 3 | Raj |

Performance

| Roll No | Course | Marks |
|---------|---------|-------|
| 1 | Math | 80 |
| 1 | English | 70 |
| 2 | Math | 75 |
| 3 | English | 80 |
| 2 | Physics | 65 |
| 3 | Math | 80 |

Consider the following SQL query.

```
SELECT S.Student_Name, sum (P.Marks)
FROM Student S, Performance P
WHERE S.Roll_No = P.Roll_No
GROUP BY S.Student_Name
```

The number of rows that will be returned by the SQL query is _____

Solution: In SQL query, order of evaluation is, "FROM", "WHERE", "GROUP-BY" and "SELECT".

Student X performance (where S.Roll No. = P. Roll No.)

| S. Roll No | Student Name | P.Roll No. | Course | Marks |
|------------|--------------|------------|---------|-------|
| 1 | Raj | 1 | Math | 80 |
| 1 | Raj | 1 | English | 70 |
| 2 | Rohit | 2 | Math | 75 |
| 2 | Rohit | 2 | Physics | 65 |
| 3 | Raj | 3 | English | 80 |
| 3 | Raj | 3 | Math | 80 |

Group By Student- Name:

| | | | | |
|---|-------|---|---------|----|
| 1 | Raj | 1 | Math | 80 |
| 1 | Raj | 1 | English | 70 |
| 3 | Raj | 3 | English | 80 |
| 3 | Raj | 3 | Math | 80 |
| 2 | Rohit | 2 | Math | 75 |
| 2 | Rohit | 2 | Physics | 65 |

Output

| Student Name | sum (marks) |
|--------------|-------------|
| Raj | 310 |
| Rohit | 140 |

∴ 2 tuples

Hence, the correct option is (2).

Question Number: 62 **Question Type: MCQ**

What is the output of the following C code? Assume that the address of x is 2000 (in decimal) and an integer requires four bytes of memory.

```
int main ( ) {
    unsigned int x[4] [3] =
    { {1, 2, 3}, {4, 5, 6}, {7, 8, 9},
      {10, 11, 12}};
    printf ("%u, %u, %u", x + 3, *(x +
    3), *(x + 2) + 3);
}
```

- (A) 2036, 2036, 2036
- (B) 2012, 4, 2204
- (C) 2036, 10, 10
- (D) 2012, 4, 6

Solution:

All the expressions

$(x + 3)$, $*(x + 3)$, $*(x + 2) + 3$ points to the same address.

It prints the address of the first element of fourth row in an array i.e., $x[3][0]$ (or) $x[3]$ (i.e., element 10)

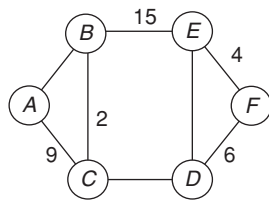
The address of $x[3]$ is 2036

∴ It prints 2036 2036 2036.

Hence, the correct option is (A).

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

The graph shown below has 8 edges with distinct integer edge weights. The minimum spanning tree (MST) is of weight 36 and contains the edges: $\{(A, C), (B, C), (B, E), (E, F), (D, F)\}$. The edge weights of only those edges which are in the MST are given in the figure shown below. The minimum possible sum of weights of all 8 edges of this graph is _____



Solution:

The Edge weight of \overline{AB} is 10 (It has to be > 9)

The edge weight of \overline{CD} (has to be > 15) is 16

\overline{ED} Edge weight is 7 (It has to be > 6)

All Edge weights =

$$\overline{AB} = 10$$

$$\overline{CD} = 16$$

$$\overline{ED} = 7$$

$$\overline{AC} = 9$$

$$\overline{BC} = 2$$

$$\overline{BE} = 15$$

$$\overline{EF} = 4$$

$$\overline{DF} = 6$$

Total = 69

Hence, the correct answer is (69).

Question Number: 64 **Question Type: MCQ**

Consider the following C function.

```
int fun1(int n) {
    int i, j, k, p, q=0;
    for (i=1; i<n; ++i) {
        p=0;
        for (j=n; j>1; j=j/2)
            ++p;
        for (k=1; k<p; k=k*2)
            ++q;
    }
    return q;
}
```

Which one of the following most closely approximates the return value of the function fun1?

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

Solution:

```
for (i = 1; i < n; ++i) → loop 1
{
    p = 0;
    for(j = n; j > 1; j = j/2) → loop 2
        ++ p;
    for (k = 1; k < p; k = k * 2) → loop 3
        ++ q;
}
return q;
}
```

Loop 1 will iterate for about ' n ' times [i.e., ' i ' value takes ' n ' values]

Loop 2 will iterate for about $(\log n)$ times, therefore, the ' p ' value will be $(\log n)$ approximately, loop 3 will iterate for about $(\log p)$ times i.e., $\log(\log n)$ times, the ' q ' will increment $\log(\log n)$ times for every value of i . Therefore

loop will iterate for about 'n' times, therefore the 'q' will increment for $n(\log(\log n))$ times. return q; will return $n(\log(\log n))$.

Hence, the correct option is (D).

Question Number: 65 **Question Type: MCQ**

Consider the following pseudo code, where x and y are positive integers

```
begin
  q := 0
  r := x
  while r ≥ y do
    begin
      r := r - y
      q := q + 1
    end
  end
```

The post condition that needs to be satisfied after the program terminates is

- (A) $\{r = qx + y \wedge r < y\}$
- (B) $\{x = qy + r \wedge r < y\}$
- (C) $\{y = qx + r \wedge 0 < r < y\}$
- (D) $\{q + 1 < r - y \wedge y > 0\}$

Solution:

Let $x = 17$. So, $r = 17$

Let $y = 12$

So $17 \geq 12$

$$r = 17 - 12 = 5$$

$$q = 1$$

lets cross check with the options

Option (A)

$$r = qx + y = 1 \times 17 + 12 = 29$$

(false)

Option (B)

$$x = qy + r = 1 \times 12 + 5 = 17$$

(True)

Option (C)

$$y = qx + r = 1 \times 17 + 5 = 22$$

(false)

Option (D)

$$q + 1 < r - y$$

(not always True)

Hence, the correct answer is (B).

GATE 2015 SOLVED PAPER
CS: COMPUTER SCIENCE AND INFORMATION TECHNOLOGY
Set – 2

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 Question.

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**

We _____ our friend's birthday and we _____ how to make it up to him

- (A) completely forgot _____ don't just know
- (B) forgot completely _____ don't just know
- (C) completely forgot _____ just don't know
- (D) forgot completely _____ just don't know

Solution: The correct answer is choice (C). here, 'completely', modifies 'forgot', which is to say that an action was missed out on. The same rule applies to the second blank as well. 'Don't know' come together, showing a misinformation and 'just' modifies it, showing an extent.

Hence, the correct option is (C).

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

Choose the statement where underlined word is used correctly.

- (A) The industrialist had a personnel jet.
- (B) I write my experience in my personnel diary.
- (C) All personnel are being given the day off.
- (D) Being religious is a personnel aspect.

Solution: The word 'personnel' means a group of people who work for a company or an organization. Choice (C) uses the word correctly. The rest of the choices should use 'personal'.

Hence, the correct option is (C).

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

A generic term that includes various items of clothing such as a skirt, a pair of trousers and a shirt is

- (A) fabric (B) textile
- (C) fibre (D) apparel

Solution: The correct answer is (D) apparel. (A) refers to the type of apparel. (B) refers to the business that makes apparels. (C) is again a material used to make an apparel.

Hence, the correct option is (D).

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

Based on the given statements, select the most appropriate option to solve the given question.

What will be the total weight of 10 poles each of same weight?

Statements:

- (I) One fourth of the weight of a pole is 5 kg.
 - (II) The total weight of these poles is 160 kg more than the total weight of two poles.
- (A) Statement I alone is not sufficient.
 - (B) Statement II alone is not sufficient.
 - (C) Either I or II alone is sufficient.
 - (D) Both statements I and II together are not sufficient.

Solution: We are asked to find the total height 10 notes, each of same height

From (I) alone we know that one fourth weight of a pole = 5 kg
Let us assume each pole to be of height W units

$$\frac{1}{4}W = 5 \text{ kg}$$

$$W = 20 \text{ kg}$$

Weight of each pole = 20K

Then, 10 poles = 200 kgs

So, I alone can give us the answer II alone tells us let us assume each pole to be of height ' W '

$$10W = 160 + 2w$$

$$8W = 160$$

$$W = 20 \text{ kgs}$$

So $10W = 200 \text{ kgs}$

II alone also is sufficient to arrive at the answer.

So, both I and II alone are sufficient to answer the question.

Hence, the correct option is (C).

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

Consider a function $f(x) = 1 - |x|$ on $-1 \leq x \leq 1$. The value of x at which the function attains a maximum and the maximum value of the function are:

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

Solution: $f(x)$ is maximum when $|x|$ is minimum i.e.,

when $|x|$ is zero i.e., when x is zero.

Maximum value of $f(x) = 1 - 0 = 1$. Which occurs at $x = 0$.

Hence, the correct option is (C).

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

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

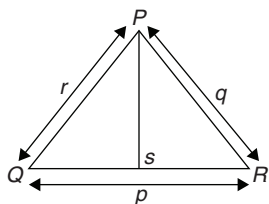
- (A) Since the report lacked needed information, it was of no use to them.
- (B) The report was useless to them because there were no needed information in it.
- (C) Since the report did not contain the needed information, it was not real useful to them.
- (D) Since the report lacked needed information, it would not had been useful to them.

Solution: Choice (A) is free of all errors. Though the article ‘the’ before ‘needed’ would render it correct, but of the given choices (A) is correct. The use of ‘there were’ in (B) is incorrect. ‘Real useful’ is ungrammatical in (C). ‘Not had been’ is ungrammatical in (D).

Hence, the correct option is (A).

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

In a triangle PQR , PS is the angle bisector of $\angle QPR$ and $\angle QPS = 60^\circ$. What is the length of PS ?



- (A) $\frac{(q+r)}{qr}$
- (B) $\frac{qr}{(q+r)}$
- (C) $\sqrt{(q^2+r^2)}$
- (D) $\frac{(q+r)^2}{qr}$

Solution: Area of triangle $PQR = \text{Area of triangle } PQS + \text{Area of triangle } PSR$

$$\text{Area of triangle } PQR = \frac{1}{2}(r)(q) \sin \angle P$$

$$= \frac{1}{2}(r)(q) \sin (2 \angle QPS) = \frac{rq}{2} \sin 120^\circ$$

($\because PS$ is the angle bisector of $\angle QPR$)

$$\therefore \frac{1}{2}(r q \sin 120^\circ) = \frac{1}{2}(r (PS) \sin 60^\circ) + \frac{1}{2}(q (PS) \sin 60^\circ)$$

$$r q \left(\frac{\sqrt{3}}{2} \right) = r(PS) \frac{\sqrt{3}}{2} + q(PS) \frac{\sqrt{3}}{2}$$

$$PS = \frac{rq}{r+q}$$

Hence, the correct option is (B).

Question Number: 8 **Question Type: NAT**

If p, q, r, s are distinct integers such that:

$$f(p, q, r, s) = \max(p, q, r, s)$$

$$g(p, q, r, s) = \min(p, q, r, s)$$

$h(p, q, r, s) = \text{remainder of } (p \times q)/(r \times s) \text{ if } (p \times q) > (r \times s)$
 or remainder of $(r \times s)/(p \times q) \text{ if } (r \times s) > (p \times q)$

Also a function $fg h(p, q, r, s) = f(p, q, r, s) \times g(p, q, r, s) \times h(p, q, r, s)$

Also the same operations are valid with two variable functions of the form $f(p, q)$

What is the value of $fg(h(2, 5, 7, 3), 4, 6, 8)$?

Solution: $h(2, 5, 7, 3) = \text{remainder of } \left(\frac{21}{10}\right) = 1 (\because (r \times s) > (p \times q))$

$$f g(h(2, 5, 7, 3), 4, 6, 8) = f g(1, 4, 6, 8) = f(1, 4, 6, 8) \times g(1, 4, 6, 8)$$

$$= \max(1, 4, 6, 8) \times \min(1, 4, 6, 8) = 8 \times 1 = 8$$

Hence, the correct answer is (8).

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

If the list of letters, P, R, S, T, U is an arithmetic sequence, which of the following are also in arithmetic sequence?

- I. $2P, 2R, 2S, 2T, 2U$
- II. $P-3, R-3, S-3, T-3, U-3$
- III. P^2, R^2, S^2, T^2, U^2

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

Solution: P, R, S, T, U is an arithmetic sequence

$\therefore R - P = S - R = T - S = U - T$. Let each of these equal values be k .

$$I : 2(R - P) = 2(S - R) = 2(T - S) = 2(U - T) = 2k$$

$\therefore 2P, 2R, 2S, 2T, 2U$ is an arithmetic sequence.

$$II. R - 3 - (P - 3) = S - 3 - (R - 3) = T - 3 - (S - 3) = U - 3 - (T - 3) = k.$$

$\therefore P - 3, R - 3, S - 3, T - 3, U - 3$ is an arithmetic sequence.

Hence, the correct option is (B).

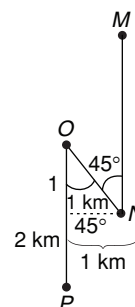
Question Number: 10 **Question Type: MCQ**

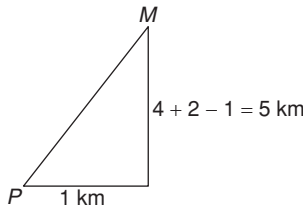
Four branches of a company are located at M, N, O and P . M is north of N at a distance of 4 km; P is south of O at a distance of 2 km; N is southeast of O by 1 km. What is the distance between M and P in km?

- (A) 5.34
- (B) 6.74
- (C) 28.5
- (D) 45.49

Solution:

Line diagram





$$\begin{aligned} \text{So, } MP &= \sqrt{(5)^2 + (1)^2} \\ &= \sqrt{25+1} = \sqrt{26} \\ &= 5.34 \text{ kms.} \end{aligned}$$

Hence, the correct option is (A).

COMPUTER SCIENCE AND INFORMATION TECHNOLOGY

Number of Questions: 55

Section Marks: 85.0

Q.11 to Q.35 carry 1 mark each and Q.36 to Q.65 carry 2 marks each.

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

Consider the following two statements.

S_1 : If a candidate is known to be corrupt, then he will not be elected.

S_2 : If a candidate is kind, he will be elected.

Which one of the following statements follows from S_1 and S_2 as per sound inference rules of logic?

- (A) If a person is known to be corrupt, he is kind
- (B) If a person is not known to be corrupt, he is not kind
- (C) If a person is kind, he is not known to be corrupt.
- (D) If a person is not kind, he is not known to be corrupt.

Solution: Given

S_1 : If a candidate is known to be corrupt, then he will not be elected.

S_2 : If a candidate is kind, he will be elected.

Let P : A candidate is known to be corrupt.

Q : A candidate will be elected.

and R : A candidate is kind

then s_1 and s_2 in symbolic form are

S_1 : $P \rightarrow \neg Q$ and S_2 : $R \rightarrow Q$

$\Rightarrow Q \rightarrow \neg P$ ($\because A \rightarrow B \Rightarrow \neg B \rightarrow \neg A$)

Now $R \rightarrow Q$, $Q \rightarrow \neg P \Rightarrow R \rightarrow \neg P$ (By Hypothetical syllogism)

i.e., If a candidate is kind, he is not known to be corrupt.

Hence, the correct option is (C).

Question Number: 12 **Question Type: NAT**

The cardinality of the power set of $\{0, 1, 2, \dots, 10\}$ is _____

Solution: Let $A = \{0, 1, 2, 3, \dots, 10\}$

The cardinality of the power set of $A =$ The number of elements in the power set of $A = 2^{n(A)} = 2^{11} = 2048$.

Hence, the correct option is (2048).

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

Let R be the relation on the set of positive integers such that aRb if and only if a and b are distinct and have a common divisor other than 1. Which one of the following statements about R is true?

- (A) R is symmetric and reflexive but not transitive
- (B) R is reflexive but not symmetric and not transitive
- (C) R is transitive but not reflexive and not symmetric
- (D) R is symmetric but not reflexive and not transitive

Solution: Given R is a relation on the set of positive integers Z^+ defined by $R = \{(a, b)/a \text{ and } b \text{ are distinct and have a common divisor other than } 1\}$

(1) R is NOT reflexive because $(a, b) \in R \Rightarrow a \uparrow b$

$\Rightarrow (a, a) \notin R \forall a \in Z^+$

(2) R is symmetric.

For, let $(a, b) \in R \Rightarrow a$ and b are distinct and have a common divisor other than 1.

$\Rightarrow b$ and a are distinct and have a common divisor other than 1.

$\Rightarrow (b, a) \in R$

(3) R is NOT symmetric

For, $(2, 6) \in R$ and $(6, 9) \in R$ but $(2, 9) \notin R$

$\therefore R$ is symmetric, but not reflexive and not transitive.

Hence, the correct option is (D).

Question Number: 14 **Question Type: NAT**

The number of divisors of 2100 is _____

Solution: We have $2100 = 2^2 \times 3 \times 5^2 \times 7$

\therefore The number of divisors of 2100 is $(2 + 1)(1 + 1)$

$(2 + 1)(1 + 1)$

$= 36$.

Hence, the correct option is (36).

Question Number: 15 **Question Type: NAT**

The larger of the two eigenvalues of the matrix $\begin{bmatrix} 4 & 5 \\ 2 & 1 \end{bmatrix}$ is _____

Solution: Let $A = \begin{bmatrix} 4 & 5 \\ 2 & 1 \end{bmatrix}$

The characteristic equation of A is $|A - \lambda I| = 0$

$$\Rightarrow \begin{vmatrix} 4-\lambda & 5 \\ 2 & 1-\lambda \end{vmatrix} = 0$$

$$\Rightarrow (4 - \lambda)(1 - \lambda) - 10 = 0$$

$$\Rightarrow \lambda^2 - 5\lambda - 6 = 0$$

$$\Rightarrow \lambda^2 + \lambda - 6\lambda - 6 = 0$$

$$\Rightarrow (\lambda + 1)(\lambda - 6) = 0$$

$$\Rightarrow \lambda = -1, \lambda = 6$$

∴ The larger of the two eigen values is 6.

Hence, the correct answer is (6).

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

An unordered list contains n distinct elements. The number of comparisons to find an element in this list that is neither maximum nor minimum is

- (A) $\theta(n \log n)$ (B) $\theta(n)$
 (C) $\theta(\log n)$ (D) $\theta(1)$

Solution: Consider the following list of elements

10 6 8 9 4 11 12 2

First compare 10, 6 (1 comparison)

Assign minimum element to MIN variable

Assign maximum element to MAX variable

MIN = 6

MAX = 10

Now compare 8 with MIN and with MAX, nothing got updated, so 8 could be that element.

∴ $\theta(1)$

Hence, the correct option is (D).

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

The minimum number of JK flip-flops required to construct a synchronous counter with the count sequence (0, 0, 1, 1, 2, 2, 3, 3, 0, 0, ...) is _____

Solution: The sequence has 4 different states each repeats are time 0, 0, 1, 1, 2, 2, 3, 3, 0, 0, ...

So total 8 states, no. of JK flip flops = $3(8 = 2^3)$

Question Number: 18 **Question Type: NAT**

Assume that for a certain processor, a read request takes 50 nanoseconds on a cache miss and 5 nanoseconds on a cache hit. Suppose while running a program, it was observed that 80% of the processor's read requests result in a cache hit. The average read access time in nanoseconds is _____

Solution: Average read access time =

$$H(T_1) + (1 - H)(T_2)$$

H – cache Hit ratio

T_1 – Time to access cache

T_2 – Time taken to access read request (on cache miss)

$$\text{Hit ratio } (H) = 80\% \Rightarrow \frac{80}{100} \Rightarrow 0.8$$

$$T_1 = 5 \text{ ns}$$

$$T_2 = 50 \text{ ns}$$

∴ Average read access time =

$$= [0.8(5) + 0.2(50)] \text{ ns}$$

$$= (4 + 10) \text{ ns}$$

$$= 14 \text{ ns}$$

Hence, the correct answer is (14).

Question Number: 19 **Question Type: NAT**

A computer system implements a 40-bit virtual address, page size of 8 kilobytes, and a 128-entry translation look-aside buffer (TLB) organized into 32 sets each having four ways. Assume that the TLB tag does not store any process id. The minimum length of the TLB tag in bits is _____

Solution: TAG bit will be 22-bits

| | | |
|-----|------------|-------------|
| 22 | 5 | 13 |
| TAG | SET OFFSET | WORD OFFSET |

Hence, the correct answer is (22).

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

Consider the following statements.

- I. The complement of every Turing decidable language is Turing decidable.
- II. There exists some language which is in NP but is not Turing decidable.
- III. If L is a language in NP, L is Turing decidable.

Which of the above statements is/are true?

- (A) Only II (B) Only III
 (C) Only I and II (D) Only I and III

Solution: Every Turing decidable is a Recursive language
 Every Turing recognizable is a Recursive – enumerable language.

Every Turing recognizable is a recursive enumerable language.

→ Complement of Turing decidable languages is decidable which is TRUE.

→ If the language is in NP, then it is turning decidable.

Hence, the correct option is (D).

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

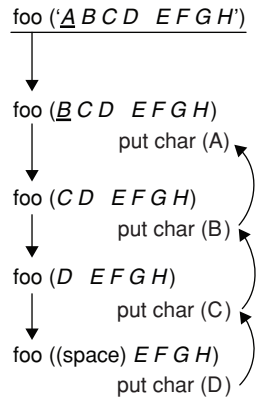
Consider the following function written in the C programming language.

```
void foo(char *a {
    if ( *a && *a != '\ '){
        foo(a + 1);
        putchar(*a);
    }
}
```

The output of the above function on input “ABCD EFGH” is

- (A) ABCD EFGH (B) ABCD
 (C) HGFE DCBA (D) DCBA

Solution: The function foo is a recursive function. The function reads the input string, character by character until the end of string (or) until the space is encountered.



It prints in reverse order of the string “A B C D” i.e., D C B A

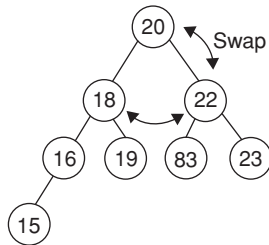
Hence, the correct option is (D).

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

Consider a complete binary tree where the left and the right subtrees of the root are max-heaps. The lower bound for the number of operations to convert the tree to a heap is

- (A) $\lfloor \log n \rfloor$
- (B) $\lfloor n \rfloor$
- (C) $\lfloor n \log n \rfloor$
- (D) $\lfloor n^2 \rfloor$

Solution: Left and right sub trees are max-heaps



$(\log n)$ operations (2 comparisons, 1 swap) $\lfloor \log n \rfloor$

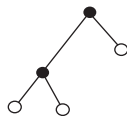
Hence, the correct option is (A).

Question Number: 23 **Question Type: NAT**

A binary tree T has 20 leaves. The number of nodes in T having two children is _____

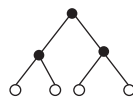
Solution: Consider the following trees.

Case 1:



- 3 – leaves
- 2 – (nodes with 2 children)

Case 2:



- 4 – leaves
 - 3(nodes with 2 – children)
- \therefore For 20 – leaves, the number of nodes having 2 – children will be 19.

Hence, the correct answer is (19).

Question Number: 24 **Question Type: NAT**

Consider the following C function

```
int fun(int n) {
    int x = 1, k;
    if (n == 1) return x;
    for (k = 1; k < n; ++k)
        x = x + fun(k) * fun(n - k);
    return x;
}
```

The return value of fun(5) is _____

Solution: Recurrence relation for above function is

$$f(n) = \begin{cases} 1 & \text{if } n=1 \\ 1 + \sum_{k=1}^{n-1} f(k).f(n-k) & \text{if } n>1 \end{cases}$$

| | | | | | | |
|--------|---|---|---|----|----|-----|
| n | 1 | 2 | 3 | 4 | 5 | 6 |
| $f(n)$ | 1 | 2 | 5 | 15 | 51 | 188 |

Hence, the correct answer is (51).

Question Number: 25 **Question Type: MCQ**

A software requirements specification (SRS) document should avoid discussing which one of the following?

- (A) User interface issues
- (B) Non-functional requirements
- (C) Design specification
- (D) Interfaces with third party software

Solution: Design specifications are not specified in SRS documents it is done in software design phase.

Hence, the correct option is (C).

Question Number: 26 **Question Type: MCQ**

Consider two decision problems Q_1, Q_2 such that Q_1 reduces in polynomial time to 3-SAT and 3-SAT reduces in polynomial time to Q_2 . Then which one of the following is consistent with the above statement?

- (A) Q_1 is in NP, Q_2 is NP hard.
- (B) Q_2 is in NP, Q_1 is NP hard.
- (C) Both Q_1 and Q_2 are in NP.
- (D) Both Q_1 and Q_2 are NP hard.

Solution: 3-SAT is a NP-complete problem if $Q_1 \leq_p 3\text{-SAT}$ then Q_1 is in NP, but Q_2 is not given in NP. Therefore Q_2 is in NP-hard.

Hence, the correct option is (A).

Question Number: 27 **Question Type: MCQ**

Match the following

| | |
|--------------------------|-------------------------|
| P. Lexical analysis | 1. Graph coloring |
| Q. Parsing | 2. DFA minimization |
| R. Register allocation | 3. Post-order traversal |
| S. Expression evaluation | 4. Production tree |

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

Solution. Lexical Analyzer is a finite automaton which is constructed from pattern recognizing rules.

Parsing of string is done using the production trees.

Register allocation is similar to that of graph coloring.

Expression evaluation is done using post order traversal.

Hence, the correct option is (C).

Question Number: 28 Question Type: MCQ

In the context of abstract-syntax-tree (AST) and control-flow-graph (CFG), which one of the following is TRUE?

- (A) In both AST and CFG, let node N_2 be the successor of node N_1 . In the input program, the code corresponding to N_2 is present after the code corresponding to N_1 .
 (B) For any input program, neither AST nor CFG will contain a cycle.
 (C) The maximum number of successors of a node in an AST and a CFG depends on the input program.
 (D) Each node in AST and CFG corresponds to at most one statement in the input program.

Solution: CFG may contain cycles, then option (A) is false.

The CFG can contain cycle, therefore option (B) is false.

Single node contains a block of statements, so option (D) is false.

The maximum number of successors in AST and CFG depends on the input program.

Hence, the correct option is (C).

Question Number: 29 Question Type: MCQ

Consider the basic COCOMO model where E is the effort applied in person-months, D is the development time in chronological months, KLOC is the estimated number of delivered lines of code (in thousands) and a_b, b_b, c_b, d_b have their usual meanings. The basic COCOMO equations are of the form

- (A) $E = a_b(\text{KLOC}) \exp(b_b), D = c_b(E) \exp(d_b)$
 (B) $D = a_b(\text{KLOC}) \exp(b_b), E = c_b(D) \exp(d_b)$
 (C) $E = a_b \exp(b_b), D = c_b(\text{KLOC}) \exp(d_b)$
 (D) $E = a_b \exp(d_b), D = c_b(\text{KLOC}) \exp(b_b)$

Solution: Basic COCOMO model takes the form effort applied $(E) = a_b(\text{KLOC})^b$

Development time $= C_b(E)d_b$.

Hence, the correct option is (A).

Question Number: 30 Question Type: MCQ

A system has 6 identical resources and N processes competing for them. Each process can request at most 2 resources. Which one of the following values of N could lead to a deadlock?

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

Solution: When $N = 6$,

The system will lead to deadlock, when each process requests for at most 2 resources.

Let us consider 6 processes P_1, P_2, \dots, P_6

| Process | P_1 | P_2 | P_3 | P_4 | P_5 | P_6 |
|-----------|-------|-------|-------|-------|-------|-------|
| Resources | 1 | 1 | 1 | 1 | 1 | 1 |

As there are only 6 resources, if it allocates one resource to each process, then there are no resources to allocate to complete their request.

Therefore it leads to deadlock, as they wait for a resource which will never be allocated.

No option is matching in the given question.

Question Number: 31 Question Type: MCQ

Consider the following transaction involving two bank accounts x and y .

read (x) ; $x := x - 50$; write (x) ; read(y); $y := y + 50$; write(y)

The constraint that the sum of the accounts x and y should remain constant is that of

- (A) Atomicity (B) Consistency
 (C) Isolation (D) Durability

Solution:

| |
|---------------|
| read (y) |
| $y = y + 50$ |
| Write (y) |

| |
|---------------|
| read (x) |
| $x = x - 50$ |
| Write (x) |

Assume that Initial balance in each account is 1000 ($x + y = 2000$)

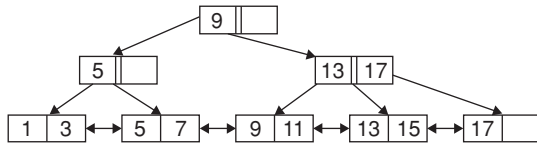
| | |
|--|---|
| read (x) \rightarrow 1000 | read (y) \rightarrow 1000 |
| $x = x - 50 \rightarrow$ 950 | $y = y + 50 \rightarrow$ 1050 |
| write (x) \rightarrow <u>950</u> | write (y) \rightarrow <u>1050</u> |
| $\therefore x + y = 2000$ | |

The balance in both accounts, after and before performing Transactions is “consistent”.

Hence, the correct option is (B).

Question Number: 32 Question Type: NAT

With reference to the B+ tree index of order 1 shown below, the minimum number of nodes (including the Root node) that must be fetched in order to satisfy the following query: “Get all records with a search key greater than or equal to 7 and less than 15” is _____



Solution: First start with root node, then,
At the leaf level,
∴ Total 5 nodes

| | | | | | |
|---|---|---|----|----|----|
| 5 | 7 | 9 | 11 | 13 | 15 |
|---|---|---|----|----|----|

Hence, the correct answer is (5).

Question Number: 33 **Question Type: MCQ**

Identify the correct order in which a server process must invoke the function calls accept, bind, listen, and recv according to UNIX socket API.

- (A) listen, accept, bind, recv
- (B) bind, listen, accept, recv
- (C) bind, accept, listen, recv
- (D) accept, listen, bind, recv

Solution: The order in which server invokes the function calls is bind, listen, accept and recv.

bind () will bind the socket to the address in the unix domain.

listen () instructs socket to listen for incoming connections from client programs.

accept () accepts a connection from a client and returns another socket descriptor.

once the connection is set client is ready to send () and recv ().

Hence, the correct option is (B).

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

A link has a transmission speed of 10^6 bits/sec. It uses data packets of size 1000 bytes each. Assume that the acknowledgement has negligible transmission delay, and that its propagation delay is the same as the data propagation delay. Also assume that the processing delays at nodes are negligible. The efficiency of the stop-and-wait protocol in this setup is exactly 25%. The value of the one-way propagation delay (in milliseconds) is _____

Solution: The efficiency of the stop and wait protocol is

$$\eta = \frac{L}{L + BR}$$

L = Length of the packet

B = Bandwidth of the link

R = Round trip delay if $\eta = 25\%$ then $L = \frac{BR}{3}$

i.e., $3L = BR$

$3 \times 1000 \times 8 = 10^6 \times R$

$R = 24 \times 10^{-3}$ [∵ $R = 2 \times \text{propagation delay}$]

$2 \times \text{Prop.delay} = 24 \times 10^{-3}$

Propagation delay = 12×10^{-3}

= 12 ms

Hence, the correct answer is (12).

Question Number: 35 **Question Type: MCQ**

Which one of the following statements is NOT correct about HTTP cookies?

- (A) A cookie is a piece of code that has the potential to compromise the security of an Internet user.
- (B) A cookie gains entry to the user's work area through an HTTP header.
- (C) A cookie has an expiry date and time.
- (D) Cookies can be used to track the browsing pattern of a user at a particular site.

Solution: A cookie is a piece of code which is sent from a website and stored in web browser. it has the potential to compromise the security of an user.

Hence, the correct option is (A).

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

Consider the following routing table at an IP router:

| Network No. | Net Mask | Next Hop |
|--------------|---------------|-------------|
| 128.96.170.0 | 255.255.254.0 | Interface 0 |
| 128.96.168.0 | 255.255.254.0 | Interface 1 |
| 128.96.166.0 | 255.255.254.0 | R2 |
| 128.96.164.0 | 255.255.252.0 | R3 |
| 0.0.0.0 | Default | R4 |

For each IP address in Group I identify the correct choice of the next hop from Group II using the entries from the routing table above.

| Group I | Group II |
|---------------------|----------------|
| i) 128.96.171.92 | a) Interface 0 |
| ii) 128.96.167.151 | b) Interface 1 |
| iii) 128.96.163.151 | c) R2 |
| iv) 128.96.165.121 | d) R3 |
| | e) R4 |

- (A) i-a, ii-c, iii-e, iv-d
- (B) i-a, ii-d, iii-b, iv-e
- (C) i-b, ii-c, iii-d, iv-e
- (D) i-b, ii-c, iii-e, iv-d

Solution:

(i) Given IP – address 128.96.171.92

Perform AND operation with given masks. If the result gives any specific Network number, the next hop of that network will be chosen.

$$\begin{array}{r} 128.96.171.92 \\ 255.255.254.0 \\ \hline 128.96.170.0 \end{array}$$

perform AND operation

∴ The next Hop will be Interface 0.

(ii)
$$\begin{array}{r} 128.96.167.151 \\ 255.255.254.0 \\ \hline \hline \end{array}$$
 perform AND operation

$$\begin{array}{r} 128.96.1010\ 0111.1001\ 0110 \\ 255.255.1111\ 1110.0000\ 0000 \\ \hline \hline 128.96.\ 166\ .0 \end{array}$$

∴ The next Hop will be R_2
i – a, ii – c, iii – e, iv – d

Hence, the correct option is (A).

Question Number: 37 **Question Type: MCQ**

Host A sends a UDP datagram containing 8880 bytes of user data to host B over an Ethernet LAN. Ethernet frames may carry data upto 1500 bytes (i.e., MTU = 1500 bytes). Size of UDP header is 8 bytes and size of IP header is 20 bytes. There is no option field in IP header. How many total number of IP fragments will be transmitted and what will be the contents of offset field in the last fragment?

- (A) 6 and 925
- (B) 6 and 7400
- (C) 7 and 1110
- (D) 7 and 8880

Solution: User data = 8880 bytes
MTU = 1500 bytes
UDP header = 8 bytes
IP header = 20 bytes
Header length = (20 + 8) = 28 bytes
Actual data in each fragment = 1500 – 28 = 1472 bytes

| | data | header | offset |
|--------------|------|--------|----------------------------------|
| 1st fragment | 1472 | 28 | 0/8 = 0 |
| 2nd fragment | 1472 | 28 | 1472/8 = 184 |
| 3rd fragment | 1472 | 28 | $\frac{2 \times 1472}{8} = 368$ |
| 4th fragment | 1472 | 28 | $\frac{3 \times 1472}{8} = 552$ |
| 5th fragment | 1472 | 28 | $\frac{4 \times 1472}{8} = 736$ |
| 6th fragment | 1472 | 28 | $\frac{5 \times 1472}{8} = 920$ |
| 7th fragment | 48 | 28 | $\frac{6 \times 1472}{8} = 1104$ |

Number of IP fragments will be ‘7’.
Offset field of last fragment is 1104.
Hence, the correct option is (C).

Question Number: 38 **Question Type: MCQ**

Assume that the bandwidth for a TCP connection is 1048560 bits/sec. Let α be the value of RTT in milliseconds (rounded off to the nearest integer) after which the TCP window scale option is needed. Let β be the maximum possible window size with window scale option. Then the values of α and β are

- (A) 63 milliseconds, 65535×2^{14}
- (B) 63 milliseconds, 65535×2^{16}
- (C) 500 milliseconds, 65535×2^{14}
- (D) 500 milliseconds, 65535×2^{16}

Solution: In TCP connection, default window size is 64 K bytes.

If then, Round Trip time (RTT) is the main factor to decide TCP throughput between 2 locations.

If, RTT = 10 msec \Rightarrow TCP throughput = 52428000 bps
RTT = 20 msec \Rightarrow TCP throughput = 26214000 bps
RTT = 100 msec \Rightarrow TCP throughput = 5242800 bps
RTT = 200 msec \Rightarrow TCP throughput = 2621400 bps
RTT = 300 msec \Rightarrow TCP throughput = 1747600 bps
RTT = 500 msec \Rightarrow TCP throughput = 1048560 bps
 $\alpha = 500$ msec

If we are not using TCP window scaling option, TCP window size will be used as 64 K bytes \Rightarrow 65536 bytes.

Actual window size, using TCP window scaling, is
 $= (\text{window size}) * 2^{(\text{window scale})}$
 $= 65535 \times 2^{14}$

The window scaling option may be sent only once during a connection by each host, in its SYN packet. The maximum valid scale value is 14 (RFC 1323).

Hence, the correct option is (C).

Question Number: 39 **Question Type: MCQ**

Consider a simple checkpointing protocol and the following set of operations in the log.

(start, T_4); (write, $T_4, y, 2, 3$); (start, T_1); (commit, T_4);
(write, $T_1, z, 5, 7$);
(checkpoint);
(start, T_2); (write, $T_2, x, 1, 9$); (commit, T_2); (start, T_3), (write, $T_3, z, 7, 2$);

If a crash happens now and the system tries to recover using both undo and redo operations. What are the contents of the undo list and the redo list?

- (A) Undo: T_3, T_1 ; Redo: T_2
- (B) Undo: T_3, T_1 ; Redo: T_2, T_4
- (C) Undo: none; Redo: T_2, T_4, T_3, T_1
- (D) Undo: T_3, T_1, T_4 ; Redo: T_2

Solution:

Check point:

The automatic recovery process by identifying a point at which all completed transactions are guaranteed to have been written to the database device.

A check point creates a known good point from which the SQL server Database engine can start applying changes contained in the log during recovery after an unexpected crash.

Before checkpoint:

- T_4 is committed
- No need to REDO T_4
- T_1 is not committed
- Need to UNDO T_1

After checkpoint:

- T_2 is committed, but for recovery, we should REDO from the point of “checkpoint”.
 - T_3 is not committed,
 - Need to UNDO.
- Hence, the correct option is (A).

Question Number: 40 **Question Type: MCQ**

Consider two relations $R_1(A, B)$ with the tuples (1, 5), (3, 7) and $R_2(A, C) = (1, 7), (4, 9)$. Assume that $R(A, B, C)$ is the full natural outer join of R_1 and R_2 . Consider the following tuples of the form (A, B, C) : $a = (1, 5, \text{null}), b = (1, \text{null}, 7), c = (3, \text{null}, 9), d = (4, 7, \text{null}), e = (1, 5, 7), f = (3, 7, \text{null}), g = (4, \text{null}, 9)$. Which one of the following statements is correct?

- (A) R contains a, b, e, f, g but not c, d .
- (B) R contains all of a, b, c, d, e, f, g .
- (C) R contains e, f, g but not a, b .
- (D) R contains e but not f, g .

Solution:

$$R_1$$

| A | C |
|---|---|
| 1 | 7 |
| 4 | 9 |

$$R_2$$

| A | B |
|---|---|
| 1 | 5 |
| 3 | 7 |

R_1 FULL OUTER JOIN R_2

| A | B | C |
|---|------|------|
| 1 | 5 | 7 |
| 3 | 7 | NULL |
| 4 | NULL | 9 |

- $a = (1, 5, \text{NULL})$ Not Present
- $b = (1, \text{Null}, 7)$ Not present
- $c = (1, 5, 7)$ present
- $f = (3, 7, \text{Null})$ present
- $g = (4, \text{Null}, 9)$ Present

Hence, the correct option is (C).

Question Number: 41 **Question Type: MCQ**

Consider six memory partitions of sizes 200 KB, 400 KB, 600 KB, 500 KB, 300 KB and 250 KB, where KB refers to kilobyte. These partitions need to be allotted to four processes of sizes 357 KB, 210 KB, 468 KB and 491 KB in that order. If the best fit algorithm is used, which partitions are NOT allotted to any process?

- (A) 200 KB and 300 KB
- (B) 200 KB and 250 KB
- (C) 250 KB and 300 KB
- (D) 300 KB and 400 KB

Solution: The memory Map from the Question is

| | | |
|---------|--|--------|
| Block 1 | | 200 KB |
| Block 2 | | 400 KB |
| Block 3 | | 600 KB |
| Block 4 | | 500 KB |
| Block 5 | | 300 KB |
| Block 6 | | 250 KB |

The process P_1, P_2, P_3, P_4 requested for sizes 357 kB, 210 kB, 468 kB and 491 kB.

∴ the process P_1 is allocated to Block 2, P_2 is allocated to Block 6, P_3 is allocated to Block 4 and P_4 is allocated in Block 3.

So, Block 1 and Block 5 are not allocated to any process, i.e., Block 1 (200 kB) and Block 5 (300 kB) are not allotted. Hence, the correct option is (A).

Question Number: 42 **Question Type: NAT**

Consider a typical disk that rotates at 15000 rotations per minute (RPM) and has a transfer rate of 50×10^6 bytes/sec. If the average seek time of the disk is twice the average rotational delay and the controller’s transfer time is 10 times the disk transfer time, the average time (in milliseconds) to read or write a 512-byte sector of the disk is _____

Solution: 60 sec → 15000 rotations

$$\frac{60}{15000} = 4 \text{ ms} \leftarrow 1 \text{ rotation}$$

$$\therefore \text{average rotational delay} = \frac{1}{2} \times 4 = 2 \text{ ms}$$

$$\text{Average seek time} = 2 \times \text{Average rotational delay} = 2 \times 2 \Rightarrow 4 \text{ ms}$$

$$1 \text{ sec} \rightarrow 50 \times 10^6 \text{ bytes}$$

$$0.01 \text{ ms} \rightarrow \frac{512}{50 \times 10^6} \Rightarrow 512 \text{ bytes}$$

$$\text{Transfer time} = 10 \times 0.01 \text{ ms} = 0.1 \text{ ms}$$

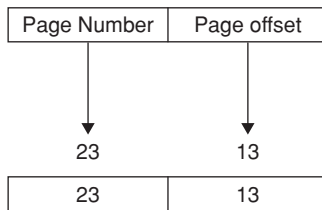
$$\text{Average time} = 4 \text{ ms} + 0.1 \text{ ms} + 2 \text{ ms} = 6.1 \text{ ms}$$

Hence, the correct answer is (6.1 to 6.2).

Question Number: 43 **Question Type: NAT**

A computer system implements 8 kilobyte pages and a 32-bit physical address space. Each page table entry contains a valid bit, a dirty bit, three permission bits, and the translation. If the maximum size of the page table of a process is 24 megabytes, the length of the virtual address supported by the system is _____ bits.

Solution: Page – Table size = $(n \times e)$
 $n \rightarrow$ number of pages
 $e \rightarrow$ page entry size (in bytes)
 Page size = 8 KB $\Rightarrow 2^{13}$
 given page-entry contains a valid bit, dirty bits, three permission bits and the translation. i.e., 5-bits are reserved, the translation requires 19-bits $\left[frames = \frac{2^{32}}{2^{13}} \Rightarrow 2^{19} \right]$
 page entry size = $(5 + 19)$ bits
 = 24-bits
 $\Rightarrow 3$ Bytes
 Number of pages are
 $n \times e =$ page table size
 $n \times (3) = 24$ MB
 $3n = 24$ MB
 $n = \frac{24 \times 2^{20}}{3}$
 $n = 2^{23}$
 Number of pages = 2^{23}
 Virtual address



= 23 + 13
 = 36-bits
 Virtual address = 36-bits
 Hence, the correct answer is (36).

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

Consider the intermediate code given below.

- (1) $i = 1$
- (2) $j = 1$
- (3) $t_1 = 5 * i$
- (4) $t_2 = t_1 + j$
- (5) $t_3 = 4 * t_2$
- (6) $t_4 = t_3$
- (7) $a[t_4] = -1$
- (8) $j = j + 1$

- (9) if $j \leq 5$ goto (3)
- (10) $i = i + 1$
- (11) if $i < 5$ goto (2)

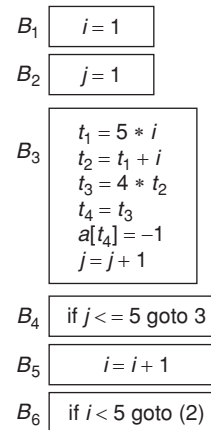
The number of nodes and edges in the control-flow-graph constructed for the above code, respectively, are

- (A) 5 and 7
- (B) 6 and 7
- (C) 5 and 5
- (D) 7 and 8

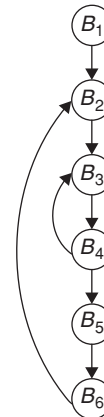
Solution:

- (1) $i = 1$
- (2) $j = 1$
- (3) $t_1 = 5 * i$
- (4) $t_2 = t_1 + j$
- (5) $t_3 = 4 * t_2$
- (6) $t_4 = t_3$
- (7) $a[t_4] = -1$
- (8) $j = j + 1$
- (9) if $j \leq 5$ goto (3) \rightarrow leader
- (10) $i = i + 1$ \rightarrow leader
- (11) if $i < 5$ goto (2) \rightarrow leader

The Basic Blocks for the above code.



There are 6 Basic blocks.
 The control flow graph is



There are 6 nodes and 7 edges.
 Hence, the correct option is (B).

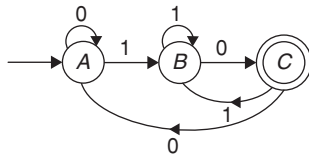
Question Number: 45 **Question Type: NAT**

The number of states in the minimal deterministic finite automaton corresponding to the regular expression $(0 + 1)^*(10)$ is _____

Solution: $(0 + 1)^*(10)$

The language for the above regular expression is all the strings which are ending with 10.

The minimal finite automaton is



The number of states in minimal FA for the above language is 3.

Hence, the correct answer is (3).

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

Which of the following languages is/are regular?

$L_1: \{wxw^R \mid w, x \in \{a, b\}^* \text{ and } |w|, |x| > 0\}$, w^R is the reverse of string w

$L_2: \{a^n b^m \mid m \uparrow n \text{ and } m, n \geq 0\}$

$L_3: \{a^p b^q c^r \mid p, q, r \geq 0\}$

- (A) L_1 and L_3 only (B) L_2 only
 (C) L_2 and L_3 only (D) L_3 only

Solution: $\{WXW^R \mid W, X \in \{a, b\}^*\}$

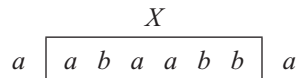
Assume that $W = a b a$

$X = a b b$

$W^R = a b a$

WXW^R

Assume as



We can write this language as, set of all strings starting and ending with same symbol.

$\therefore L_1$ is Regular

$L_2: \{a^n b^m \mid m \uparrow n\}$

We need a stack to compare, that every time $m \uparrow n$.

$\therefore L_2$ is not Regular

$L_3: \{a^p b^q c^r \mid p, q, r \geq 0\}$

We can generate a 's independently need not check (or) save (or) count, again same for b 's and c 's also.

Regular Expression = $aa^* bb^* cc^*$

$\therefore L_3$ is Regular.

Hence, the correct option is (A).

Question Number: 47 **Question Type: MCQ**

Given below are some algorithms, and some algorithm design paradigms.

- | | |
|--|-------------------------|
| 1. Dijkstra's Shortest Path | i. Divide and Conquer |
| 2. Floyd-Warshall algorithm to compute all pairs shortest path | ii. Dynamic Programming |
| 3. Binary search on a sorted array | iii. Greedy design |
| 4. Backtracking search on a graph | iv. Depth-first search |
| | v. Breadth-first search |

Match the above algorithms on the left to the corresponding design paradigm they follow.

- (A) 1-i, 2-iii, 3-i, 4-v (B) 1-iii, 2-iii, 3-i, 4-v
 (C) 1-iii, 2-ii, 3-i, 4-iv (D) 1-iii, 2-ii, 3-i, 4-v

Solution: Greedy Design \rightarrow Dijkstra's shortest path
 Dynamic programming \rightarrow Floyd - Warshall algorithm to compute all pairs shortest path.

Divide and conquer \rightarrow Binary search on a sorted array.

Depth First search \rightarrow Back tracking, search on a graph.

Hence, the correct option is (C).

Question Number: 48 **Question Type: NAT**

A Young tableau is a 2D array of integers increasing from left to right and from top to bottom. Any unfilled entries are marked with \circ , and hence there cannot be any entry to the right of, or below a \circ . The following Young tableau consists of unique entries.

| | | | |
|----|---------|---------|---------|
| 1 | 2 | 5 | 14 |
| 3 | 4 | 6 | 23 |
| 10 | 12 | 18 | 25 |
| 31 | \circ | \circ | \circ |

When an element is removed from a Young tableau, other elements should be moved into its place so that the resulting table is still a Young tableau (unfilled entries maybe filled in with a \circ). The minimum number of entries (other than 1) to be shifted, to remove 1 from the given Young tableau is _____

Solution:

| | | | |
|----|---------|---------|---------|
| 2 | | 5 | 14 |
| 3 | 4 | 6 | 23 |
| 10 | 12 | 18 | 25 |
| 31 | \circ | \circ | \circ |

| | | | |
|----|---------|---------|---------|
| 2 | 4 | 5 | 14 |
| 3 | 6 | | 23 |
| 10 | 12 | 18 | 25 |
| 31 | \circ | \circ | \circ |

| | | | |
|----|---------|---------|---------|
| 2 | 4 | 5 | 14 |
| 3 | 6 | 18 | 23 |
| 10 | 12 | 25 | \circ |
| 31 | \circ | \circ | \circ |

| | | | |
|----|---------|---------|---------|
| 2 | 4 | 5 | 14 |
| 3 | 6 | 18 | 23 |
| 10 | 12 | | 25 |
| 31 | \circ | \circ | \circ |

| | | | |
|----|----|----|----|
| 2 | 4 | 5 | 14 |
| 3 | | 6 | 23 |
| 10 | 12 | 18 | 25 |
| 31 | ° | ° | ° |

∴ 5 elements should be moved.

Hence, the correct answer is (5).

Question Number: 49 **Question Type: MCQ**

Suppose you are provided with the following function declaration in the C programming language.

int partition (int a[], int n);

The function treats the first element of a[] as a pivot, and rearranges the array so that all elements less than or equal to the pivot is in the left part of the array, and all elements greater than the pivot is in the right part in addition, it moves the pivot so that the pivot is the last element of the left part. The return value is the number of elements in the left part.

The following partially given function in the C programming language is used to find the k th smallest element in an array a[] of size n using the partition function. We assume $k \ll n$.

```
int kth_smallest (int a [], int n, int k)
{
    int left_end = partition(a, n);
    if (left_end+1 == k) {
        return a [left_end];
    }
    if (left_end+1 > k) {
        return kth_smallest (_____);
    } else {
        return kth_smallest (_____);
    }
}
```

The missing argument lists are respectively

- (A) (a, left_end, k) and (a+left_end+1, n-left_end-1, k-left_end-1)
 (B) (a, left_end, k) and (a, n-left_end-1, k-left_end-1)
 (C) (a+left_end+1, n-left_end-1, k-left_end-1) and (a, left_end, k)
 (D) (a, n-left_end-1, k-left_end-1) and (a, left_end, k)

Solution: The above program gets the k th smallest element using the concept of Quick sort and the binary search [using Divide and Conquer strategy]

When the condition, $\text{leftend} + 1 > k$ is true, the k th smallest element is present left to the pivot, therefore we have to search to the left of pivot. i.e., K th smallest (a, left-end, K)

When the condition $\text{leftend} + 1 < k$ is true, the k th smallest element is present right to the pivot, therefore we have to search between the left end and k th element.

K th smallest (a+left-end+1, n-left_end-1, k-left_end-1)

Hence, the correct option is (A).

Question Number: 50

Question Type: MCQ

Which one of the following hash functions on integers will distribute keys most uniformly over 10 buckets numbered 0 to 9 for i ranging from 0 to 2020?

- (A) $h(i) = i^2 \bmod 10$
 (B) $h(i) = i^3 \bmod 10$
 (C) $h(i) = (11 * i^2) \bmod 10$
 (D) $h(i) = (12 * i) \bmod 10$

Solution: Lets take first 10 elements that is 0, 1, 2, 3, 4, 5, 6, 7, 8, 9 bucket numbers (0 – 9)

Option (A)

$h(i) = i^2 \bmod 10$

- $0^2 \bmod 10 \Rightarrow 0 \bmod 10 = 0$
 $1^2 \bmod 10 \Rightarrow 1 \bmod 10 = 1$
 $2^2 \bmod 10 \Rightarrow 4 \bmod 10 = 4$
 $3^2 \bmod 10 \Rightarrow 9 \bmod 10 = 9$
 $4^2 \bmod 10 \Rightarrow 16 \bmod 10 = 6$
 $5^2 \bmod 10 \Rightarrow 25 \bmod 10 = 5$
 $6^2 \bmod 10 \Rightarrow 36 \bmod 10 = 6$
 $7^2 \bmod 10 \Rightarrow 49 \bmod 10 = 9$
 $8^2 \bmod 10 \Rightarrow 64 \bmod 10 = 4$
 $9^2 \bmod 10 \Rightarrow 81 \bmod 10 = 1$

Hash table:

| | | |
|---|---|-------------|
| 0 | 0 | |
| 1 | 1 | 9 collision |
| 2 | | |
| 3 | | |
| 4 | 2 | 8 collision |
| 5 | 5 | |
| 6 | 4 | 6 collision |
| 7 | | |
| 8 | | |
| 9 | 3 | 7 collision |

Let us consider the numbers from 0 to 9. Perform hash function $h(i) = i^3 \bmod 10$

- $0^3 \bmod 10 \rightarrow 0$
 $1^3 \bmod 10 \rightarrow 1$
 $2^3 \bmod 10 \rightarrow 8$
 $3^3 \bmod 10 \rightarrow 7$
 $4^3 \bmod 10 \rightarrow 4$
 $5^3 \bmod 10 \rightarrow 5$
 $6^3 \bmod 10 \rightarrow 6$
 $7^3 \bmod 10 \rightarrow 3$
 $8^3 \bmod 10 \rightarrow 2$
 $9^3 \bmod 10 \rightarrow 9$

From 0 to 9 the numbers are stored in hash table without any collision, similarly from 10 – 19, 20 – 29, ... the numbers are stored uniformly with the above sequence [0, 1, 8, 7, 4, 5, 6, 3, 2, 9]

Hence, the correct option is (B).

| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 |
|---|---|---|---|---|---|---|---|---|----|----|----|----|
| | O | P | P | P | W | | | | | | | |
| I | I | O | - | - | P | P | P | P | P | W | | |
| | | I | - | - | O | - | - | - | - | P | W | |
| | | | I | - | - | - | - | - | - | - | P | W |

Hence, the correct option is (13).

Question Number: 54 **Question Type: MCQ**

Consider a processor with byte-addressable memory. Assume that all registers, including Program Counter (PC) and Program Status Word (PSW), are of size 2 bytes. A stack in the main memory is implemented from memory location $(0100)_{16}$ and it grows upward. The stack pointer (SP) points to the top element of the stack. The current value of SP is $(016E)_{16}$. The CALL instruction is of two words, the first word is the op-code and the second word is the starting address of the subroutine (one word = 2 bytes). The CALL instruction is implemented as follows:

- Store the current value of PC in the stack
- Store the value of PSW register in the stack
- Load the starting address of the subroutine in PC

The content of PC just before the fetch of a CALL instruction is $(5FA0)_{16}$. After execution of the CALL instruction, the value of the stack pointer is

- (A) $(016A)_{16}$
- (B) $(016C)_{16}$
- (C) $(0170)_{16}$
- (D) $(0172)_{16}$

Solution: To execute CALL instruction, the contents of PC and PSW will be stored on to the stack.

Both PC and PSW are of 2 bytes in size

Given Top of stack is $(016E)_{16}$

Hence, the correct option is (D).

We need to add 4 bytes to the stack address to get stack address to get stack pointer address after execution of CALL instruction $(016E)_{16} + 4 = (0172)_{16}$.

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

The number of min-terms after minimizing the following Boolean expression is _____

$$[D^1 + AB^1 + A^1C + AC^1D + A^1C^1D]^1$$

Solution: Number of min terms

$$[D^1 + AB^1 + A^1C + AC^1D + A^1C^1D]^1$$

If we consider $f = D^1 + AB^1 + A^1C + C^1D$

We need to find minimum terms of f' , which are same as max terms of f .

| | | | | | | |
|----|----|----|----|----|----|----|
| | | CD | 00 | 01 | 11 | 10 |
| AB | 00 | 1 | 1 | 1 | 1 | 1 |
| | 01 | 1 | 1 | 1 | 1 | 1 |
| | 11 | 1 | 1 | 1 | 1 | 1 |
| | 10 | 1 | 1 | 1 | 1 | 1 |

$$D^1 = x x x 0$$

(0, 2, 4, 6, 8, 10, 12, 14)

$$AB^1 = 10XX$$

(8, 9, 10, 11)

$$A^1C = 0X1X$$

(2, 3, 6, 7)

$$C^1D = XX01$$

(1, 5, 9, 13)

So the only maximum term of $f = 1111$

So no. of minimum terms of $f^1 = 1$

Hence, the correct answer is (1).

Question Number: 56 **Question Type: MCQ**

Let $f(x) = x^{-(1/3)}$ and A denote the area of the region bounded by $f(x)$ and the X-axis, when x varies from -1 to 1 . Which of the following statements is/are TRUE?

- I) f is continuous in $[-1, 1]$
 - II) f is not bounded in $[-1, 1]$
 - III) A is nonzero and finite
- (A) II only (B) III only
 (C) II and III only (D) I, II and III

Solution: Given $f(x) = x^{-(1/3)}$

Clearly $f(x) = x^{-(1/3)} \rightarrow \infty$ as $x \rightarrow 0$

$\Rightarrow f(x)$ is not bounded in $[-1, 1]$

\therefore II is TRUE \rightarrow (1)

$\Rightarrow f(x)$ is NOT continuous in $[-1, 1]$

\therefore I is NOT TRUE \rightarrow (2)

The area bounded by the curve $f(x)$, X-axis and the lines $x = -1$ to $x = 1$

$$= A = \int_{-1}^1 f(x) dx = \int_{-1}^1 x^{-(1/3)} dx = - \int_{-1}^0 x^{(1/3)} dx + \int_0^1 x^{-(1/3)} dx$$

$$= \left[\frac{x^{2/3}}{2/3} \right]_{-1}^0 + \left[\frac{x^{2/3}}{2/3} \right]_0^1 = \left[\frac{-3}{2} x^{2/3} \right]_{-1}^0 + \left[\frac{3}{2} x^{2/3} \right]_0^1$$

$$= \frac{-3}{2} (0-1) + \frac{3}{2} (1-0) = \frac{3}{2} + \frac{3}{2}$$

$\therefore A = 3$

$\therefore A$ is non zero and finite.

\therefore III is TRUE \rightarrow (3)

Hence from (1), (2) and (3) the statements.

II and III only are true.

Hence, the correct option is (C).

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

Perform the following operations on the matrix

$$\begin{bmatrix} 3 & 4 & 45 \\ 7 & 9 & 105 \\ 13 & 2 & 195 \end{bmatrix}$$

- (1) Add the third row to the second row
- (2) Subtract the third column from the first column

The determinant of the resultant matrix is _____

Solution: Let $A = \begin{bmatrix} 3 & 4 & 45 \\ 7 & 9 & 105 \\ 13 & 2 & 195 \end{bmatrix}$

- (1) Add the third row to the second row
- (2) subtract the third column from the first column.

We know that operations of the type (1) and (2) on a matrix cannot change its determinant.

∴ The determinant of the matrix obtained by applying the operations (1) and (2) on A

$$= \text{Det of } A = \begin{vmatrix} 3 & 4 & 45 \\ 7 & 9 & 105 \\ 13 & 2 & 195 \end{vmatrix}$$

$$= 15 \begin{vmatrix} 3 & 4 & 3 \\ 7 & 9 & 7 \\ 13 & 2 & 13 \end{vmatrix} = 15 \times 0 = 0$$

Hence, the correct answer is (0).

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

The number of onto functions (surjective functions) from set $X = \{1, 2, 3, 4\}$ to set $Y = \{a, b, c\}$ is _____.

Solution: Given $X = \{1, 2, 3, 4\}$ and $Y = \{a, b, c\}$

∴ $n(X) = 4$ and $n(Y) = 3$

The number of onto functions from a set A to a set B, where

$$n(A) \geq n(B) \text{ is } \sum_{r=0}^{n-1} (-1)^r n_c (n-r)^m$$

where $n(A) = m$ and $n(B) = n$

Here $m = n(X) = 4$ and $n = n(Y) = 3$

∴ The number of onto functions from X to Y is

$$\sum_{r=0}^{n-1} (-1)^r {}^n C_r (n-r)^m = \sum_{r=0}^{3-1} (-1)^r {}^3 C_r (3-r)^4$$

$$= {}^3 C_0 3^4 - {}^3 C_1 2^4 + {}^3 C_2 1^4$$

$$= 81 - 48 + 3 = 36$$

Hence, the correct answer is (36).

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

Let X and Y denote the sets containing 2 and 20 distinct objects respectively and F denote the set of all possible functions be from X to Y. Let f be randomly chosen from F. The probability of f being one-to-one is _____.

Solution: Given $n(X) = 2$ and $n(Y) = 20$

$n(F) =$ The number of elements in F

$=$ The number of functions that can be defined from X to Y.

$= n(Y)^{n(X)} = 20^2 = 400$

The number of one-one functions from X to

$Y = {}^{n(Y)} P_{n(X)}$

$= {}^{20} P_2 = 380$

The probability that a randomly chosen function f from F is

one-one $= \frac{380}{400} = 0.95$

Hence, the correct answer is (0.95).

Number: 60 **Question Type: MCQ**

Consider the alphabet $\Sigma = \{0, 1\}$, the null/empty string λ and the sets of strings X_0, X_1 and X_2 generated by the corresponding non-terminals of a regular grammar. X_0, X_1 and X_2 are related as follows

$X_0 = 1 X_1$

$X_1 = 0 X_1 + 1 X_2$

$X_2 = 0 X_1 + \{\lambda\}$

Which one of the following choices precisely represents the strings in X_0 ?

- (A) $10(0^* + (10)^*)1$
- (B) $10(0^* + (10)^*)^*1$
- (C) $1(0 + 10)^*1$
- (D) $10(0 + 10)^*1 + 110(0 + 10)^*1$

Solution:

$X_0 \rightarrow 1 X_1$

$X_1 \rightarrow 0 X_1 \mid 1 X_2$

$X_2 \rightarrow 0 X_1 \mid \epsilon$

The above grammar represents a language with the strings starts and ends with '1', with 0's as substring $[10^*1]$ (or) with (10)'s as substring $[1(10)^*1]$

The Regular expression is

$10^* 1 + 1 (10)^* 1$

↓

$1(0 + 10)^* 1$

Hence, the correct option is (C).

Question Number: 61 **Question Type: MCQ**

A graph is self-complementary if it is isomorphic to its complement. For all self-complementary graphs on n vertices, n is

- (A) A multiple of 4
- (B) Even
- (C) Odd
- (D) Congruent to 0 mod 4, or, 1 mod 4

Solution: Let G be a graph of n vertices which is isomorphic to its complement \bar{G} .

∴ G and \bar{G} should have same no. of edges. This is possible only when the no. of edges in G and \bar{G} must be half of the no. of edges in the complete graph of n vertices K_n .

The no. of edges of $G = |E_G| = \frac{1}{2} |E_{k_n}|$
 $= \frac{1}{2} \left(\frac{n(n-1)}{2} \right) = \frac{n(n-1)}{4}$

As $|E_G|$ being a positive integer, $\frac{n(n-1)}{4}$ is a positive integer.
 $\Rightarrow n(n-1)$ is a multiple of 4.
 $\Rightarrow n$ is a multiple of 4 (or) $n-1$ is a multiple of 4.
 $\Rightarrow n \equiv 0 \pmod{4}$ (or) $n-1 \equiv 0 \pmod{4}$
 $\Rightarrow n \equiv 0 \pmod{4}$ (or) $n \equiv 1 \pmod{4}$
 $\therefore n$ is congruent to 0 mod 4 or n is congruent to 1 mod 4.

Hence, the correct option is (D).

Question Number: 62 **Question Type: MCQ**

In a connected graph, a bridge is an edge whose removal disconnects a graph. Which one of the following statements is true?

- (A) A tree has no bridges
- (B) A bridge cannot be part of a simple cycle
- (C) Every edge of a clique with size ≥ 3 is a bridge (A clique is any complete subgraph of a graph)
- (D) A graph with bridges cannot have a cycle

Solution: In a simple cycle of a connected graph, the graph cannot be disconnected by removing any edge of that cycle.

Hence edge of a simple cycle cannot be a bridge.

Hence, the correct option is (B).

Question Number: 63 **Question Type: MCQ**

Which one of the following well formed formulae is a tautology?

- (A) $\forall x \exists y R(x, y) \leftrightarrow \exists y \forall x R(x, y)$
- (B) $(\forall x [\forall y R(x, y) \rightarrow S(x, y)] \forall x \exists y S(x, y))$
- (C) $[\forall x \exists y (P(x, y) \rightarrow R(x, y))] \leftrightarrow [\forall x \exists y (P(x, y) \vee R(x, y))]$
- (D) $\forall x \forall y P(x, y) \rightarrow \forall x \forall y P(y, x)$

Solution: Consider $\forall x \exists y (P(x, y) \rightarrow R(x, y))$

$$\forall x \exists y (\neg P(x, y) \vee R(x, y))$$

$$(\neg P \rightarrow Q \leftrightarrow \neg P \vee Q)$$

$$\therefore [\forall x \exists y (P(x, y) \rightarrow R(x, y))] \leftrightarrow [\forall x \exists y (\neg P(x, y) \vee R(x, y))]$$

is a tautology.

Hence, the correct option is (C).

Question Number: 64 **Question Type: MCQ**

Which one of the following assertions concerning code inspection and code walkthrough is true?

- (A) Code inspection is carried out once the code has been unit tested.
- (B) Code inspection and code walkthrough are synonyms
- (C) Adherence to coding standards is checked during code inspection
- (D) Code walkthrough is usually carried out by independent test team

Solution: Inspection is used to verify the compliance of the product with specified standards and requirements, it is done by examining, meetings are needed, on the basis of feedback, rework is done.

Walk through is different from inspections.

In walk through author presents their artifacts to audience of peers. Peer questions and comments on these, to identify as many as possible.

Inspection is done by examining comparing the product with design, code, artifacts and any other documentation available.

Hence, the correct option is (C).

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

A half adder is implemented with XOR and AND gates. A full adder is implemented with two half adders and one OR gate. The propagation delay of an XOR gate is twice that of an AND/OR gate. The propagation delay of an AND/OR gate is 1.2 microseconds. A 4-bit ripple-carry binary adder is implemented by using four full adders. The total propagation time of this 4-bit binary adder in microseconds is _____

Solution: Half adder \rightarrow XOR gate, AND gate

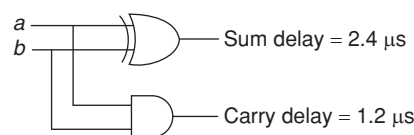
Full adder \rightarrow 2 Half adder, OR gate

Propagation delay of XOR = 2 \times propagation delay of AND/OR

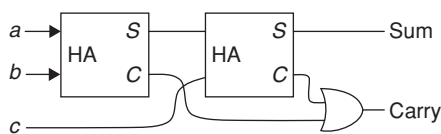
$$= 2 \times 1.2 \mu\text{s}$$

$$= 2.4 \mu\text{s}$$

Half adder delay



Full adder delay



$$\text{Sum delay} = 2 \text{ XOR} = 4.8 \mu\text{s}$$

$$\text{Carry delay} = \text{xor} + \text{AND} + \text{OR}$$

$$= 4.8 \mu\text{s}$$

For 4-bit ripple carry adder

$$t_{\text{delay}} = (n-1)t_{\text{carry}} + t_{\text{sum}} = 3 \times 4.8 + 4.8$$

$$= 19.2 \mu\text{s}$$

Hence, the correct answer is (19.2).

GATE 2015 SOLVED PAPER
CS: COMPUTER SCIENCE AND INFORMATION TECHNOLOGY
Set – 3

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**

Extreme focus on syllabus and studying for tests has become such a dominant concern of Indian students that they close their minds to anything _____ to the requirements of the exam

- (A) related (B) extraneous
 (C) outside (D) useful

Solution: The sentence implies that students study only that which is prescribed within the syllabus and nothing beyond it. 'Extraneous' means 'not important'. 'Outside' cannot be used as 'to' is present after the blank. 'Outside to' is ungrammatical. The other choices are irrelevant to the given sentence.

Hence, the correct option is (B).

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

Select the pair that best expresses a relationship similar to that expressed in the pair:

Children : Pediatrician

- (A) Adult : Orthopaedist
 (B) Females : Gynaecologist
 (C) Kidney : Nephrologist
 (D) Skin : Dermatologist

Solution: A pediatrician treats children. In the same context, a gynaecologist treats females. Though a nephrologist treats kidneys and a dermatologist treats the skin, kidneys and skin are not living beings or humans.

Hence, the correct option is (B).

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

The Tamil version of _____ John Abraham-starrer Madras Café _____ cleared by the Censor Board with no cuts last week, but the film's distributors _____ no takers among the exhibitors for a release in Tamil Nadu _____ this Friday.

- (A) Mr., was, found, on
 (B) a, was, found, at
 (C) the, was, found, on
 (D) a, being, find, at

Solution: The use of 'the' shows that only a certain John Abraham is being referred to 'Was' and 'found' fit the next two blanks. 'On' is correct over 'at'. Though, the last blank can be deleted as well.

Hence, the correct option is (C).

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

If ROAD is written as URDG, then SWAN should be written as:

- (A) VXDQ (B) VZDQ
 (C) VZDP (D) UXDQ

Solution: R O A D is written as U R D G

| | | | |
|----|----|----|----|
| R | O | S | D |
| +3 | +3 | +3 | +3 |
| ↓ | ↓ | ↓ | ↓ |
| U | R | D | G |

Applying the same logic to SWAN
 Then

| | | | |
|----|----|----|----|
| S | W | A | N |
| +3 | +3 | +3 | +3 |
| ↓ | ↓ | ↓ | ↓ |
| V | Z | D | Q |

Hence, the correct option is (B).

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

A function $f(x)$ is linear and has a value of 29 at $x = -2$ and 39 at $x = 3$. Find its value at $x = 5$.

- (A) 59 (B) 45
 (C) 43 (D) 35

Solution: Let $f(x) = ax + b$ where a and b are constants $f(-2) = 29$ and $f(3) = 39$ $a(-2) + b = 29$ and $a(3) + b = 39$
 Solving these, $a = 2$ and $b = 33 \Rightarrow f(x) = 2x + 33$

$\therefore f(5) = 2(5) + 33 = 43$

Hence, the correct option is (C).

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

Alexander turned his attention towards India, since he had conquered Persia.

Which one of the statements below is logically valid and can be inferred from the above sentence?

- (A) Alexander would not have turned his attention towards India and had he not conquered Persia.
- (B) Alexander was not ready to rest on his laurels, and wanted to march to India.
- (C) Alexander was completely in control of his army and could command it to move towards India.
- (D) Since Alexander's kingdom extended to Indian borders after the conquest of Persia, he was keen to move further.

Solution: The logically consistent form of the above given statement is implicit only from (A)

Hence, the correct option is (A).

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

Most experts feel that in spite of possessing all the technical skills required to be a batsman of the highest order, he is unlikely to be so due to lack of requisite temperament. He was guilty of throwing away his wicket several times after working hard to lay a strong foundation. His critics pointed out that until he addressed this problem, success at the highest level will continue to elude him.

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

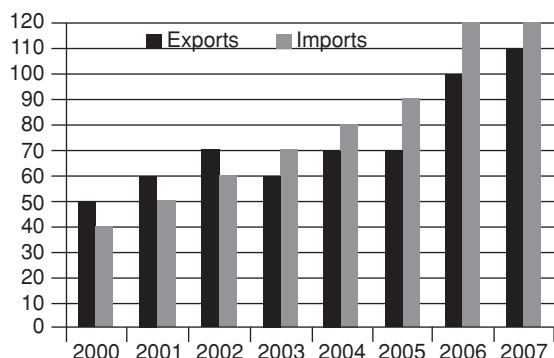
- (1) He was already a successful batsman at the highest level.
 - (2) He has to improve his temperament in order to become a great batsman.
 - (3) He failed to make many of his good starts count.
 - (4) Improving his technical skills will guarantee success.
- (A) (3) and (4) (B) (2) and (3)
 (C) (1), (2) and (3) (D) (2) only

Solution: Form the given passage only statement (2) and (3) can be inferred. Whereas, statement (1) is contradicting the main essence of the passage and (4) is a farfetched conclusion.

Hence, the correct option is (B).

Question Number: 8 **Question Type: NAT**

The exports and imports (in crores of Rs.) of a country from the year 2000 to 2007 are given in the following bar chart. In which year is the combined percentage increase in imports and exports the highest?



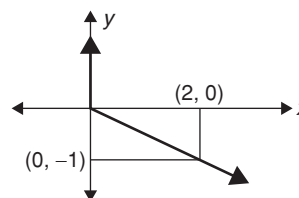
Solution: From 2005 to 2006, the combined imports and exports increased by ₹60 crores.

∴ The combined percentage increase in imports and exports in 2006 (over the previous year) was $\frac{60}{160} (100)\%$ i.e., 37.5). This was the maximum combined percentage increase in imports and exports in any year over the given period.

Hence, the correct answer is (2006).

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

Choose the most appropriate equation for the function drawn as a thick line, in the plot below.



- (A) $x = y - |y|$
- (B) $x = -(y - |y|)$
- (C) $x = y + |y|$
- (D) $x = -(y + |y|)$

Solution: Given,
 $x = 0$ for $y > 0$

$x = -2y$ for $y \leq 0$

Going from the options,

Choice (A) $\Rightarrow x = 0$ for $y \geq 0$
 $x = 2y$ for $y \leq 0$

Choice (B) $\Rightarrow x = 0$ for $y \geq 0$
 $x = -2y$ for $y \leq 0$

Choice (C) $\Rightarrow x = 2y$ for $y \geq 0$
 $x = 0$ for $y \leq 0$

Choice (D) $\Rightarrow x = -2y$ for $y \geq 0$

$x = 0$ for $y \leq 0$

∴ $x = -(y - |y|)$

Hence, the correct option is (B).

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

The head of a newly formed government desires to appoint five of the six selected members P, Q, R, S, T and U to portfolios of Home, Power, Defense, Telecom and Finance. U does not want any portfolio if S gets one of the five. R wants either Home or Finance or no portfolio. Q says that if S gets either Power or Telecom, then she must get the other one. T insists on a portfolio if P gets one.

Which is the valid distribution of portfolios?

- (A) P-Home, Q-Power, R-Defense, S-Telecom, T-Finance.
- (B) R-Home, S-Power, P-Defense, Q-Telecom, T-Finance.
- (C) P-Home, Q-Power, T-Defense, S-Telecom, U-Finance.
- (D) Q-Home, U-Power, T-Defense, R-Telecom, P-Finance.

Solution: Only option (B) is complying with all the rules and constrictions.

Hence, the correct option is (B)

COMPUTER SCIENCE AND INFORMATION TECHNOLOGY

Number of Questions: 55

Section marks: 85.0

Q.11 to Q.35 carry 1 mark each and Q.36 to Q.65 carry 2 marks each.

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

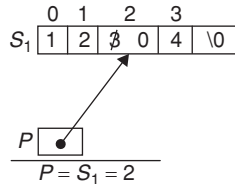
Consider the following C program segment.

```
#include <stdio.h>
int main()
{
    char s1[7] = "1234", *p;
    p = s1 + 2;
    *p = '0';
    printf("%s", s1);
}
```

What will be printed by the program?

- (A) 12
- (B) 120400
- (C) 1204
- (D) 1034

Solution:



P is a pointer pointing to the 3rd character of S1
 * P = '0';
 it rewrites the value of S1[2] ('3' is replaced with 0)
 S1 had "1204", when S1 is printed, it prints 1204.

Hence, the correct option is (C).

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

Suppose U is the power set of the set $S = \{1,2,3,4,5,6\}$. For any $T \in U$, let $|T|$ denote the number of elements in T and T^c denote the complement of T . For any $T, R \in U$, let $T \setminus R$ be the set of all elements in T which are not in R . Which one of the following is true?

- (A) $\forall X \in U (|X| = |X^c|)$
- (B) $\exists X \in U \exists Y \in U (|X| = 5, |Y| = 5 \text{ and } X \cap Y = \phi)$
- (C) $\forall X \in U \forall Y \in U (|X| = 2, |Y| = 3 \text{ and } X \setminus Y = \phi)$
- (D) $\forall X \in U \forall Y \in U (X \setminus Y = Y \setminus X^c)$

Solution: Given $S = \{1, 2, 3, 4, 5, 6\}$
 $U = P(S)$
 Consider the set $X \setminus Y = \{x/x \in S, x \in X \text{ and } x \notin Y\}$
 $= \{x/x \in S, x \in X \text{ and } x \notin Y^c\}$
 $= \{x/x \in S, x \in Y^c \text{ and } x \notin X^c\}$
 $= Y^c \setminus X^c, \forall X \in U, \forall Y \in U$

Hence, the correct option is (D).

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

Consider the relation $X(P, Q, R, S, T, U)$ with the following set of functional dependencies

```
F = {
    {P, R} → {S, T}
    {P, S, U} → {Q, R}
}
```

Which of the following is the trivial functional dependency in F^+ , where F^+ is closure of F ?

- (A) $\{P, R\} \rightarrow \{S, T\}$
- (B) $\{P, R\} \rightarrow \{R, T\}$
- (C) $\{P, S\} \rightarrow \{S\}$
- (D) $\{P, S, U\} \rightarrow \{Q\}$

Solution:

Trivial:

If $A \rightarrow B$
 B has to be subset of A
 $\{P, S\} \rightarrow \{S\}$
 $\{S\}$ is subset of $\{P, S\}$

Hence, the correct option is (C).

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

The maximum number of processes that can be in Ready state for a computer system with n CPUs is

- (A) n
- (B) n^2
- (C) 2^n
- (D) Independent of n

Solution: The maximum number of processes that are running will be ' n ', with each process assigned to CPU, but the number of processes present in Ready Queue is independent of number of CPU's.

Hence, the correct option is (D).

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

Among simple LR (SLR), canonical LR, and look-ahead LR (LALR), which of the following pairs identify the method that is very easy to implement and the method that is the most powerful, in that order?

- (A) SLR, LALR
- (B) Canonical LR, LALR
- (C) SLR, canonical LR
- (D) LALR, canonical LR

Solution: CLR is more powerful among all the parsers. SLR parser is easy to implement, as it works on only LR(0) items, CLR parser works on LR(0) items and their corresponding look – ahead's.

Hence, the correct option is (C).

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

Let # be a binary operator defined as $X \# Y = X^1 + Y^1$ where X and Y are Boolean variables.

Consider the following two statements.

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

$$(S2)Q \# R = R \# Q$$

Which of the following is/are true for the Boolean variables P , Q and R ?

- (A) Only S_1 is true
- (B) Only S_2 is true
- (C) Both S_1 and S_2 are true
- (D) Neither S_1 nor S_2 are true

Solution: $X \# Y = X^1 + Y^1 = (XY)^1$ – this is NAND gate.

$$(S_1) = (P \# Q) \# R \uparrow P \# (Q \# R)$$

NAND gate does not obey associative law

$$((PQ)^1.R)^1 \uparrow (P.(QR)^1)^1$$

$$PQ + R^1 \uparrow P^1 + QR$$

$$(S_2) Q \# R = R \# Q$$

Commutative law is, true for NAND gate

$$(QR)^1 = (RQ)^1$$

$$Q^1 + R^1 = R^1 + Q^1$$

(S_2) is true.

Hence, the correct option is (B).

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

Consider a software project with the following information domain characteristics for calculation of function point metric.

Number of external inputs (I) = 30

Number of external outputs (O) = 60

Number of external inquiries (E) = 23

Number of files (F) = 08

Number of external interfaces (N) = 02

It is given that the complexity weighting factors for I , O , E , F and N are 4, 5, 4, 10 and 7, respectively. It is also given that, out of fourteen value adjustment factors that influence the development effort, four factors are not applicable, each of the other four factors have value 3, and each of the remaining factors have value 4. The computed value of function point metric is _____

Solution: Number of external inputs (I) = 30

Number of external outputs (O) = 60

Number of external enquires (E) = 23

Number of files (F) = 08

Number of external interfaces (N) = 2

The weighting factors for I , O , E , F and N are 4, 5, 4, 10 and 7

$$\begin{aligned} \text{Count-total} &= 30 \times 4 + 60 \times 5 + 23 \times 4 + 8 \times 10 + 2 \times 7 \\ &= 120 + 300 + 92 + 80 + 14 \\ &= 606 \end{aligned}$$

| |
|---|
| Function Point = Count _ total * EAF |
| Effort adjustment factor (EAF) = $0.65 + 0.01 * \sum f_i$ |

$$\text{EAF} = 0.65 + 0.01 * \sum f_i$$

$\sum f_i$ = sum of the fourteen adjustment factors

Out of 14, we will consider only 10 [given in problem, 4 are neglected]

$$\sum f_i = 3 + 3 + 3 + 3 + 4 + 4 + 4 + 4 + 4 + 6$$

$$\sum f_i = 4 \times 3 + 6 \times 4$$

$$= 12 + 24$$

$$= 36$$

$$\text{EAF} = 0.65 + 0.01 \times 36$$

$$= 1.01$$

$$\text{FP} = 606 * 1.01$$

$$= 612.06$$

Hence, the correct answer is 612 to 613

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

In a web server, ten WebPages are stored with the URLs of the form `http://www.yourname.com/var.html`; where, var is a different number from 1 to 10 for each Webpage. Suppose, the client stores the Webpage with var = 1 (say W_1) in local machine, edits and then tests. Rest of the WebPages remains on the web server. W_1 contains several relative URLs of the form ‘var.html’ referring to the other WebPages. Which one of the following statements needs to be added in W_1 , so that all the relative URLs in W_1 refer to the appropriate WebPages on the web server?

- (A) `<a href: http://www.yourname.com/”, href: “var.html”>`
- (B) `<base href: http://www.yourname.com/”>`
- (C) `<a href: http://www.yourname.com/”>`
- (D) `<base href: http://www.yourname.com/”, range: “var.html”>`

Solution: `<base href : “http ://www .yourname.com/”>`

It reflects to the given data

Hence, the correct option is (B).

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

Consider the following statements

1. TCP connections are full duplex
 2. TCP has no option for selective acknowledgement
 3. TCP connections are message streams
- (A) Only 1 is correct
 - (B) Only 1 and 3 are correct
 - (C) Only 2 and 3 are correct
 - (D) All of 1, 2 and 3 are correct

Solution: TCP connections are full duplex.

Hence, the correct option is (A).

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

Consider the equality $\sum_{i=0}^n i^3 =$ and the following choices for X

1. $\theta(n^4)$
2. $\theta(n^5)$
3. $O(n^5)$
4. $\lfloor(n^3)$

The equality above remains correct if X is replaced by

- (A) Only 1
- (B) Only 2
- (C) 1 or 3 or 4 but not 2
- (D) 2 or 3 or 4 but not 1

Solution: $\sum_{i=0}^n i^3$

$$\Rightarrow 0^3 + 1^3 + 2^3 + 3^3 + 4^3 + \dots + n^3$$

$$\Rightarrow 1^3 + 2^3 + \dots + n^3$$

It is sum of cubes of 1st 'n' natural numbers

$$\Rightarrow \frac{n^2(n+1)^2}{4}$$

It is $\theta(n^4)$ as $n^4 \sim \frac{n^2(n+1)^2}{4} \sim 4n^4$

It is $O(n^5)$ as $\frac{n^2(n+1)^2}{4} \leq Cn^5$

(C = constant, C > 0)

It is $\Omega(n^3)$ as $\frac{n^2(n+1)^2}{4} \geq n^3$

But it is not $\theta(n^5)$

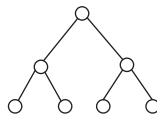
Hence, the correct option is (C).

Question Number: 21

Question Type: NAT

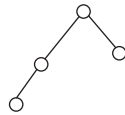
Consider a binary tree T that has 200 leaf nodes. Then, the number of nodes in T that have exactly two children are _____.

Solution: Let us consider the following Trees.



4 – leaves

(3 – nodes has exactly 2 children)



2 – leaves

(1 – node has exactly 2 children)

\therefore 200 leaf nodes \Rightarrow 199 nodes will have exactly 2 – children

Hence, the correct answer is 199.

Question Number: 22

Question Type: NAT

Given a hash table T with 25 slots that stores 2000 elements, the load factor ∞ for T is _____

Solution:

$$\text{Load factor} = \frac{\text{Number of elements}}{\text{slots}} = \frac{2000}{25} = 80$$

Hence, the correct answer is 80.

Question Number: 23

Question Type: MCQ

In the given matrix $\begin{bmatrix} 1 & -1 & 2 \\ 0 & 1 & 0 \\ 1 & 2 & 1 \end{bmatrix}$, one of the eigen values

is 1. The eigenvectors corresponding to the eigenvalue 1 are

(A) $\{\infty(4, 2, 1) \mid \infty \uparrow 0, \infty \in R\}$

(B) $\{\infty(-4, 2, 1) \mid \infty \uparrow 0, \infty \in R\}$

(C) $\{\infty(\sqrt{2}, 0, 1) \mid \infty \uparrow 0, \infty \in R\}$

(D) $\{\infty(-\sqrt{2}, 0, 1) \mid \infty \uparrow 0, \infty \in R\}$

Solution: Let $A = \begin{bmatrix} 1 & -1 & 2 \\ 0 & 1 & 0 \\ 1 & 2 & 1 \end{bmatrix}$

Given $\lambda = 1$ is an eigen value of A.

Let $X = \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix}$ be an eigen vector of A corresponding to the

eigen value $\lambda = 1$

$$\Rightarrow (A - \lambda I)X = 0$$

$$\Rightarrow (A - I)X = 0$$

$$\Rightarrow \begin{bmatrix} 0 & -1 & 2 \\ 0 & 0 & 0 \\ 1 & 2 & 0 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix} = \begin{bmatrix} 0 \\ 0 \\ 0 \end{bmatrix}$$

$$\Rightarrow -x_2 + 2x_3 = 0 \Rightarrow x_3 = \frac{x_2}{2} \text{ and } x_1 + 2x_2 = 0$$

$$\Rightarrow x_1 = -2x_2$$

Let $x_2 = k$, where K is arbitrary

$$\therefore x_1 = -2k \text{ and } x_3 = \frac{k}{2}$$

\therefore The eigen vector of A corresponding to the eigen value

$$\lambda = 1 \text{ is } X = \begin{bmatrix} -2k \\ k \\ \frac{k}{2} \end{bmatrix} \Rightarrow = \begin{bmatrix} -4\alpha \\ 2\alpha \\ \alpha \end{bmatrix},$$

where $k = 2\alpha$, α being arbitrary

$$= \alpha \begin{bmatrix} -4 \\ 2 \\ 1 \end{bmatrix}$$

Hence, the correct option is (B).

Question Number: 24

Question Type: MCQ

The value of $\lim_{x \rightarrow \infty} (1+x^2)^{e^{-x}}$ is

(A) 0

(B) $\frac{1}{2}$

(C) 1

(D) ∞

Solution: Let $y = \lim_{x \rightarrow \infty} (1+x^2)^{e^{-x}}$
 $\Rightarrow \ln y = \ln (\lim_{x \rightarrow \infty} (1+x^2)^{e^{-x}})$
 $= \lim_{x \rightarrow \infty} [\ln((1+x^2)^{e^{-x}})] \Rightarrow = \lim_{x \rightarrow \infty} [e^{-x} \ln(1+x^2)]$
 $= \lim_{x \rightarrow \infty} \left[\frac{\ln(1+x^2)}{e^x} \right] \Rightarrow = \lim_{x \rightarrow \infty} \left[\frac{2x}{(1+x^2)e^x} \right]$

(By L'Hospital's Rule)

$= \lim_{x \rightarrow \infty} \left[\frac{1}{e^x} \cdot \frac{\frac{2}{x}}{\left(1 + \frac{1}{x^2}\right)} \right] \Rightarrow \ln y = 0 \Rightarrow y = e^0 = 1$
 $\Rightarrow \lim_{x \rightarrow \infty} (1+x^2)^{e^{-x}} = 1$

Hence, the correct option is (C).

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

The number of 4 digit numbers having their digits in non-decreasing order (from left to right) constructed by using the digits belonging to the set {1, 2, 3} is _____

Solution:

Following are the 4 digit numbers having their digits in non-decreasing order (from left to right) constructed by using the digits 1, 2 and 3.

- 1111 1122 1222 1333 2233
- 1112 1123 1223 2222 2333
- 1113 1133 1233 2223 3333

∴ The number of such 4 digit numbers = 15.

Hence, the correct answer is 15.

Question Number: 26 **Question Type: MCQ**

In a room there are only two types of people, namely Type 1 and Type 2. Type 1 people always tell the truth and Type 2 people always lie. You give a fair coin to a person in that room, without knowing which type he is from and tell him to toss it and hide the result from you till you ask for it. Upon asking, the person replies the following

“The result of the toss is head if and only if I am telling the truth.”

Which of the following options is correct?

- (A) The result is head
- (B) The result is tail
- (C) If the person is of Type 2, then the result is tail
- (D) If the person is of Type 1, then result is tail

Solution: Let us assume that the person is of Type 1 – a truth teller. His statement is “The result of the toss is head if and only if I am telling the truth.” We can symbolize this as $S: “p \text{ iff } q”$

S is true, q is true.

∴ p is true.

Let us assume that the person is of Type 2 – a liar.

His statement is $S: “p \text{ iff } q”$

S is false, q is false.

∴ p has to be true.

In either case, P is true, the result of the toss is head.

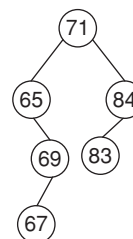
Hence, the correct option is (A).

Question Number: 27 **Question Type: MCQ**

While inserting the elements 71, 65, 84, 69, 67, 83 in an empty binary search tree (BST) in the sequence shown, the element in the lowest level is

- (A) 65
- (B) 67
- (C) 69
- (D) 83

Solution:



The element in the lowest level is 67.

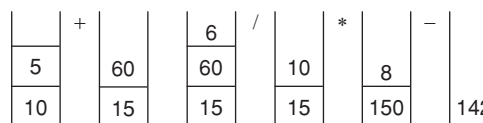
Hence, the correct option is (B).

Question Number: 28 **Question Type: MCQ**

The result of evaluating the postfix expression 10 5 + 60 6 / * 8 - is

- (A) 284
- (B) 213
- (C) 142
- (D) 71

Solution: 10 5 + 60 6 / * 8 -



Result: 142

Hence, the correct option is (C).

Question Number: 29 **Question Type: MCQ**

Consider the following relation Cinema (theater, address, capacity)

Which of the following options will be needed at the end of the SQL query

SELECT P_1 .address
 FROM Cinema P_1

such that it always finds the addresses of theaters with maximum capacity?

- (A) WHERE P_1 .capacity >= All (select P_2 . Capacity from Cinema P_2)
- (B) WHERE P_1 .capacity >= Any (select P_2 . Capacity from Cinema P_2)

- (C) WHERE $P_1.capacity > \text{All}$ (select $\max(P_2.capacity)$ from Cinema P_2)
- (D) WHERE $P_1.capacity > \text{Any}$ (select $\max(P_2.capacity)$ from Cinema P_2)

Solution: Consider the Relation cinema, with some sample tuples:

| Theater | Address | Capacity |
|---------|---------|----------|
| T_1 | A_1 | 100 |
| T_2 | A_2 | 200 |
| T_3 | A_3 | 150 |
| T_4 | A_4 | 200 |

$P_1.capacity \geq \text{ALL}$ ($P_2.Capacity$)

$\begin{bmatrix} T_1 & A_1 & 100 \end{bmatrix} \geq$
 100✓
 200×
 150×
 200×
 $\therefore A_1$ is not retrieved

$\begin{bmatrix} T_2 & A_2 & 200 \end{bmatrix} \geq$
 100✓
 200✓
 150✓
 200✓
 $\therefore A_2$ is retrieved

$\begin{bmatrix} T_3 & A_3 & 150 \end{bmatrix} \geq$
 100✓
 200×
 150✓
 200×
 $\therefore A_3$ is not retrieved

$\begin{bmatrix} T_4 & A_4 & 200 \end{bmatrix} \geq$
 100✓
 200✓
 150✓
 200✓
 $\therefore A_4$ is retrieved

Option (A) always finds the addresses of theaters with maximum capacity.

Hence, the correct option is (A).

Question Number: 30 **Question Type: MCQ**

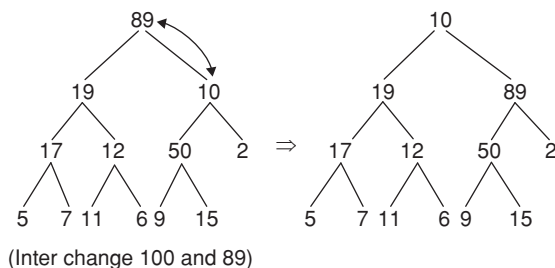
Consider the following array of elements

<89, 19, 50, 17, 12, 15, 2, 5, 7, 11, 6, 9, 100>

The minimum number of interchanges needed to convert it into a max-heap is

- (A) 4
- (B) 5
- (C) 2
- (D) 3

Solution:



\therefore 3 Interchanges are required to convert it into a max-Heap. Hence, the correct option is (D).

Question Number: 31 **Question Type: MCQ**

Two processes X and Y need to access a critical section. Consider the following synchronization construct used by both the processes

| Process X | Process Y |
|--|--|
| <pre> /* other code for process X */ while (true) { varP = true; while(varQ == true) { /* Critical Section */ /* Critical Section */ varP = false; } } /* other code for process X */ </pre> | <pre> /* other code for process Y */ while (true) { varQ = true; while (varP == true) { /* Critical Section */ varQ = false; } } /* other code for process Y */ </pre> |

Here, $varP$ and $varQ$ are shared variables and both are initialized to false. Which one of the following statements is true?

- (A) The proposed solution prevents deadlock but fails to guarantee mutual exclusion.
- (B) The proposed solution guarantees mutual exclusion but fails to prevent deadlock.
- (C) The proposed solution guarantees mutual exclusion and prevents deadlock.
- (D) The proposed solution fails to prevent deadlock and fails to guarantee mutual exclusion.

Solution:

| Process X | Process Y |
|--|--|
| <pre> while (true) { 1. var P = true; 2. while (var Q == true) { /* critical section*/ var P = false; } } </pre> | <pre> while(true) { 1. var Q = true; 2. while(varP == true) { /*critical section */ varQ = false; } } </pre> |

The process X has executed instruction (1) and got preempted and given chance to process Y , similar to process X it executes instruction (1) and got preempted, given chance to process X process X executes (2) instruction and enters into critical section, and got preempted when it is in critical section and given chance to process Y . Process Y executes (2) instruction and enters into critical section in which process X and Y are in critical section which violates mutual exclusion principle. There is no deadlock between process X and Y with these solution.

Hence, the correct option is (A).

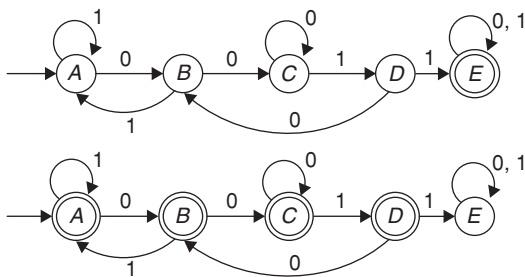
Question Number: 32 **Question Type: MCQ**

Let L be the language represented by the regular expression $\Sigma^* 0011 \Sigma^*$ where $\Sigma = \{0, 1\}$. What is the minimum number of states in a DFA that recognizes \bar{L} (complement of L)?

- (A) 4
- (B) 5
- (C) 6
- (D) 8

Solution: The language ' L ' accepts all the strings with the substring 0011.

The DFA for language ' L ' is



The DFA for \bar{L} will be

Number of states for \bar{L} is 5.

Hence, the correct option is (B).

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

Consider a software program that is artificially seeded with 100 faults. While testing this program, 159 faults are detected, out of which 75 faults are from those artificially seeded faults. Assuming that both real and seeded faults are of same nature and have same distribution, the estimated number of undetected real faults is _____.

Solution:

- Number of artificial seeds = 100 faults
- Number of faults detected (artificial) = 75
- Number of faults detected = 159
- Number of real faults = 159 – 75 = 84

As the real and seeded faults are of same nature then number of undetected real faults = $\frac{1}{3} \times 84 = 28$

Hence, the correct answer is 28.

Question Number: 34 **Question Type: MCQ**

Consider a machine with a byte addressable main memory of 2^{20} bytes, block size of 16 bytes and a direct mapped cache having 2^{12} cache lines. Let the addresses of two consecutive bytes in main memory be $(E201F)_{16}$ and $(E2020)_{16}$. What are the tag and cache line address (in hex) for main memory address $(E201F)_{16}$?

- (A) E, 201
- (B) F, 201
- (C) E, E20
- (D) 2, 01F

Solution:

Given,
Block size = 2^4 B

So word offset = 4-bits

Number of lines = 2^{12} so line field length = 12-bits

Main memory address is $(E201F)_{16}$ and main memory has 20-bits length address:

| | | |
|-----|-------|--------|
| TAG | Lines | Offset |
|-----|-------|--------|

In the address last 4-bits will be offset that is F

Next 12-bits from and will be line field that is 201 and remaining bits, tag as E

Hence, the correct option is (A).

Question Number: 35 **Question Type: MCQ**

Consider a CSMA/CD network that transmits data at a rate of 100 Mbps (10^8 -bits per second) over a 1 km (kilometer) cable with no repeaters. If the minimum frame size required for this network is 1250 bytes, what is the signal speed (km/sec) in the cable?

- (A) 8000
- (B) 10000
- (C) 16000
- (D) 20000

Solution: The condition for the minimum packet size in Ethernet (CSMA/CD) is

$$\text{Transmission delay} = \text{Round trip time}$$

$$\frac{L}{B} = 2 \times \frac{d}{V}$$

$$V = 2 \times d \times \frac{B}{L}$$

$$= 2 \times 1 \times \frac{10^8}{1250 \times 8}$$

$$V = 20000 \text{ km/sec}$$

Hence, the correct option is (D).

Question Number: 36 **Question Type: NAT**

The velocity v (in kilometer/minute) of a motorbike which starts from rest, is given at fixed intervals of time t (in minutes) as follows:

| | | | | | | | | | | |
|-----|----|----|----|----|----|----|----|----|----|----|
| t | 2 | 4 | 6 | 8 | 10 | 12 | 14 | 16 | 18 | 20 |
| v | 10 | 18 | 25 | 29 | 32 | 20 | 11 | 5 | 2 | 0 |

The approximate distance (in kilometers) rounded to two places of decimals covered in 20 minutes using Simpson's 1/3rd rule is _____

Solution: The velocity V of a motorcycle at fixed intervals of time t is given as

| | | | | | | | | | | |
|-----|----|----|----|----|----|----|----|----|----|----|
| t | 2 | 4 | 6 | 8 | 10 | 12 | 14 | 16 | 18 | 20 |
| V | 10 | 18 | 25 | 29 | 32 | 20 | 11 | 5 | 2 | 0 |

The distance traveled in 20 minutes = $\int_{t=0}^{20} V dt$

By Simpson's $\frac{1}{3}$ rule, we have

$$\int_0^{20} V dt = \frac{h}{3} [(V_0 + V_{10}) + 4(V_1 + V_3 + V_5 + V_7 + V_9) + 2(V_2 + V_4 + V_6 + V_8)]$$

Here $h = 2, V_0 = V_{at t=0} = 0$ (\because starting from rest)
 \therefore from (1),

$$\int_0^{20} V dt = \frac{2}{3} [(0+0) + 4(10+25+32+11+2) + 2(18+29+20+5)]$$

$$= 309.33 \text{ km}$$

Hence, the correct answer is 308 to 310.

Question Number: 37 **Question Type: MCQ**

Assume that a mergesort algorithm in the worst case takes 30 seconds for an input of size 64. Which of the following most closely approximates the maximum input size of a problem that can be solved in 6 minutes?

- (A) 256
- (B) 512
- (C) 1024
- (D) 2048

Solution: Time complexity of Merge sort is $\theta(n \log n)$

For 64 elements, the algorithm took 30 seconds to sort

$$\Rightarrow (n \log n) = 30 \text{ seconds}$$

$$(64 \log 64) = 30 \text{ seconds}$$

Lets convert the time taken to sort 'n' element into some time units.

$$64 \log 64 = 30$$

$$64 = \frac{30}{\log 64}$$

$$\Rightarrow 64 = \frac{30}{6} = 5 \text{ time units}$$

Options (A)

$$256 \log_2 256 = 6 \text{ minutes}$$

$$256 \log 256 = 360 \text{ seconds}$$

$$256 = \frac{360}{8} = 45 \text{ time units}$$

Option (B)

$$512 \log 512 = 360 \text{ seconds}$$

$$512 = \frac{360}{9} = 40 \text{ time units}$$

$$\text{Elements} - 64 = 2^6 = 5 \text{ time units}$$

$$\text{Elements} - 128 = 2^7 = 10 \text{ time units}$$

$$\text{Elements} - 256 = 2^8 = 20 \text{ time units}$$

$$\text{Elements} - 512 = 2^9 = 40 \text{ time units}$$

Option (B) 512 is the maximum input size of a problem that can be solved in 6 minutes.

Hence, the correct option is (B).

Question Number: 38 **Question Type: MCQ**

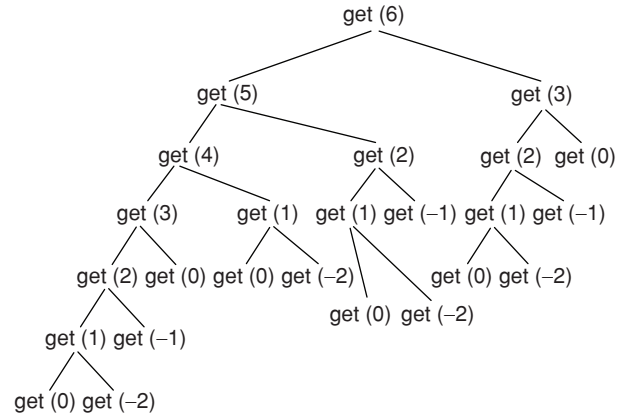
Consider the following recursive C function

```
void get (int n)
{
    if (n < 1) return;
    get (n - 1);
    get (n - 3);
    printf("%d", n);
}
```

If get (6) function is being called in main () then how many times will the get () function be invoked before returning to the main ()?

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

Solution:



Total calls: 25

Hence, the correct option is (B).

Question Number: 39 **Question Type: NAT**

Consider a B+ tree in which the search key is 12 bytes long, block size is 1024 bytes, record pointer is 10 bytes long and block pointer is 8 bytes long. The maximum number of keys that can be accommodated in each non-leaf node of the tree is _____.

Solution: Search key = 12 bytes

Block size = 1024 bytes

Record pointer = 10 bytes

Block pointer = 8 bytes

The order (P) of the Internal node in a B+ tree,

$$P * 8 + (P - 1) (12) \leq 1024$$

$$8P + 12P - 12 \leq 1024$$

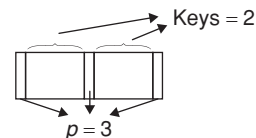
$$20P \leq 1024 + 12$$

$$P \leq \frac{1036}{20} = 51.8 \approx 51$$

$$P = 51$$

If the order $p = 51$, then the keys would be 50.

Example:



Hence, the correct answer is 50.

Question Number: 40 **Question Type: MCQ**

Given the function $F = P^1 + QR$, where F is a function in three Boolean variables P, Q and R and $P^1 = !P$, consider the following statements.

$$(S_1) F = \Sigma(4, 5, 6)$$

$$(S_2) F = \Sigma(0, 1, 2, 3, 7)$$

(S₃) $F = \pi(4, 5, 6)$

(S₄) $F = \pi(0, 1, 2, 3, 7)$

Which of the following is true?

- (A) (S₁) – False, (S₂) – True, (S₃) – True, (S₄) – False
- (B) (S₁) – True, (S₂) – False, (S₃) – False, (S₄) – True
- (C) (S₁) – False, (S₂) – False, (S₃) – True, (S₄) – True
- (D) (S₁) – True, (S₂) – True, (S₃) – False, (S₄) – False

Solution: $F = P' + QR$

The given statements are in canonical form, BY converting F to canonical form.

$$\begin{aligned}
 F &= P^1(Q + Q^1)(R + R^1) + (P + P^1)QR \\
 &= P^1(QR + Q^1R + QR^1 + Q^1R^1) + PQR + P^1QR \\
 &= P^1QR + P^1Q^1R + P^1QR^1 + P^1Q^1R^1 + PQR \\
 &= \bullet m(0, 1, 2, 3, 7) \\
 &= \pi M(4, 5, 6)
 \end{aligned}$$

only (S₂) and (S₃) are true.

Hence, the correct option is (A).

Question Number: 41 **Question Type: MCQ**

Language L_1 is polynomial time reducible to language L_2 . Language L_3 is polynomial time reducible to L_2 , which in turn is polynomial time reducible to language L_4 . Which of the following is/are true?

- (1) if $L_4 \in P$, then $L_2 \in P$
- (2) if $L_1 \in P$ or $L_3 \in P$, then $L_2 \in P$
- (3) $L_1 \in P$, if and only if $L_3 \in P$
- (4) if $L_4 \in P$, then $L_1 \in P$ and $L_3 \in P$

Solution:

$$\begin{aligned}
 L_1 &\rightarrow L_2 \\
 L_3 &\rightarrow L_2 \\
 L_3 &\rightarrow L_4 \\
 L_2 &\leq_p L_4 \\
 L_1 &\leq_p L_2
 \end{aligned}$$

Hence, the correct option is (C).

Question Number: 42 **Question Type: NAT**

Consider the following C program

```

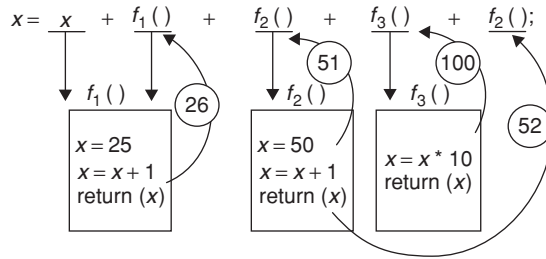
#include<stdio.h>
int f1(void);
int f2(void);
int f3(void);
int x = 10;
int main ( )
{
    int x = 1;
    x += f1( ) + f2( ) + f3( ) + f2( );
    printf("%d", x);
    return 0;
}
int f1 ( ) { int x = 25; x++;
return x;}
    
```

```

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

The output of the program is _____

Solution:



In $f_2()$, x is a static variable it is initialized only once i.e., $x = 50$ it increments the x with '1'. ($x = 51$). When $f_2()$ is called once again, x retains the previous value and is incremented.

In $f_3()$, ' x ' is not declared, but ' C ' implements static scoping, it takes global value of ' x ' [which is 10].

$$\therefore x = 1 + 26 + 51 + 100 + 52 \Rightarrow 230$$

Hence, the correct answer is 230.

Question Number: 43 **Question Type: NAT**

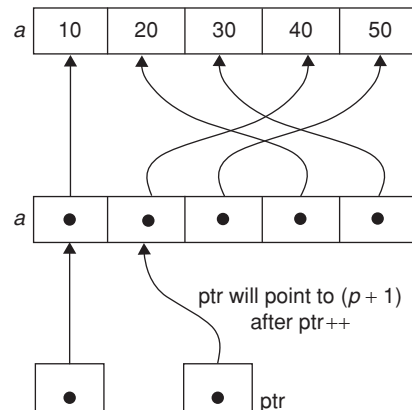
Consider the following C program

```

#include<stdio.h>
int main ( )
{
    static int a[ ] = {10, 20, 30, 40,
50};
    static int *p[ ] = {a, a+3, a+4,
a+1, a+2};
    int **ptr = p;
    ptr++;
    printf("%d%d", ptr-p, **ptr);
}
    
```

The output of the program is _____

Solution:



$p \text{ tr} - p = [\text{pointer Arithmetic}]$
 **ptr will contain 140
 \therefore it prints 140.

Hence, the correct answer is 140.

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

Which of the following languages are context-free?

$$L_1 = \{a^m b^n a^n b^m \mid m, n \geq 1\}$$

$$L_2 = \{a^m b^n a^m b^n \mid m, n \geq 1\}$$

$$L_3 = \{a^m b^n \mid m = 2n + 1\}$$

- (A) L_1 and L_2 only (B) L_1 and L_3 only
 (C) L_2 and L_3 only (D) L_3 only

Solution: $L_1 = \{a^m b^n a^n b^m \mid m, n \geq 1\}$

L_1 is context free language

Consider a stack, push the 'a' elements followed by 'b' element, then for every 'a' pop the elements should be 'b', for every b pop the elements [The element should be 'a']

$$L_2 = \{a^m b^n a^m b^n \mid m, n \geq 1\}$$

L_2 is not context free

Two stacks should be maintained for the element count of 'a' and 'b'.

$$L_3 = \{a^m b^n \mid m = 2n + 1\}$$

L_3 is context free language.

Hence, the correct option is (B).

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

Consider the following policies for preventing deadlock in a system with mutually exclusive resources.

- (1) Processes should acquire all their resources at the beginning of execution. If any resource is not available, all resources acquired so far are released.
- (2) The resources are numbered uniquely, and processes are allowed to request for resources only in increasing resource numbers.
- (3) The resources are numbered uniquely, and processes are allowed to request for resources only in decreasing resource numbers.
- (4) The resources are numbered uniquely. A process is allowed to request only for a resource with resource number larger than its currently held resources.

Which of the above policies can be used for preventing deadlock?

- (A) Any one of 1 and 3 but not 2 or 4
 (B) Any one of 1, 3 and 4 but not 2
 (C) Any one of 2 and 3 but not 1 or 4
 (D) Any one of 1, 2, 3 and 4

Solution: Option 1, 2, 3 and 4 are Deadlock prevention policies. Implementing any one of these can make system deadlock free.

Hence, the correct option is (D).

Question Number: 46 **Question Type: NAT**

In the network 200.10.11.144/27, the fourth octet (in decimal) of the last IP address of the network which can be assigned to a host is _____

Solution: Given network 200.10.11.144/27

To find the last IP-address of the network

Set $((32 - 27) = 5)$ the last 5-bits to '1' in the given IP-address.

200.10.11.144

200.10.11.100 10000

Last 5-bits set to 1

200.10.11.100 11111

200 . 10 . 11 . 159

Octet 1 octet 2 octet 3 octet 4

The fourth octet value in the last IP-address is 159, but last address cannot be assigned to a host hence we have to assign 158 to a host.

Hence, the correct answer is 158.

Question Number: 47 **Question Type: NAT**

Consider a network connecting two systems located 8000 kilometers apart. The bandwidth of the network is 500×10^6 -bits per second. The propagation speed of the media is 4×10^6 meters per second. It is needed to design a Go-Back-N sliding window protocol for this network. The average packet size is 10^7 -bits. The network is to be used to its full capacity. Assume that processing delays at nodes are negligible. Then, the minimum size in bits of the sequence number field has to be _____

Solution:

$$T_r = \frac{\text{packet size}}{\text{Bandwidth}} = \frac{L}{B} = \frac{10 \times 10^6}{500 \times 10^6} = 0.02 \text{ sec}$$

$$T_p = \frac{\text{distance}}{\text{velocity}} = \frac{d}{v} = \frac{8000 \times 10^3}{4 \times 10^6} = \frac{8 \times 10^6}{4 \times 10^6} = 2 \text{ sec}$$

Link utilization is 100% ($\eta = 100$)

$$a = \frac{T_p}{T_r} = \frac{2}{0.02} = 100$$

$$\text{In Go-Back-N-Protocol, Efficiency} = \eta = \frac{W}{1 + 2a}$$

$$(W = 2^n - 1) \quad (\eta = 100\%)$$

$$\eta = \frac{2^n - 1}{1 + 2a}$$

$$1 = \frac{2^n - 1}{1 + 2a} \Rightarrow 1 + 2a = 2^n - 1$$

$$1 + 2(100) = 2^n - 1$$

$$201 + 1 = 2^n$$

$$2^n = 202$$

$$2^n \approx 2^8$$

$$n = 8$$

In sequence number, minimum bits required is 8.

Hence, the correct answer is 8.

Question Number: 48 **Question Type: NAT**

Consider the following reservation table for a pipeline having the stages S_1, S_2 and S_3 .

| | | | | | |
|-------|--------|---|---|---|---|
| | Time → | | | | |
| | 1 | 2 | 3 | 4 | 5 |
| S_1 | X | | | | X |
| S_2 | | X | | X | |
| S_3 | | | X | | |

The minimum average latency (MAL) is _____

Solution:

The time slot info for stage 1 – 10001

time Slot info for stage 2 – 1010

time slot info for stage 3 – 00100

From the above, the average latency will be 3.

Hence, the correct answer is 3.

Question Number: 49 **Question Type: MCQ**

Consider the following code sequence having five instructions I_1 to I_5 . Each of these instructions has the following format.

$OP\ Ri,\ Rj,\ Rk$

Where operation OP is performed on contents of registers Rj and Rk and the result is stored in register Ri .

I_1 : ADD R_1, R_2, R_3

I_2 : MUL R_7, R_1, R_3

I_3 : SUB R_4, R_1, R_5

I_4 : ADD R_3, R_2, R_4

I_5 : MUL R_7, R_8, R_9

Consider the following three statements.

S_1 : There is an anti-dependence instructions between instructions I_2 and I_5

S_2 : There is an anti-dependence between Instructions I_2 and I_4

S_3 : Within an instruction pipeline an anti-dependence always creates one or more stalls

Which one of the above statements is/are correct?

- (A) Only S_1 is true
- (B) Only S_2 is true
- (C) Only S_1 and S_3 are true
- (D) Only S_2 and S_3 are true

Solution: An Anti-dependency between instructions can also be refereed as WAR hazard. There is no WAR between I_2 and I_5 . There is anti-dependency between I_2 and I_4 as I_4 writes R_3 , Which is reed by I_2 .

An anti-dependency may or may not create a stall.

Hence, the correct option is (B).

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

Consider the following two C code segments. Y and X are one and two dimensional arrays of size n and $n \times n$ respectively, where $2 \leq n \leq 10$. Assume that in both code segments, elements of Y are initialized to 0 and each element $X[i][j]$ of array X is initialized to $i + j$. Further assume that when stored in main memory all elements of X are in same main memory page frame.

Code segment 1:

```
//initialize elements of Y to 0
//initialize elements X[i][j] of X to i+j
```

```
for (i = 0; i < n; i++)
```

```
Y[i] += X[0][i];
```

Code Segment 2:

```
//initialize elements of Y to 0
```

```
//initialize elements X[i][j] of X to i + j
```

```
for (i = 0; i < n; i++)
```

```
Y[i] += X[i][0];
```

Which of the following statements is/are correct?

S_1 : Final contents of array Y will be same in both code segments

S_2 : Elements of array X accessed inside the for loop shown in code segment 1 are contiguous in main memory

S_3 : Elements of array X accessed inside the for loop shown in code segment 2 are contiguous in main memory.

- (A) Only S_2 is correct
- (B) Only S_3 is correct
- (C) Only S_1 and S_2 are correct
- (D) Only S_1 and S_3 are correct

Solution: Both the code segments will be initialized first [Y to 0, and $X[i][j]$ with $i + j$] the values of $Y[i]$ will be same in both segments as it is assigned $i + j$ values to $Y[i]$.

As the elements of X are in page frame, in code segment 1 the elements of X belong to same row, therefore they are stored in one frame.

In code segment 2 the elements of X belong to different column, it needs to access different page frames.

Hence, the correct option is (C).

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

Consider the following partial schedule S involving two transactions T_1 and T_2 . Only the read and the write operations have been shown. The read operation on data item P is denoted by $read(P)$ and the write operation on data item P is denoted by $write(P)$

| Time Instance | Transaction – id | |
|---------------|------------------|----------|
| | T_1 | T_2 |
| 1 | read(A) | |
| 2 | write(A) | |
| 3 | | read(C) |
| 4 | | write(C) |
| 5 | | read(B) |
| 6 | | write(B) |
| 7 | | read(A) |
| 8 | | commit |
| 9 | read(B) | |

Schedule S

Suppose that the transaction T_1 fails immediately after time instance 9. Which one of the following statements is correct?

- (A) T_2 must be aborted and then both T_1 and T_2 must be re-started to ensure transaction atomicity.
- (B) Schedule S is non-recoverable and cannot ensure transaction atomicity.
- (C) Only T_2 must be aborted and then re-started to ensure transaction atomicity.
- (D) Schedule S is recoverable and can ensure atomicity and nothing else needs to be done.

Solution:

| Transaction-Id | | |
|----------------|----------|----------|
| | T_1 | T_2 |
| 1 | read(A) | |
| 2 | write(A) | |
| 3 | | read(C) |
| 4 | | write(C) |
| 5 | | read(B) |
| 6 | | write(B) |
| 7 | | read(A) |
| 8 | | Commit |
| 9 | read(B) | |

There is one RW-conflict (2 → 7)

In the RW-conflict, The transaction T_1 is performing write operation, so T_1 has to commit first, T_2 is performing read operation so it has to commit Later.

⇒ It is not recoverable.

Hence, the correct option is (B)

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

If the following system has non-trivial solution,

$$\begin{aligned} px + qy + rz &= 0 \\ qx + ry + pz &= 0 \\ rx + py + qz &= 0, \end{aligned}$$

then which one of the following options is TRUE?

- (A) $p - q + r = 0$ or $p = q = -r$
- (B) $p + q - r = 0$ or $p = -q = r$
- (C) $p + q + r = 0$ or $p = q = r$
- (D) $p - q + r = 0$ or $p = -q = -r$

Solution: Given system of equations is

$$\begin{aligned} px + qy + rz &= 0 \\ qx + ry + pz &= 0 \\ rx + py + qz &= 0 \end{aligned}$$

which can be written in matrix form as $AX = 0$

Where $A = \begin{bmatrix} p & q & r \\ q & r & p \\ r & p & q \end{bmatrix}; X = \begin{bmatrix} x \\ y \\ z \end{bmatrix}$ and $O = \begin{bmatrix} 0 \\ 0 \\ 0 \end{bmatrix}$

Given (1) has non-trivial solutions

$$\Rightarrow \text{Det } A = 0 \Rightarrow \begin{vmatrix} p & q & r \\ q & r & p \\ r & p & q \end{vmatrix} = 0$$

$$\begin{aligned} \Rightarrow pqr - p^3 - q^3 + pqr + pqr - r^3 &= 0 \\ \Rightarrow p^3 + q^3 + r^3 - 3pqr &= 0 \\ \Rightarrow p^3 + q^3 + r^3 &= 3pqr \end{aligned}$$

which is possible only when

$$p + q + r = 0 \text{ (OR) } p = q = r.$$

Hence, the correct option is (C).

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

Consider the following C program:

```
#include<stdio.h>
int main( )
{
    int i, j, k = 0;
    j = 2 * 3 / 4 + 2.0 / 5 + 8 / 5;
    k -= --j;
    for (i = 0; i < 5; i++)
    {
        switch(i + k)
        {
            case 1:
            case 2: printf("\n%d", i + k);
            case 3: printf("\n%d", i + k);
            default: printf("\n%d", i + k);
        }
    }
    return 0;
}
```

The number of times printf statement is executed is _____.

Solution: $j = 2 * 3 / 4 + 2.0 / 5 + 8 / 5;$

$$\begin{aligned} &\underbrace{6|4}_{1} + \underbrace{2.0|5}_{0} + \underbrace{8|5}_{1} \\ &\downarrow \quad \downarrow \quad \downarrow \\ &1 + 0 + 1 \\ &1 + 0 + 1 \\ &= 2 \end{aligned}$$

$$K = K - (-j)$$

$$K = 0 - 1$$

$$K = -1$$

$$i = 0$$

$$i + k \Rightarrow 0 - 1 \Rightarrow -1$$

only one printf() is executed

$$i = 1$$

$$i + k \Rightarrow -1 + 1 \Rightarrow 0$$

only one printf() is executed

$$i = 2$$

$$i + k \Rightarrow 2 - 1 \Rightarrow 1$$

(1)

the printf() is executed 3 times.

$$i = 3$$

$$i + k \Rightarrow 3 - 1 \Rightarrow 2$$

The printf() is executed 3 times

$$i = 4$$

$$i + k \Rightarrow 4 - 1 \Rightarrow 3$$

the printf() is executed 2 times

∴ The printf() is executed 10 times.

Hence, the correct answer is 10.

Question Number: 54

Question Type: MCQ

If for non-zero x , $af(x) + bf\left(\frac{1}{x}\right) = \frac{1}{x} - 25$ where $a \neq b$ then

$\int_1^2 f(x)dx$ is

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

(B) $\frac{1}{a^2 - b^2} \left[a(2 \ln 2 - 25) - \frac{47b}{2} \right]$

(C) $\frac{1}{a^2 - b^2} \left[a(2 \ln 2 - 25) + \frac{47b}{2} \right]$

(D) $\frac{1}{a^2 - b^2} \left[a(\ln 2 - 25) - \frac{47b}{2} \right]$

Solution:

Given $af(x) + bf\left(\frac{1}{x}\right) = \frac{1}{x} - 25$

Replacing x by $\frac{1}{x}$, we have $af\left(\frac{1}{x}\right) + bf(x)$

$$= x - 25$$

$$a(1) - b(2) \Rightarrow a^2 f(x) + abf\left(\frac{1}{x}\right) = a\left(\frac{1}{x} - 25\right)$$

$$abf\left(\frac{1}{x}\right) + b^2 f(x) = b(x - 25)$$

$$a^2 f(x) - b^2 f(x) = a\left(\frac{1}{x} - 25\right) - b(x - 25)$$

$$\Rightarrow (a^2 - b^2) f(x) = \left(\frac{a}{x} - bx\right) - (a - b)25$$

$$\Rightarrow f(x) = \frac{1}{a^2 - b^2} \left[\frac{a}{x} - bx - (a - b)25 \right]$$

$$\text{Now } \int_1^2 f(x)dx = \int_1^2 \left[\frac{1}{a^2 - b^2} \left(\frac{a}{x} - bx - (a - b)25 \right) \right]$$

$$= \frac{1}{a^2 - b^2} \left[a \ln x - \frac{b}{2} x^2 - (a - b)25x \right]_1^2$$

$$= \frac{1}{a^2 - b^2} \left[a(\ln 2 - 25) + \frac{47b}{2} \right]$$

Hence, the correct option is (A).

Question Number: 55

Question Type: NAT

Let G be a connected undirected graph of 100 vertices and 300 edges. The weight of a minimum spanning tree of G is 500. When the weight of each edge of G is increased by five, the weight of a minimum spanning tree becomes _____

Solution: Vertices = 100

Edges = 300

Minimum spanning Tree Weight = 500

In minimum spanning Tree, if there are n -vertices there will be $(n - 1)$ edges

∴ For 100 vertices, we will have 99 Edges in the minimum spanning Tree.

99 Edges, Weight is 500,

Now each edge weight is increased by 5

$$\Rightarrow 99 \times 5 = 495$$

$$\text{Total weight} = 500 + 495 = 995$$

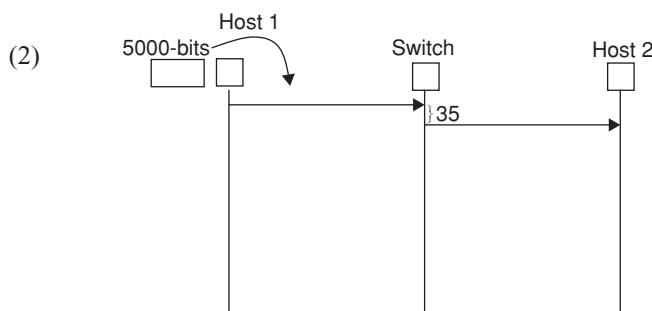
Hence, the correct answer is 995.

Question Number: 56

Question Type: MCQ

Two hosts are connected via a packet switch with 10^7 bits per second links. Each link has a propagation delay of 20 microseconds. The switch begins forwarding a packet 35 microseconds after it receives the same. If 10000-bits of data are to be transmitted between the two hosts using a packet size of 5000-bits, the time elapsed between the transmission of the first bit of data and the reception of the last bit of the data in microseconds is _____

Solution:



Transmission Time (TT) = The time taken to put the packet on line:

$$TT = \frac{\text{packet size}}{\text{Bandwidth}} = \frac{5000}{10^7} = 500 \text{ micro seconds}$$

$T_p = 20$ micro seconds

T_p^t = The amount of time taken for the packet to transfer from one end to another.

1. One packet is kept on line in 500 micro seconds.
2. Immediately second packet is also kept on line ($T_p = 20$ micro seconds of first packet is merged with $TT = 500$ micro seconds of second packet) $\Rightarrow 500$ micro seconds

The value of McCabe's Cyclomatic complexity of program-X, Program-Y, and Program-Z respectively are

- (A) 4, 4, 7 (B) 3, 4, 7
(C) 4, 4, 8 (D) 4, 3, 8

Solution:

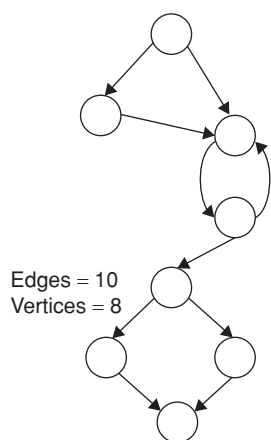
Program X:

Cyclomatic complexity of program X is, the number of conditions +1.

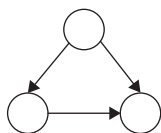
There are 2 'if' conditions and 1 'while' condition

$$\therefore \text{program 'X'} = 4$$

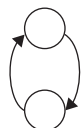
Control flow diagram for program – X:



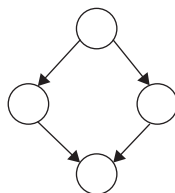
If condition:



While condition:



If-else condition:



Program y:

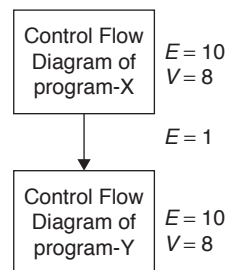
Edges = 10

Vertices = 8

Cyclomatic complexity = $10 - 8 + 2 = 4$

$$\therefore \text{program 'Y'} = 4$$

Program Z:



Cyclomatic complexity

Total number of edges = $10 + 1 + 10 = 21$

Total number of vertices = $8 + 8 = 16$

$\Rightarrow 21 - 16 + 2 = 7$

$$\therefore \text{program 'Z'} = 7$$

Hence, the correct option is (A).

Question Number: 59

Question Type: NAT

Consider the equation $(43)_x = (y3)_8$ where x and y are unknown. The number of possible solutions is _____

Solution:

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

By converting to decimal system

$$4x^1 + 3x^0 = y \cdot 8^1 + 3 \cdot 8^0$$

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

$$4x = 8y$$

$$x = 2y$$

x is base of number system $x > 4$

y is number in the number system with base 8, so $y < 8$.

| x | y |
|-----|-----|
| 6 | 3 |
| 8 | 4 |
| 10 | 5 |
| 12 | 6 |
| 14 | 7 |

Number of possible solutions = 5

Question Number: 60

Question Type: MCQ

Let R be a relation on the set of ordered pairs of positive integers such that $((p, q), (r, s)) \in R$ if and only if $p - s = q - r$. Which one of the following is true about R ?

- (A) Both reflexive and symmetric
(B) Reflexive but not symmetric
(C) Not reflexive but symmetric
(D) Neither reflexive nor symmetric

Solution: The relation R on the set of ordered pairs of positive integers given by

$$R = \{((p, q), (r, s)) / p - s = q - r\}$$

Consider $((a, b), (a, b))$

$$((a, b), (a, b)) \in R \text{ only if } a - b = b - a$$

which is NOT true always

$\therefore R$ is NOT reflexive

(1)

Let $((a, b), (c, d)) \in R \Rightarrow a - d = b - c$
 (By definition of R)
 $\Rightarrow d - a = c - b$
 $\Rightarrow c - b = d - a$
 $\Rightarrow ((c, d), (a, b)) \in R$
 $\Rightarrow R$ is symmetric (2)
 Hence from (1) and (2), R is NOT reflexive but symmetric.
 Hence, the correct option is (C).

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

Suppose X_i for $i = 1, 2, 3$ are independent and identically distributed random variables whose probability mass functions are $Pr[X_i = 0] = Pr[X_i = 1] = 1/2$ for $i = 1, 2, 3$. Define another random variable $Y = X_1 X_2 \oplus X_3$, where \oplus denotes XOR. Then

$Pr[Y = 0 | X_3 = 0] = \underline{\hspace{2cm}}$

Solution:

| x_1 | x_2 | x_3 | $x_1 x_2$ | $x_1 x_2 \oplus x_3$ |
|-------|-------|-------|-----------|----------------------|
| 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 1 | 0 | 1 |
| 0 | 1 | 0 | 0 | 0 |
| 0 | 1 | 1 | 0 | 1 |
| 1 | 0 | 0 | 0 | 0 |
| 1 | 0 | 1 | 0 | 1 |
| 1 | 1 | 0 | 1 | 1 |
| 1 | 1 | 1 | 1 | 0 |

$P_r [Y = 0/x_3 = 0]$ is the probability of $Y = 0$, when $x_3 = 0$ from the truth table, $x_3 = 0$, 4 times, and $Y = x_1 x_2 \oplus x_3 = 0$ 3 times

So $P_r [Y = 0/x_3 = 0] = \frac{3}{4} = 0.75$

Hence, the correct answer is 0.75.

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

The total number of prime implicants of the function $f(w, x, y, z) = \Sigma(0, 2, 4, 5, 6, 10)$ is _____

Solution: $f(w, x, y, z) = \Sigma m(0, 2, 4, 5, 6, 10)$

| | | | | | |
|----|----|----|----|----|----|
| | | yz | | | |
| | | 00 | 01 | 11 | 10 |
| wx | 00 | 1 | | | 1 |
| | 01 | 1 | 1 | | 1 |
| | 11 | | | | |
| | 10 | | | | 1 |

$f = w^1 x y^1 + w^1 z^1 + x^1 y z^1$
 3 prime implicants (2 pairs, 1 Quad)
 Hence, the correct answer is 3.

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

Suppose $c = \langle c[0], \dots, c[k - 1] \rangle$ is an array of length k , where all the entries are from the set $\{0, 1\}$. For any positive integers a and n , consider the following pseudo code.

DOSOMETHING (c, a, n)

```

z ← 1
for i ← 0 to k - 1
do z ← z2 mod n
if c[i] = 1
then z ← (z × a) mod n
return z
    
```

If $k = 4$, $c = \langle 1, 0, 1, 1 \rangle$, $a = 2$ and $n = 8$, then the output of DOSOMETHING(c, a, n) is _____

Solution: $K = 4$; $C = \langle 1, 0, 1, 1 \rangle$; $a = 2$; $n = 8$

```

z = 1
at i = 0:-
z = 12 mod 8 = 1
if (C[0] = 1)
z = 1 × 2 mod 8 = 2
i = 1:-
z = 22 mod 8 = 4
i = 2
z = 42 mod 8 = 0
z = (0 × 2) mod 8 = 0
i = 3
z = 02 mod 8 = 0
z = (0 × 2) mod 8 = 0
z = 0
    
```

Hence, the correct answer is 0.

Question Number: 64 **Question Type: MCQ**

Let $f(n) = n$ and $g(n) = n^{(1 + \sin n)}$, where n is a positive integer. Which of the following statements is/are correct?

- I. $f(n) = O(g(n))$
 - II. $f(n) = \Omega(g(n))$
- (A) Only I (B) Only II
 (C) Both I and II (D) Neither I nor II

Solution:

$f(n) = n$
 $g(n) = n^{(1 + \sin n)}$
 $n = \text{positive integer}$
 $-1 < \sin n < 1$

Suppose if we take '-1' in the place of $(\sin n)$ then $g(n) = n^0 = 1$

Suppose If we take '1' in the place of $(\sin n)$ then $g(n) = n^2$
 $g(n)$ value keeps changing. So neither I nor II can be correct.
 Hence, the correct option is (D).

Question Number: 65 **Question Type: MCQ**

Consider the following grammar G

```

S → F | H
F → p | c
H → d | c
    
```

Where S, F and H are non-terminal symbols, p, d and c are terminal symbols. Which of the following statement(s) is/are correct?

$S_1.LL(1)$ can parse all strings that are generated using grammar G

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S_2 . LR(1) can parse all strings that are generated using grammar G

- (A) Only S_1 (B) Only S_2
 (C) Both S_1 and S_2 (D) Neither S_1 nor S_2

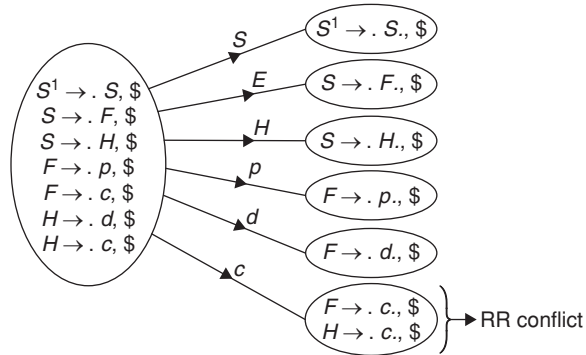
Solution:

$S \rightarrow F|H$

$F \rightarrow |C$

$H \rightarrow d|c$

LR(1)



The above grammar is having RR conflict therefore it is not LR(1) grammar.

LL(1)

$S \rightarrow F$

$S \rightarrow H$

$F \rightarrow p|c$

$H \rightarrow d|c$

First(S) = $\{p, c, d\}$

The productions of $S \rightarrow F, S \rightarrow H$ will be at $M[S, c]$

i.e., at $M[S, c]$ there will be multiple productions.

\therefore it is not LL(1).

Hence, the correct option is (D).

GATE 2016 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 Question.

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**

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

- (A) I will not leave the place until the minister does not meet me.
- (B) I will not leave the place until the minister doesn't meet me.
- (C) I will not leave the place until the minister meet me.
- (D) I will not leave the place until the minister meets me.

Solution: The use of does not and doesn't after until is redundant. Hence (A) and (B) are incorrect. The verb 'meet' does not agree with the singular noun minister. Only option (D) is a grammatically correct statement.

Hence, the correct option is (D).

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

A rewording of something written or spoken is a _____ .

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

Solution: Paraphrase suits the given description.

Hence, the correct option is (A).

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

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

The sentence above is an example of a _____ statement.

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

Solution: Here, the words lever and fulcrum are used figuratively. A figurative expression is used in a way that is different from the usual meaning in order to create a particular mental picture.

Hence, the correct option is (A).

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

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

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

Solution: By comparing the codes of 'carefree' and 'careless', we can conclude that the code for the word 'care' is 'taga'. We need the code for 'aftercare'. The word 'after' is used in the previous word. Hence, we look for an answer choice which has code 'taga' in it and a new code. That either (A) or (C) could be the answer but observing the given words and their respective codes, it can be concluded that the codes are given in the reverse order. Hence, 'tagazen' is the required code.

Hence, the correct option is (C).

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

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

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

Solution: From the corner of the big $(4 \times 4 \times 4)$ cube if one unit cube is removed, there is no change in the surface area. (Every face that is missing produces another face in the remaining block). This holds for all the 8 corners. The total surface area of the body after the 8 unit cubes are removed, is $6(16)$, viz 96.

Hence, the correct option is (D).

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

A shaving set company sells 4 different types of razors, Elegance, smooth, soft and Executive. Elegance sells at Rs. 48, Smooth at Rs. 63, soft at Rs.78 and Executive at Rs. 173 per price. The table below shows the numbers of each razor sold in each quarter of a year.

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

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

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

Solution: The approximated data is shown below. the numbers of razors have been divided by 1000.

| Quarter | El | Sm | Sf | Ex |
|---------|------|------|------|------|
| Q1 | 27 | 20 | 18 | 10 |
| Q2 | 25 | 19 | 18 | 9 |
| Q3 | 29 | 22 | 20 | 10 |
| Q4 | 21 | 18 | 17 | 10 |
| Total | 102 | 79 | 73 | 39 |
| Rate | 48 | 63 | 78 | 173 |
| Revenue | 4896 | 4977 | 5694 | 6747 |

The product that contributes the greatest amount is Executive.

Hence, the correct option is (B).

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

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

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

- (A) India is a country of exactly seventeen languages.
(B) Linguistic pluralism is the only indicator of a nation's diversity.
(C) Indian currency notes have sufficient space for all the Indian languages.
(D) Linguistic pluralism is strong evidence of India's diversity.

Solution: The statement uses the word 'at least', while referring to the number of languages. Hence, (A) cannot be inferred. According to the statement nothing can indicate the nation's diversity better than the currency note. This is a clear indication that there are other things that indicate the nation's diversity. Hence, (B) cannot be inferred. The context of the statement is not about the space on the note. Hence, (C) cannot be inferred.

According to the statement nothing else, apart from the currency note, can represent the diversity better. Hence, (D) can be inferred.

Hence, the correct option is (D).

Question Number: 8 **Question Type: NAT**

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

- I. P always beats Q
II. R always beats S
III. S loses to P only sometimes

IV. R always loses to Q

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

- (i) P is likely to beat all the three other players
(ii) S is the absolute worst player in the set
(A) (i) only (B) (ii) only
(C) (i) and (ii) (D) neither (i) nor (ii)

Solution: If the level of a player is a transitive property, we would get the following results from I, II and IV

$$S < R < Q < P$$

But III says that S loses to P only sometimes, i.e., some times he wins. There is also a suggestion that S wins against P more often than P wins against S

Consider the statements (i) and (ii)

(ii) definitely cannot be inferred

(i) As S loses to P only sometimes, it is not likely that P beats S . Therefore,

(i) too cannot be inferred.

Hence, the correct option is (D).

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

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

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

Solution: $f(x) = 2x^7 + 3x - 5$

$f(1) = 2 + 3 - 5 = 0 \Rightarrow x - 1$ is a factor of $f(x)$

The other expressions are not factors.

Hence, the correct option is (B).

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

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

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

Solution: Let the load be x and the number of cycles to failure be y . As y decreases exponentially with x

$$y = \frac{k}{a^x} \text{ ----- (1)} \Rightarrow ya^x = k \Rightarrow \log y + x \log a = \log k$$

For $x = 40$, $y = 10^4$ and for $x = 80$, $y = 10^2$

$$\therefore \log 10^4 + 40 \log a = \log 10^2 + 80 \log a$$

$$\Rightarrow \frac{4-2}{40} = \log a \Rightarrow a = 10^{\frac{1}{20}}$$

From (1), $y = \frac{k}{10^{\frac{x}{20}}}$ As $y = 10^4$ for $x = 40$, it follows that $k = 10^6$
 \therefore from (1), $y = \frac{10^6}{10^{\frac{x}{20}}}$
 If $y = 5000$, $10^{\frac{x}{20}} = \frac{10^6}{5000} = 200$
 $\Rightarrow \frac{x}{20} = \log 200 = 2.3010$
 $\Rightarrow x = 46.02$.

Hence, the correct option is (B).

COMPUTER SCIENCE & ENGINEERING

Number of Questions: 55

Section marks: 85.0

Q.11 to Q.35 carry 1 mark each and Q.36 to Q.65 carry 2 marks each.

Question Number: 11 **Question Type: NAT**

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

- $p : x \in \{8, 9, 10, 11, 12\}$
- $q : x$ is a composite number
- $r : x$ is a perfect square
- $s : x$ is a prime number
- The integer $x \geq 2$ which satisfies $\neg((p \Rightarrow q) \wedge (\neg r \vee \neg s))$ is _____.

Solution: Given

- $p : x \in \{8, 9, 10, 11, 12\}$
- $q : x$ is a composite number
- $r : x$ is a perfect square
- $s : x$ is a prime number
- and $x \geq 2$

$$\begin{aligned} \therefore & \neg[(p \Rightarrow q) \wedge (\neg r \vee \neg s)] \\ \equiv & \neg[(\neg p \vee q) \wedge (\neg r \vee \neg s)] \\ \equiv & \neg(\neg p \vee q) \vee \neg(\neg r \vee \neg s) \\ \equiv & (p \wedge \neg q) \vee (r \wedge s) \end{aligned}$$

\therefore The value of x that satisfies the above proposition is 11 only.
 Hence, the correct answer is (11).

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

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

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

Solution: $a_1 = 0, 1$ (2 strings)

$a_2 = 00, 01, 10$ (3 strings)

$a_3 = 000, 001, 010, 100, 101$ (5 strings)

$$\begin{aligned} a_3 &= a_2 + a_1 \\ &= 2 + 3 = 5 \text{ strings} \end{aligned}$$

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

Hence, the correct option is (B).

Alternate Solution: Let the number of bit strings of length n in which no two consecutive bits are 1 be a_n .

If the bit string is of length 1, then two bit strings are possible viz 0 or 1. If the bit string is of length 2, then three bit strings are possible viz 00, 01, 10 i.e, $a_2 = 3$

Case1: Consider the bit string of length n ending with 0. These are formed by placing a 0 at the end of all the strings of size $(n - 1)$. Hence we have a_{n-1} strings ending with 0.

Case2: Consider the bit string of length n is ending with 1. The $(n - 1)^{\text{th}}$ place must be 0. So, these are formed by placing a 01 at the end of all the strings of size $(n - 2)$. Hence we have a_{n-2} strings ending with 01. The sum of these two gives the total number of strings of length n .

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

Hence, the correct option is (C).

Question Number: 13 **Question Type: NAT**

$$\lim_{x \rightarrow 4} \frac{\sin(x-4)}{x-4} = \underline{\hspace{2cm}}$$

Solution:

$$\lim_{x \rightarrow 4} \frac{\sin(x-4)}{x-4} = \lim_{(x-4) \rightarrow 0} \frac{\sin(x-4)}{x-4} = 1$$

$$\left(\because \lim_{\theta \rightarrow 0} \frac{\sin \theta}{\theta} = 1 \right)$$

Hence, the correct answer is (1).

Question Number: 14 **Question Type: NAT**

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

$$\text{Solution: Let } f(x) = \begin{cases} \frac{1}{x^2}; & x \in [a, 1] \\ 0 & ; \text{ otherwise} \end{cases}$$

As $f(x)$ is a probability density function,

We have

$$\int_{-\infty}^{\infty} f(x) dx = 1$$

$$\Rightarrow \int_a^1 \frac{1}{x^2} dx = 1$$

$$\Rightarrow \left[\frac{-1}{x} \right]_a^1 = 1$$

$$\Rightarrow -1 + \frac{1}{a} = 1$$

$$\Rightarrow a = \frac{1}{2} = 0.5.$$

Hence, the correct answer is (0.5).

Question Number: 15 **Question Type: NAT**

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

Solution: Given two eigen values of 3×3 matrix P are $2 + \sqrt{-1}$ and 3.

As $2 + \sqrt{-1}$ is an eigen value of P , $2 - \sqrt{-1}$ is also an eigen value of P .

The determinant of $P \equiv |P|$

= Product of the eigen vales of P

$$= (2 + \sqrt{-1})(2 - \sqrt{-1}) \times 3 = 15.$$

Hence, the correct answer is (15).

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

Consider the Boolean operator # with the following properties:

$$x \# 0 = x, x \# 1 = \bar{x}, x \# x = 0 \text{ and}$$

$$x \# \bar{x} = 1. \text{ Then } x \# y \text{ is equivalent to}$$

$$(A) x \bar{y} + \bar{x} y \quad (B) x \bar{y} + \bar{x} \bar{y}$$

$$(C) \bar{x} y + x y \quad (D) x y + \bar{x} \bar{y}$$

Solution: $x \# 0 = x$

$$x \# 1 = x^1$$

$x \# x = 0, x \# x^1 = 1$, by observing, # operation is XOR

$$\text{so } x \# y = x^1 y + x y^1$$

Hence, the correct option is (A).

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

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

Solution: 2's complement representation

$$= 1111 1111 1111 0101$$

By looking at MSB, we can understand it is negative number (MSB = 1), so by taking the 2's complement we will get positive number.

2's complement of given number

$$= 0000 0000 0000 1011$$

Its decimal equivalent is 11

So given number is -11

Hence, the correct answer is (-11).

Question Number: 18 **Question Type: NAT**

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

Solution: For 6 states we required 3-flipflops

Hence, the correct answer is (3).

Question Number: 19 **Question Type: NAT**

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

Solution: Memory = 4 GB

Memory is word - addressable

$$1 \text{ word} = 2 \text{ Bytes} = 2 \times 8 \text{ bits}$$

$$= 16 \text{ - bits}$$

Number of words in memory

$$= \frac{4 \times 2^{30} \times 2^3}{16}$$

$$= 2 \times 2^{30} = 2^{31}$$

Address bus has atleast 31 - bit length

Hence, the correct answer is (31).

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

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

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

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

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

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

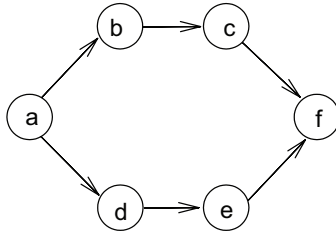
Solution: Enqueue and Dequeue operations always take one unit of time.

\therefore Both operations can be performed in $O(1)$ time.

Hence, the correct option is (A).

Question Number: 21 **Question Type: NAT**

Consider the following directed graph:



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

Solution: ‘a’ and ‘f’ are fixed in first and last positions respectively.

Topological orderings.

- (1) a b c d e f
- (2) a d e b c f
- (3) a b d c e f
- (4) a b d e c f
- (5) a d b c e f
- (6) a d b e c f

∴ 6 different topological orderings are possible.

Hence, the correct answer is (6).

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

Consider the following C program.

```
void f(int, short);
void main()
{
    int i = 100;
    short s = 12;
    short *p = &s;
    ____; // call to f()
}
```

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

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

Solution: The function prototype is void and its arguments are int, short with return type as void.

So $f(i,*p)$ matches with the arguments.

Hence, the correct option is (D).

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

The worst case running times of *Insertion sort*, *Merge sort* and *Quick sort*, respectively, are :

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

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

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

Solution: The worst case running time of Insertion sort is $\theta(n^2)$

The worst case running time of Merge sort is $\theta(n \log n)$

The worst case running time of Quick sort is $\theta(n^2)$

Hence, the correct option is (D).

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

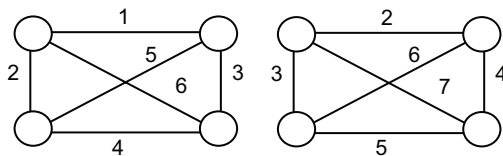
Let G be a weighted connected undirected graph with distinct positive edge weights. If every edge weight is increased by the same value, then which of the following statements is/are TRUE?

P : Minimum spanning tree of G does not change.

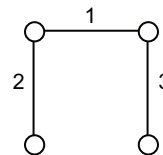
Q : Shortest path between any pair of vertices does not change.

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

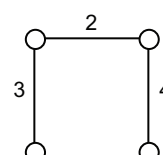
Solution: Let us consider a graph G



Spanning tree:

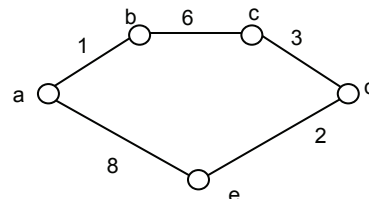


Spanning tree



∴ P is TRUE

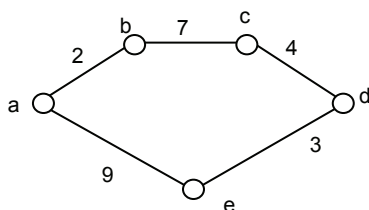
Q



Shortest path:

$a - b - c - d$

$1 + 6 + 3 = 10$



Shortest path:

$a - e - d$

$9 + 3 = 12$

Q is false

Hence, the correct option is (A).

Question Number: 25

Question Type: NAT

Consider the following C program.

```
#include<stdio.h>
void mystery (int *ptr a, int *ptr b) {
    int *temp;
    temp = ptr b;
    ptr b = ptr a;
    ptr a = temp;
}
int main () {
    int a = 2016, b = 0, c = 4, d = 42;
    mystery (&a, &b);
    if (a < c)
        mystery (&c, &a);
    mystery (&a, &d);
    printf ("%d\n", a)
}
```

The output of the program is _____.

Solution: The routine `mystery()` is manipulating with the addresses of variables and the values of variables a , b , c , d are not changing (the swap is not happening) so the value of “ a ” will be 2016.

Hence, the correct answer is 2016

Question Number: 26

Question Type: MCQ

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

$S \rightarrow aS \mid bS \mid \epsilon$

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

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

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

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

Solution: Given grammar,

$S \rightarrow aS \mid bS \mid \epsilon$

Consider some string derivations from given grammar:

$S \rightarrow \epsilon$

$S \rightarrow aS$

$S \rightarrow a$

$S \rightarrow bS$

$\rightarrow b$

$S \rightarrow aS$

$\rightarrow abS$

$\rightarrow ab$

$S \rightarrow bS$

$\rightarrow baS$

$\rightarrow ba$

$S \rightarrow aS$

$\rightarrow abS$

$\rightarrow abaS$

$\rightarrow aba.$

The strings generated by given grammar are

$\{\epsilon, a, b, ab, ba, aba, \dots\}$

From these strings we can conclude that the language is $\{a, b\}^*$

Hence, the correct option is (D).

Question Number: 27

Question Type: MCQ

Which of the following decision problems are undecidable?

I. Given NFAs N_1 and N_2 , is

$L(N_1) \cap L(N_2) = \Phi$?

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

III. Given CFGs G_1 and G_2 , is

$L(G_1) = L(G_2)$?

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

(A) I and IV only

(B) II and III only

(C) III and IV only

(D) II and IV only

Solution:

I. Checking whether the intersection of two NFA's is empty or not is decidable.

- II. Checking whether a string belongs to a CFL or not is decidable.
- III. Checking the equality of two CFLs is undecidable.
- IV. Checking whether the language accepted by a TM is empty or not is undecidable.

\therefore III and IV are undecidable.

Hence, the correct option is (C).

Question Number: 28 **Question Type: MCQ**

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

- (A) $(0+1)^* 0011 (0+1)^* + (0+1)^* 1100 (0+1)^*$
- (B) $(0+1)^* (00(0+1)^* 11 + 11 (0+1)^* 00) (0+1)^*$
- (C) $(0+1)^* 00 (0+1)^* + (0+1)^* 11 (0+1)^*$
- (D) $00 (0+1)^* 11 + 11 (0+1)^* 00$

Solution: The required regular expression represents the set of all binary strings having two consecutive 0's and two consecutive 1's. Consider each choice:

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

This RE accepts the strings which has 0011 or 1100 as substrings. This does not accept strings of the form 001010111.

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

This accepts all the strings having two consecutive 0's and two consecutive 1's.

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

This accepts the strings which have either 00 or 11 as sub strings.

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

This accepts the strings which starts with 00 or 11 and ends with 11 or 00 respectively.

Hence, the correct option is (B).

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

Consider the following code segment.

```

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

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

Solution: Static single assignment form (SSA) is an intermediate representation that facilitates certain code optimizations. All the assignment in SSA are to variables with distinct names.

SSA

```

x = u - t;           x1 = u - t;
y = x * v;           y1 = x1 * v;
x = y + w;           x2 = y1 + w;
y = t - z;           t2 = t - y1;
y = x * y;           y3 = x2 * t2;
    
```

Here total 10 variables are used:

```
(x1, y1, x2, t2, y3, u, t, v, w, y)
```

Hence, the correct answer is 10

Question Number: 30 **Question Type: MCQ**

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

- (A) Shortest remaining time first
- (B) Round-robin with time quantum less than the shortest CPU burst
- (C) Uniform random
- (D) Highest priority first with priority proportional to CPU burst length

Solution: In CPU scheduling, the scheduling policy - shortest job first will give a minimal average turn around time, minimal waiting time and high throughput. One of its flavor is shortest remaining time first which gives minimum waiting time

Hence, the correct option is (A).

Question Number: 31 **Question Type: MCQ**

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

- (A) $VXYZ$ (B) $VWXZ$
- (C) $VWXY$ (D) $VWXYZ$

Solution: Primary key = VY

- (A) $\boxed{V} X \boxed{Y} Z \longrightarrow$ Super key
- (B) $\boxed{V} W X Z \longrightarrow$ Not a super key because Y is not present
- (C) $\boxed{V} W X \boxed{Y} \longrightarrow$ Super key
- (D) $\boxed{V} W X \boxed{Y} Z \longrightarrow$ Super key

Hence, the correct option is (B).

Question Number: 32 **Question Type: MCQ**

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

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

Solution: ACID Properties:

- (1) Atomicity
(2) Consistency
(3) Isolation
(4) Durability

Hence, the correct option is (D).

Question Number: 33 **Question Type: MCQ**

A database of research articles in a journal uses the following schema.

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

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

(VOLUME, NUMBER, STARTPAGE, ENDPAGE) → TITLE

(VOLUME, NUMBER) → YEAR

(VOLUME, NUMBER,

STARTPAGE, ENDPAGE) → PRICE

The database is redesigned to use the following schemas.

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

(VOLUME, NUMBER, YEAR)

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

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

Solution: Old database:

Primary key =(Volume, Number, Start page, End page)

Volume, Number, Startpage, Endpage → Title

(Fully dependency)

Volume, Number → year (Partial dependency)

Volume, Number, Start page, End page → price

(Full dependency)

Old database does not satisfy 2NF because it has partial dependency.

New database:

(Volume, Number, Start page, End page, Title, price)

(volume, Number, Year)

All three given functional dependencies satisfy second Normal form.

Hence, the correct option is (B).

Question Number: 34 **Question Type: MCQ**

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

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

Solution: DNS: This is used for mapping host names and email destinations to IP addresses.

ARP: This protocol is used to map IP network addresses to the hardware addresses.

DHCP: This is a client/server protocol that automatically provides an IP host with its IP address and other related configuration information.

RARP: Using this protocol, a physical machine in a LAN can request to learn its IP address from a gateway server ARP table.

From these, we can conclude that DHCP is not an address resolver protocol.

Hence, the correct option is (C).

Question Number: 35 **Question Type: MCQ**

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

- (i) HTTP (ii) FTP
(iii) TCP (iv) POP3
(A) (i) and (ii) only
(B) (ii) and (iii) only
(C) (ii) and (iv) only
(D) (iv) only

Solution: From the given four protocols application layer protocols are HTTP, FTP, POP3.

TCP is transport layer protocol.

A stateful protocol is one which requires keeping of the internal state on the server.

HTTP is stateless protocol.

FTP is stateful protocol

POP3 is stateful protocol.

∴ (ii) and (iv) are stateful application layer protocols.

Hence, the correct option is (C).

Question Number: 36

Question Type: NAT

The coefficient of x^{12} in

$(x^3 + x^4 + x^5 + x^6 + \dots)^3$ is _____ .

Solution: We have

$$\begin{aligned} (x^3 + x^4 + x^5 + \dots)^3 &= [x^3(1 + x + x^2 + \dots)]^3 \\ &= x^9 (1 + x + x^2 + \dots)^3 \\ &= x^9 \left(\frac{1}{1-X} \right)^3 \\ &= x^9 \frac{1}{(1-X)^3} \\ &= x^9 \sum_{r=0}^{\infty} C(3-1+r, r)x^r \\ &= x^9 \sum_{r=0}^{\infty} C(r+2, r)x^r \\ &= x^9 [C(2, 0)x^0 + C(3, 1)x^1 + C(4, 2)x^2 + C(5, 3)x^3 + \dots] \\ &= x^9 + 3x^{10} + 6x^{11} + 10x^{12} + \dots \end{aligned}$$

The coefficient of x^{12} in $(x^3 + x^4 + x^5 + \dots)^3$

$$= 10$$

Hence, the correct answer is (10)

Question Number: 37

Question Type: NAT

Consider the recurrence relation $a_1=8,$

$a_n = 6n^2 + 2n + a_{n-1}$. Let $a_{99} = K \times 10^4$. The value of K is _____.

Solution: Given recurrence relation is

$$\begin{aligned} a_n &= 6n^2 + 2n + a_{n-1} \text{ ----- (1)} \\ \text{where } a_1 &= 8 \\ \text{From (1),} \\ a_2 &= 6 \times 2^2 + 2 \times 2 + a_1 \\ a_3 &= 6 \times 3^2 + 2 \times 3 + a_2 \\ &= 6 \times 3^2 + 2 \times 3 + 6 \times 2^2 + 2 \times 2 + a_1 \\ &= 6 \times (2^2 + 3^2) + 2 \times (2 + 3) + a_1 \\ a_4 &= 6 \times 4^2 + 2 \times 4 + a_3 \\ &= 6 \times 4^2 + 2 \times 4 + 6 \times (2^2 + 3^2) + 2 \times (2 + 3) + a_1 \\ &= 6 \times (2^2 + 3^2 + 4^2) + 2 \times (2 + 3 + 4) + a_1 \end{aligned}$$

And in general

$$\begin{aligned} a_n &= 6 \times (2^2 + 3^2 + 4^2 + \dots + n^2) + 2 \times (2 + 3 + 4 + \dots + n) + a_1 \\ &= 6 \times [(1^2 + 2^2 + 3^2 + \dots + n^2) - 1^2] + 2 \times [(1 + 2 \end{aligned}$$

$$\begin{aligned} &+ 3 + \dots + n) - 1] + a_1 \\ &= 6 \sum n^2 - 6 \times 1^2 + 2 \sum n - 2 \times 1 + a_1 \\ &= 6 \left(\frac{n(n+1)(2n+1)}{6} \right) - 6 + 2 \left(\frac{n(n+1)}{2} \right) - 2 + a_1 \\ &= (2n^3 + 3n^2 + n) + (n^2 + n) - 8 + 8 \\ &= 2n^3 + 4n^2 + 2n \\ \therefore a_n &= 2n(n+1)^2 \text{ ----- (2)} \end{aligned}$$

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

i.e. $2 \times 99 \times (99+1)^2 = k \times 10^4$ (from (2))

$$\begin{aligned} \Rightarrow 198 \times 100^2 &= k \times 10^4 \\ \Rightarrow 198 \times 10^4 &= k \times 10^4 \\ \Rightarrow k &= 198 \end{aligned}$$

Hence, the correct answer is (197.9 : 198.1)

Question Number: 38

Question Type: NAT

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

$$\begin{aligned} f(n) &= f(n/2) && \text{if } n \text{ is even} \\ f(n) &= f(n+5) && \text{if } n \text{ is odd} \end{aligned}$$

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

Solution: Given $f: N^+ \rightarrow N^+$ as

$$f(n) = \begin{cases} f\left(\frac{n}{2}\right), & \text{if } n \text{ is even} \\ f(n+5); & \text{if } n \text{ is odd} \end{cases}$$

From the definition of $f(n)$ it can be observed that,

$$\begin{aligned} f(1) &= f(2) = f(3) = f(4) = f(6) = f(7) = f(8) = f(9) = \\ f(11) &= f(12) = f(13) = f(14) = f(16) = \dots \\ \text{and } f(5) &= f(10) = f(15) = f(20) \end{aligned}$$

The maximum possible size of $R = \{i \mid \exists j: f(j) = i\}$ is 2.

Hence the correct answer is (2)

Question Number: 39

Question Type: NAT

Consider the following experiment.

- Step1. Flip a fair coin twice.
- Step2. If the outcomes are (TAILS, HEADS) then output Y and stop.
- Step3. If the outcomes are either (HEADS, HEADS) or (HEADS, TAILS), then output N and stop.
- Step4. If the outcomes are (TAILS, TAILS), then go to Step 1.

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

Solution: Let A = Getting the output Y and B = Getting the output other than Y and N

$$\therefore P(A) = \frac{1}{4} \text{ and } P(B) = \frac{1}{4}$$

The possible events that are favourable for getting the output Y are

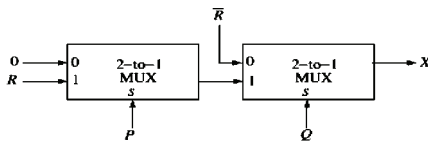
$$A, B \cap A, B \cap B \cap A, \dots\dots$$

The probability of getting the output Y

$$\begin{aligned} &= P[A \cup (B \cap A) \cup (B \cap B \cap A) \cup \\ &(B \cap B \cap B \cap A) \cup \dots\dots] \\ &= P(A) + P(B \cap A) + P(B \cap B \cap A) + \dots\dots \\ &= \frac{1}{4} + \frac{1}{4} \times \frac{1}{4} + \frac{1}{4} \times \frac{1}{4} \times \frac{1}{4} + \dots\dots \\ &= \frac{1}{4} + \left(\frac{1}{4}\right)^2 + \left(\frac{1}{4}\right)^3 + \dots\dots \\ &= \frac{1}{4} \\ &= \frac{1}{\left(1 - \frac{1}{4}\right)} \\ &= \frac{1}{3} = 0.33 \end{aligned}$$

Hence, the correct answer is (0.33 to 0.34)

Question Number: 40 **Question Type: MCQ**
Consider the two cascaded 2-to-1 multiplexers as shown in the figure.



minimal sum of products form of the output x is

- The minimal sum of products form of the output X is
 (A) $\bar{P} \bar{Q} + PQR$ (B) $\bar{P} \bar{Q} + QR$
 (C) $PQ + \bar{P} \bar{Q} R$ (D) $\bar{P} \bar{Q} + PQR$

Solution:

$$\begin{aligned} \text{Output of first multiplexer} &= I_0 \bar{S} + I_1 S \\ &= 0 \cdot \bar{P} + R \cdot P \\ &= PR \end{aligned}$$

$$\begin{aligned} \text{Output of second multiplexer} &= I_0 \bar{S} + I_1 S \\ &= \bar{R} \cdot \bar{Q} + PR \cdot Q \\ &= \bar{Q} \bar{R} + PRQ \end{aligned}$$

Hence, the correct option is (D).

Question Number: 41 **Question Type: NAT**

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

processor to transfer the file from the disk to main memory is _____.

Solution: Given,

Size of Data count register = 16 bits

The size of the file to be transferred is 29,154 KB.

Memory is byte addressable.

The DMA will transfer Data once when the Data count register reached its maximum value.

With 16 - bits, maximum number possible is $2^{16} = 65536$.

i.e., one interrupt will be generated for every 65536 bytes.

\therefore Total numbers of interrupts

$$\begin{aligned} \text{Required} &= \frac{29154 \times 2^{10}}{65536} \\ &= 455.5 \\ &\approx 456 \end{aligned}$$

\therefore The minimum number of times the DMA controller needs to get the control of the system bus in 456.

Hence, the correct answer is (456)

Question Number: 42 **Question Type: NAT**

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

Solution: Given delays for 4 - stage pipeline are 800, 500, 400, 300 ps.

Cycle time = 800 ps (maximum delay)

$$\text{Throughput} = \frac{1}{\text{cycletime}} = \frac{1}{800}$$

Delays for new 5 - stage pipeline are 600, 350, 500, 400, 300 ps.

Cycle time = 600 ps.

$$\text{Throughput} = \frac{1}{600}$$

Percent of increase in throughput

$$\begin{aligned} &= \frac{\frac{1}{600} - \frac{1}{800}}{\frac{1}{800}} \times 100 \\ &= \frac{4 - 3}{2400} \times 800 \times 100 \\ &= \frac{800}{2400} \times 100 \\ &= 33.33\% \end{aligned}$$

Hence the correct answer is 33.0 : 34.0

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

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

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

Solution: : Carry look ahead adder implement carry output in SOP form, so 2 level AND – OR is required to implement carry outputs, but the number of inputs of AND/OR gate will increase with number of bits. But here maximum fan in (number of inputs of gate) is 2. So to implement higher order bits more number of stages required.

| Number of inputs | Number of stages of 2 input gates |
|------------------|-----------------------------------|
| 1–2 | 1 |
| 3–4 | 2 |
| 5–8 | 3 |
| 9–16 | 4 |

So far ' n ' bit adder, it requires $\log_2 n$ stages. So delay is also in the order of $\log_2 n$.

Hence, the correct option is (B).

Question Number: 44 **Question Type: NAT**

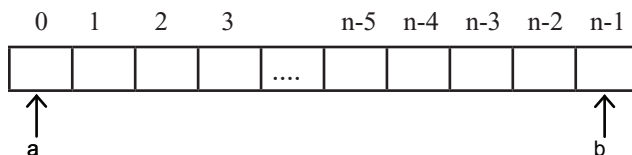
The following function computes the maximum value contained in an integer array p [] of size n ($n >= 1$).

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

The missing loop condition is

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

Solution: The routine max() computes the maximum value contained in an array p[] of size n.



The maximum value is computed by comparing the values from both ends of an array. The routine should stop, when ' a ' and ' b ' get intersect each other. The condition for it will be $b != a$

Hence, the correct answer is (D).

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

What will be the output of the following C program?

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

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

Solution: The initial values of n, d , are

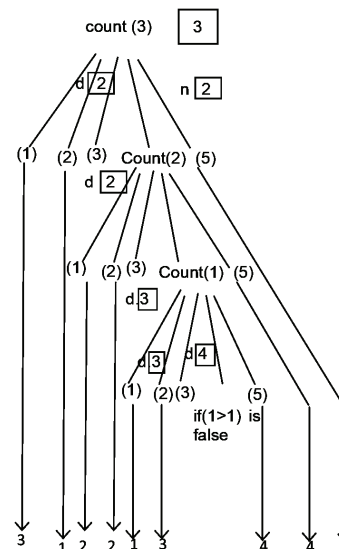


here ' d ' is a static variable. Initialization is done only once.

count() performs five operations.

- (1) print n
- (2) print d
- (3) increment d
- (4) call recursively count ($n - 1$) if $n > 1$
- (5) print d

The ' d ' value is printed from the present updated values rather activation record value.



The output is 3 1 2 2 1 3 4 4 4
Hence, the correct option is (A).

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

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

```

a = 3;
void n(x) { x = x * a; print (x);}
void m(y) { a = 1; a = y - a; n(a) ; print (a)}
void main() {m(a);}

```

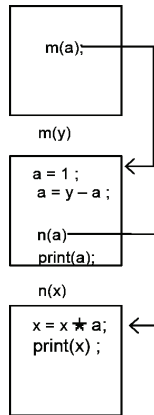
(A) 6,2 (B) 6,6
 (C) 4,2 (D) 4,4

Solution:

```

a = 3
main()

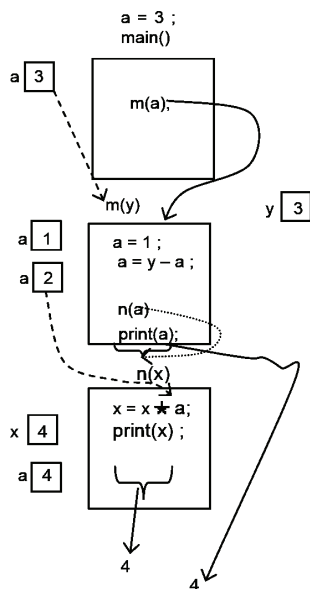
```



```

a 3 1 2 4
y = 3
x = 2
x = 2 * 2
= 4

```



It prints 4 4.

Hence, the correct option is (D).

Question Number: 47 **Question Type: MCQ**

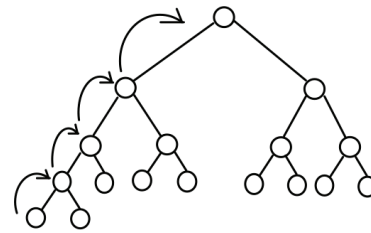
An operator `delete(i)` for a binary heap data structure is to be designed to delete the item in the *i*-th node. Assume that the heap is implemented in an array and *i* refers to the *i*-th index of the array. If the heap tree has depth *d* (number of edges on the path from the root to the farthest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

- (A) $O(1)$
- (B) $O(d)$ but not $O(1)$
- (C) $O(2^d)$ but not $O(d)$
- (D) $O(d2^d)$ but not $O(2^d)$

Solution:

Binary heap is a complete binary tree, heap is implemented in an array.

Assume a binary heap with 4 - levels (depth = 4)



Suppose the root node is deleted, then it has to be replaced with either left child or right child (lets take left child by default) To re-fix the heap, We performed 4 swap operations that is equal to the depth of the tree (d).

∴ $O(d)$ but not $O(1)$.

Hence, the correct option is (B).

Question Number: 48 **Question Type: MCQ**

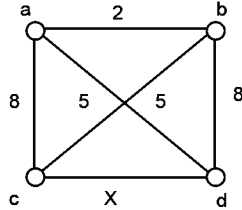
Consider the weighted undirected graph with 4 vertices, where the weight of edge $\{i, j\}$ is given by the entry W_{ij} in the matrix W .

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

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

Solution:

$$W = \begin{matrix} & a & b & c & d \\ a & 0 & 2 & 8 & 5 \\ b & 2 & 0 & 5 & 8 \\ c & 8 & 5 & 0 & X \\ d & 5 & 8 & X & 0 \end{matrix}$$



Distance from a to $c = 7$

b to $c = 5$

d to $c = 13$ ($d - a - c$)

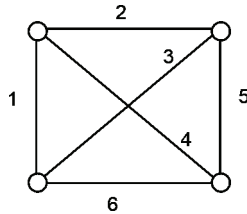
If we take X value as 12, We would have taken shortest path from d to c as $d - c$. the largest possible value for X is 12.

Hence, the correct Answer is (12)

Question Number: 49 **Question Type: NAT**

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

Solution:



The edge weights 1 and 2 will appear in minimum spanning tree, if we take 3 (assuming that 1, 2, 3 are not part of a cycle) then it will become minimum spanning tree.

– But, if 3 is part of a cycle (with 1, 2, 3 edge weights) then we have to take edge weight 4 to complete the spanning tree.

– Maximum possible minimum spanning tree weight = $1 + 2 + 4 = 7$

Hence, the correct answer is (7)

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

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

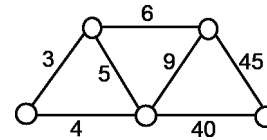
I.If e is the lightest edge of some cycle in G , then every

MST of G includes e

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

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

Solution:



In cycle 1 we will consider edge weights 3 and 4 but not 5, In cycle 2 we take 6, In cycle 3 we take 40, so we may not take a lightest edge weight in MST for every cycle.

Hence, the correct option is (B).

Question Number: 51 **Question Type: NAT**

Let Q denote a queue containing sixteen numbers and S be an empty stack.

Head (Q) returns the element at the head of the queue Q **without** removing it from Q . Similarly Top(S) returns the element at the top of S **without** removing it from S .

Consider the algorithm given below.

```

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

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

Solution: If the number of elements are 1.

The maximum number of iterations are 1.

| N | Maximum Iterations |
|----|--------------------|
| 1 | 1 |
| 2 | 4 |
| 3 | 9 |
| . | . |
| . | . |
| . | . |
| 16 | 256 |

[if the elements present in the Queue ascending order].

Hence the correct answer is 256

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

Consider the following context-free grammars:

$$G_1: S \rightarrow aS|B, B \rightarrow b|bB$$

$$G_2: S \rightarrow aA|bB, A \rightarrow aA|B| \epsilon, B \rightarrow bB| \epsilon$$

Which one of the following pairs of languages is generated by G_1 and G_2 , respectively?

- (A) $\{a^m b^n \mid m > 0 \text{ or } n > 0\}$ and $\{a^m b^n \mid m > 0 \text{ and } n > 0\}$
- (B) $\{a^m b^n \mid m > 0 \text{ and } n > 0\}$ and $\{a^m b^n \mid m > 0 \text{ or } n \geq 0\}$
- (C) $\{a^m b^n \mid m \geq 0 \text{ or } n > 0\}$ and $\{a^m b^n \mid m > 0 \text{ and } n > 0\}$
- (D) $\{a^m b^n \mid m \geq 0 \text{ and } n > 0\}$ and $\{a^m b^n \mid m > 0 \text{ or } n > 0\}$

Solution:

Given grammar,

$$G_1 : S \rightarrow aS|B, B \rightarrow b|bB$$

Lets consider the strings derived by this grammar.

$$\begin{array}{ll} S \rightarrow B & S \rightarrow aS \\ \rightarrow b & \rightarrow ab \\ & \rightarrow ab \end{array}$$

G_1 can generate strings without a's also. But there need to be atleast one b for getting terminal string.

G_1 generates the language.

$$\{a^m b^n \mid m \geq 0 \text{ and } n > 0\}$$

$$G_2 : S \rightarrow aA|bB$$

$$A \rightarrow aA|B| \epsilon$$

$$B \rightarrow bB| \epsilon$$

Consider the strings which are generated by G_2 :

$$\begin{array}{ll} S \rightarrow aA & S \rightarrow bB \\ \rightarrow a & \rightarrow b \end{array}$$

G_2 may contain one or more a's (or) one or more b's.

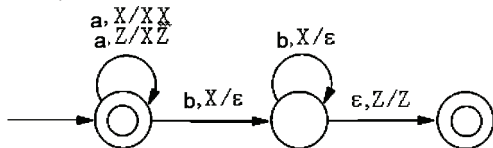
The language generated by G_2 is

$$\{a^m b^n \mid m > 0 \text{ or } n > 0\}$$

Hence, the correct option is (D).

Question Number: 53 **Question Type: MCQ**

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



Which one of the following is TRUE?

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

automata.

- (B) $L = \{a^n \mid n \geq 0\} \cup \{a^n b^n \mid n \geq 0\}$ and is not accepted by any deterministic PDA.
- (C) L is not accepted by any Turing machine that halts on every input.
- (D) $L = \{a^n \mid n \geq 0\} \cup \{a^n b^n \mid n \geq 0\}$ and is deterministic context-free.

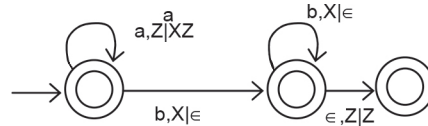
Solution:

Given, input alphabet $\Sigma = \{a, b\}$

Stack alphabet $\Gamma = \{X, Z\}$

Z is initial stack symbol.

L is the language accepted by below PDA:



This PDA accepts the strings with n number of a's () or strings with equal number of a's and b's in the form an bn such that n ≥ 0.

$$L = \{a^n \mid n \geq 0\} \cup \{a^n b^n \mid n \geq 0\}$$

And is accepted by a deterministic CFL.

Hence, the correct option is (D).

Question Number: 54 **Question Type: MCQ**

Let X be a recursive language and Y be a recursively enumerable but not recursive language. Let W and Z be two languages such that \bar{y} reduces to W , and Z reduces to \bar{x} (reduction means the standard many-one reduction). Which one of the following statements is TRUE?

- (A) W can be recursively enumerable and Z is recursive.
- (B) W can be recursive and Z is recursively enumerable.
- (C) W is not recursively enumerable and Z is recursive.
- (D) W is not recursively enumerable and Z is not recursive.

Solution:

Given,

X is recursive language.

Y is recursively enumerable but not recursive.

W is a language such that \bar{y} reduces to W .

Z is a language such that Z reduces to \bar{x} .

As X is recursive, \bar{x} is also recursive.

As Y is recursively enumerable but not recursive so \bar{y} is not recursively enumerable.

Z reduces to \bar{x} and \bar{x} is recursive so Z is recursive.

\bar{y} reduces to W and \bar{y} is not recursively enumerable. So, W is not recursively enumerable.

Hence, the correct option is (C).

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

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

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

The value of the expression

$2 - 5 + 1 - 7 * 3$ in this language is _____.

Solution:

$2 - 5 + 1 - 7 * 3$

‘+’ has high precedence, so it evaluates

$5 + 1 = 6$

$2 - 6 - 7 * 3$

‘-’ has medium precedence, and associates from Right. so it evaluates to

$6 - 7 = -1$ and $2 - (-1) = 3$

$3 * 3$

* has low precedence.

$3 * 3 = 9$

Hence the correct answer is 9

Question Number: 56 **Question Type: MCQ**

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

$S \rightarrow aA$ { print 1 }

$S \rightarrow a$ { print 2 }

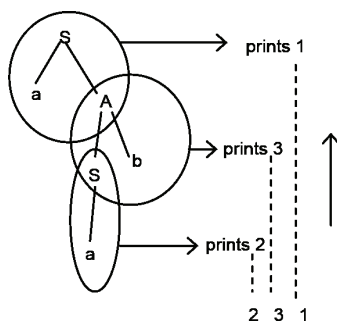
$A \rightarrow Sb$ { print 3 }

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

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

Solution:

Input string = **a a b**



Its prints 2 3 1.

Hence, the correct option is (C).

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

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

Solution:

Virtual address = 40 bits

Page size = 16 KB

Page table entry = 48 bits

Number of pages = $\frac{2^{40}}{2^{14}} = 2^{26}$

Page table size = $2^{26} \times 48$ bits
= 3072 M bits

= 384 MB

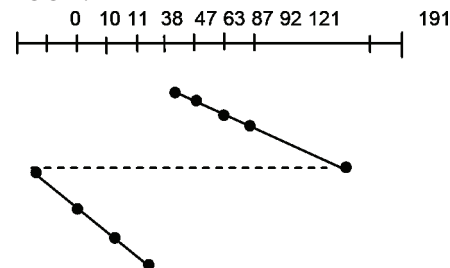
Hence, the correct Answer is (384)

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

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

Solution:

C – LOOK:



Total head movement =

$87 - 63 + 92 - 87 + 121 - 92 + 191 - 121 + 191 - 10 + 11 - 10 + 38 - 11 + 47 - 38$

= 346

Hence, the correct answer is 346

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

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

Solution:

LIFO

It just simulates the operation of stack.

 $a_1, a_2, a_3, \dots, a_{10}$ $a_{11}, a_{12}, a_{13}, \dots, a_{20}$ $a_1, a_2, a_3, \dots, a_{10}$ $a_{11}, a_{12}, a_{13}, \dots, a_{20}$

Using LIFO the system will having 31 pages faults.

Using optimal page replacement policy the system will be having 30 page faults.

The difference in page faults = $31 - 30$.

Hence, the correct answer is (1)

Question Number: 60 **Question Type: MCQ**

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

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

Critical Section;

 $t[i] = 0$;

Remainder Section;

} while (true);

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

- (A) At most one process can be in the critical section at any time.
- (B) The bounded wait condition is satisfied.
- (C) The progress condition is satisfied.
- (D) It cannot cause a deadlock.

Solution: The synchronization solution for the above n processes guarantees mutual exclusion. But it doesn't guarantee progress. The above solution may lead the processes in dead lock position.

Hence, the correct option is (A)

Question Number: 61 **Question Type: MCQ**

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

Step 1. T acquires exclusive locks to O_1, \dots, O_k in increasing order of their addresses.

Step 2. The required operations are performed.

Step 3. All locks are released.

This protocol will

- (A) guarantee serializability and deadlock-freedom.
- (B) guarantee neither serializability nor deadlock-

freedom.

(C) guarantee serializability but not deadlock-freedom.

(D) guarantee deadlock-freedom but not serializability.

Solution: If every transaction in a schedule follows 2-phase Locking protocol, that schedule is definitely serializable.

→ So it guarantees serializability.

→ If a transaction acquires write-locks on all data items, further no locks are allowed.

→ We have only one transaction T , there are no other transactions, So there no scope of waiting.

→ So there is Deadlock freedom.

Hence, the correct option is (A)

Question Number: 62 **Question Type: MCQ**

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

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

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

Solution: B wants to send a message m , that is digitally signed, to A .

Private & Public keys of A are K_A^- & K_A^+ .

Private and public keys of B are K_B^- and K_B^+ .

$K_x(m)$ represents encryption of m with key K_x .

$H(m)$ represents message digest.

To send a digitally signed message from B to A , the message need to be encrypted by private key of B . i.e., $\{m, K_B^-(H(M))\}$

Hence, the correct option is (B)

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

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

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

Solution:

IP datagram has a size of 1000 Bytes.

Maximum transmission unit capacity is 100 bytes.

In these 100 bytes, 20 bytes is for header.

So 80 Bytes is for Data.

To transfer 1000 bytes, with 80 byte data in the packet,

$$\frac{1000}{80} = 12.5 = 13 \text{ packets required.}$$

Hence, the correct answer is (13)

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

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

Solution:

Given

Maximum burst rate (m) = 20 MB

Token arrival rate (ρ) = 10 MB

Bucket capacity (c) = 1 MB

$$\text{Time taken for 1 MB of data (s)} = \frac{c}{m - \rho}$$

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

$$\begin{aligned} \text{Data transmitted in 0.1 sec} \\ &= 0.1 \times \text{output rate} \\ &= 0.1 \times 20 \text{ MBPS} \\ &= 2 \text{ MB} \end{aligned}$$

$$\begin{aligned} \text{Remaining data} &= 12 \text{ MB} - 2 \text{ MB} \\ &= 10 \text{ MB} \end{aligned}$$

$$\begin{aligned} \text{To transmit 10 MB, time taken} \\ &= 0.1 \times 10 = 1 \text{ sec.} \end{aligned}$$

$$\begin{aligned} \text{Total time required to transmit 12 MB} \\ &= 1 + 0.1 = 1.1 \text{ sec} \end{aligned}$$

Hence, the correct answer is (1.1)

Question Number: 65**Question Type: MCQ**

A sender uses the Stop-and-Wait ARQ protocol for reliable transmission of frames. Frames are of size 1000 bytes and

the transmission rate at the sender is 80 Kbps (1 Kbps = 1000 bits/second). Size of an acknowledgement is 100 bytes and the transmission rate at the receiver is 8 Kbps. The one-way propagation delay is 100 milliseconds. Assuming no frame is lost, the sender throughput is _____ bytes/second.

Solution:

Given, frame size = 1000 Bytes

Sender transmission rate = 80 Kbps

$$80 \times 10^3 \text{ bits} \quad 1 \text{ sec}$$

$$1000 \times 8 \text{ bits} \quad ?$$

Time taken to transmit

$$1 \text{ frame} = \frac{8000}{80 \times 10^3} = 0.1 \text{ sec}$$

1-way propagation delay = 100 msec

$$\begin{aligned} \text{Round-trip delay} &= 2 * 100 \text{ msec} \\ &= 0.2 \text{ msec.} \end{aligned}$$

Size of Acknowledgment = 100 Bytes

Transmission rate at the receiver

= 8Kbps

$$8 \times 10^3 \text{ bits} \text{ --- } 1 \text{ sec}$$

$$100 \times 8 \text{ bits} \text{ --- } ?$$

$$\begin{aligned} \text{Time to transmit one ack} &= \frac{800}{8 \times 10^3} \\ &= 0.1 \text{ sec} \end{aligned}$$

$$\text{Throughput} = \frac{1}{T}$$

T = Transmission time + Propagation delay + Acknowledgment delay

$$= 0.1 + 0.2 + 0.1 = 0.4 \text{ sec.}$$

$$\text{Throughput} = \frac{1}{0.4} = 2.5 \text{ frames/sec}$$

One frame = 1000 bytes

2.5 frames = 2500 bytes/sec.

Hence, the correct answer is (2500)

GATE 2016 SOLVED PAPER
CS: COMPUTER SCIENCE AND INFORMATION TECHNOLOGY
Set – 2

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 Question.

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**

The man who is now Municipal Commissioner worked as _____.

- (A) the security guard at a university
- (B) a security guard at the university
- (C) a security guard at university
- (D) the security guard at the university

Solution: The reference is to a particular person who worked as a security guard. Hence the correct option is '.....a security guard at the university'.

Hence, the correct option is (B).

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

Nobody knows how the Indian cricket team is going to cope with the difficult and seamer-friendly wickets in Australia. Choose the option which is closest in meaning to the underlined phrase in the above sentence.

- (A) put up with
- (B) put in with
- (C) put down to
- (D) put up against

Solution: To cope with something or someone is to put up with or bear with something or someone.

Hence, the correct option is (A).

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

Find the odd in the following group of words.

Mock, deride, praise, jeer

- (A) mock
- (B) deride
- (C) praise
- (D) jeer

Solution: The words mock, deride, and jeer convey the same meaning. Praise is the odd man out.

Hence, the correct option is (C)

Alternate Solution: 'Mock', 'deride' and 'jeer' are synonyms, while 'praise' is opposite of the other three words.

Hence, the correct option is (C)

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

Pick the odd one from the following options.

- (A) CADBE
- (B) JHKIL
- (C) XVYWZ
- (D) ONPMQ

Solution: Each group contains five consecutive letters from the English alphabet. The arrangement within the group is similar in (A), (B) and (C), but different in (D).

Hence, the correct option is (D)

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

In a quadratic function, the value of the product of the roots ($\alpha\beta$) is 4. Find the value

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

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

Solution: Let the quadratic equation (not function: a function has zeroes while an equation has roots) be $ax^2 + bx + c = 0$. The roots are α, β

$$\therefore \alpha + \beta = \frac{-b}{a} \text{ and } \alpha\beta = \frac{c}{a}. \text{ Given } \alpha\beta = 4$$

$$\frac{\alpha^n + \beta^n}{\alpha^{-n} + \beta^{-n}} = \frac{\alpha^n + \beta^n}{\alpha^n + \beta^n} \alpha^n \beta^n = (\alpha\beta)^n = 4^n.$$

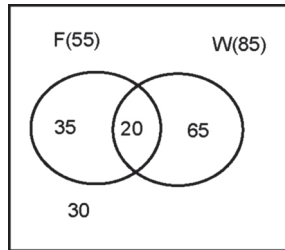
Hence, the correct option is (B)

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

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

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

Solution: The data is shown in the Venn diagram below. F is Face book and W is Whats App.



As 30 faculty members have neither account, 120 have accounts. As 55 have a Face book account and 85 have a WhatsApp account, but only 120 have either account $55 + 85 - 120$, i.e. 20 members have both accounts The number of faculty members who have only a Facebook account is $55 - 20$, i.e. 35.

Hence, the correct option is (A)

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

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

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

- (i) The author believes that computers are not good for us.
 - (ii) Mobile computers and the internet are both intended inventions
- (A) (i) only (B) (ii) only
 (C) both (i) and (ii) (D) neither (i) nor (ii)

Solution: The author is expressing doubt whether computers are good. He/She is not concluding that the computers are not good. Hence, (i) is not valid.

According to the author many people think internet is an unintended consequence, but did not make such comment about mobile computers. Hence, (ii) is not valid.

Hence, neither (i) nor (ii) is valid.

Hence, the correct option is (D)

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

All hill – stations have a lake. Ooty has two lakes.

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

- (i) Ooty is not a hill- station.
 - (ii) No hill – station can have more than one lake.
- (A) (i) only (B) (ii) only
 (C) both (i) and (ii) (D) neither (i) nor (ii)

Solution: The statement ‘All hill-stations have a lake’ does not mean that the hill stations have ‘only one lake’. Hence, neither (i) nor (ii) is logically valid.

Hence, the correct option is (D)

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

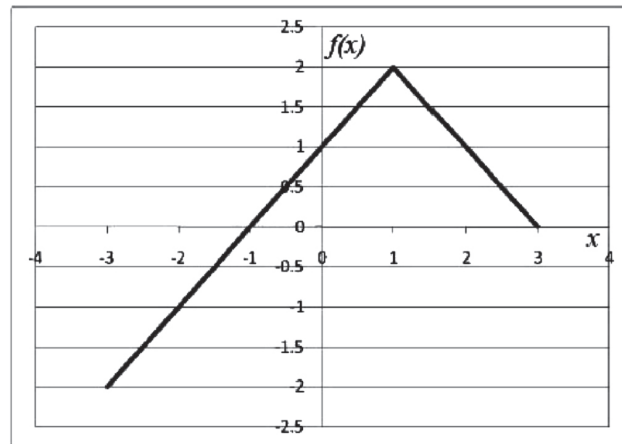
In a 2×4 rectangle grid shown below, each cell is a rectangle. How many rectangles can be observed in the grid?

- (A) 21 (B) 27
 (C) 30 (D) 36

Solution: To select a rectangle from the grid, from the 5 vertical lines we have to select 2 and from the 3 horizontal lines we have to select 2. This can be done in ${}^5C_2 {}^3C_2$ viz $10(3)$ or 30 ways.

Hence, the correct option is (C)

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



Choose the correct expression for $f(x)$ given in the graph.

- (A) $f(x) = 1 - |x - 1|$ (B) $f(x) = 1 + |x - 1|$
 (C) $f(x) = 2 - |x - 1|$ (D) $f(x) = 2 + |x - 1|$

Solution: The graph shows a V which opens downwards. The mod expression has to be preceded by a negative sign (we reject B, D) At the vertex of the V, i.e., at $x = 1, y$ is 2. We accept C and reject A.

Hence, the correct option is (C)

COMPUTER SCIENCE & ENGINEERING

Number of Question:

Section Marks:

Q.1 to Q.25 carry 1 mark each and Q.26 to Q.55 carry 2 marks each.

Question Number: 1

Question Type: MCQ

Consider the following expressions

- | | |
|---------------------|-----------------|
| (i) <i>false</i> | (ii) Q |
| (iii) <i>true</i> | (iv) $P \vee Q$ |
| (v) $\neg Q \vee P$ | |

The number of expressions given above that are logically implied by $P \wedge (P \Rightarrow Q)$ is _____.

Solution: We have

$$P \wedge (P \rightarrow Q) \Rightarrow Q \text{ (modus ponens)}$$

$$P \wedge (P \rightarrow Q) \Rightarrow Q \Rightarrow P \vee Q \text{ (Addition)}$$

Also, every proposition tautologically implies “True”

$$\therefore P \wedge (P \rightarrow Q) \Rightarrow \text{True}$$

Consider $P \wedge (P \rightarrow Q) \rightarrow (\neg Q \vee P)$

$\neg Q \vee P$ is false only when P is false and Q is true.

In that case $P \wedge (P \rightarrow Q)$ is false

$$\therefore P \wedge (P \rightarrow Q) \rightarrow (\neg Q \vee P) \text{ is a tautology.}$$

Hence the number of expressions among (i), (ii), (iii), (iv) and (v) that are tautologically implied by

$$P \wedge (P \rightarrow Q) \text{ are 4.}$$

Hence, the correct option is 4

Question Number: 2

Question Type: MCQ

Let $f(x)$ be a polynomial and $g(x) = f'(x)$ be its derivative. If the degree of $f(x) + f(-x)$ is 10, then the degree of $(g(x) - g(-x))$ is _____.

Solution: Given $f(x)$ is a polynomial and $f'(x) = g(x)$

As $f(x) + f(-x)$ is a polynomial of degree 10,

$$\frac{d}{dx} [f(x) + f(-x)] \text{ will be a polynomial of degree 9.}$$

$$\Rightarrow f'(x) + f'(-x) \cdot (-1) \text{ is a polynomial degree 9.}$$

$$\Rightarrow g(x) - g(-x) \text{ is a polynomial of degree 9}$$

$$(\because g(x) = f'(x))$$

Hence, the correct option is (9)

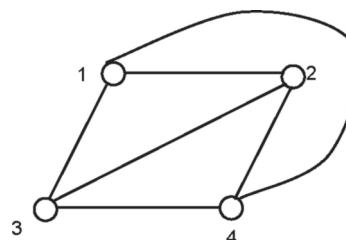
Question Number: 3

Question Type: NAT

The minimum number of colours that is sufficient to vertex-colour any planar graph is _____.

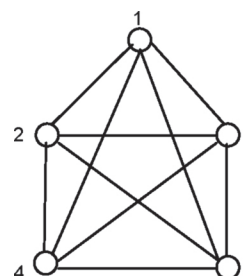
Solution: Any planar graph can be colored with 4 – colors.

Planer graph



4 – colors

Non planar graph



4 – colors are not sufficient.

Hence, the correct answer is (4)

Question Number: 4

Question Type: MCQ

Consider the systems, each consisting of m linear equations in n variables.

- I. If $m < n$, then all such systems have a Solution
- II. If $m > n$, then none of these systems has a Solution
- III. If $m = n$, then there exists a system which has a Solution

Which one of the following is **CORRECT**?

- (A) I, II and III are true
- (B) Only II and III are true
- (C) Only III is true
- (D) None of them is true

Solution:

Counter example for I:

Consider the system

$$2x - 3y - z = 4$$

$$-2x + 3y + z = -3$$

This system has no solution

\therefore I is False

Counter example for II:

$$2x + 3y = 3$$

$$X + 2y = 1$$

$$3x + 2y = 7$$

This system has a Solution $x = 3$ and $y = -1$

\therefore II is False.

And in a system of 3 linear equations in 3 unknowns say, $A X = B$.

If $\rho(A) = \rho([A/B])$, then the system has a Solution.

Hence III is True.

Hence, the correct option is (C)

Question Number: 5 **Question Type: NAT**

Suppose that a shop has an equal number of LED bulbs of two different types. The probability of an LED bulb lasting more than 100 hours given that it is of Type 1 is 0.7, and given that it is Type 2 is 0.4. The probability that an LED bulb chosen uniformly at random lasts more than 100 hours is _____.

Solution: Let B_1 and B_2 denote the events of choosing a Type 1 and Type 2 LED bulbs respectively.

$$\therefore P(B_1) = 0.5 \text{ and } P(B_2) = 0.5$$

Let A denote the event of choosing an LED bulb that lasts more than 100 hours.

$$\therefore P(A/B_1) = 0.7 \text{ and } P(A/B_2) = 0.4$$

The probability that an LED bulb chosen uniformly at random lasts more than 100 hours

$$= P(A) = P(B_1) \cdot P(A/B_1) + P(B_2) \cdot P(A/B_2)$$

$$= 0.5 \times 0.7 + 0.5 \times 0.4$$

$$= 0.55.$$

Hence, the correct answer is (0.55)

Question Number: 6 **Question Type: NAT**

Suppose that the eigenvalues of matrix A are 1, 2, 4. The determinant of $(A^{-1})^T$ is _____.

Solution: Given the eigen values of A are 1, 2 and 4.

The eigen values of A^{-1} are $1, \frac{1}{2}$ and $\frac{1}{4}$

\Rightarrow The eigen values of $(A^{-1})^T$ are $1, \frac{1}{2}$ and $\frac{1}{4}$

The determinant of $(A^{-1})^T$ = The product of the eigen values of $(A^{-1})^T$

$$= 1 \times \frac{1}{2} \times \frac{1}{4}$$

$$= \frac{1}{8} = 0.125$$

Hence, the correct answer is 0.125 to 0.126

Question Number: 7

Question Type: NAT

Consider an eight-bit ripple-carry adder for computing the sum of A and B, where A and B are integers represented in 2's complement form. If the decimal value of A is one, the decimal value of B that leads to the longest latency for the sum to stabilize is _____.

Solution: To have longest latency, the carry should propagate from all bits. Input A is 1, so other input should have 1 1 1 1 1 1 1. (in 2's complement form) its value is decimal = -1.

Hence, the correct answer is -1.0

Question Number: 8

Question Type: MCQ

Let $x_1 \oplus x_2 \oplus x_3 \oplus x_4 = 0$ where x_1, x_2, x_3, x_4 are Boolean variables, and \oplus is the XOR operator. Which one of the following must always be TRUE?

(A) $x_1 x_2 x_3 x_4 = 0$

(B) $x_1 x_3 + x_2 = 0$

(C) $\bar{x}_1 \oplus \bar{x}_3 = \bar{x}_3 \oplus \bar{x}_4$

(D) $x_1 + x_2 + x_3 + x_4 = 0$

Solution:

XOR of x_1, x_2, x_3, x_4 is zero means, it will

have even number of 1's.

eg: 0000, 0011, 0110, 1100, 0101, 1010, 1001, 1111, these combinations are true for choice (c). $x_1 \oplus x_3 = x_2 \oplus x_4$

Hence, the correct answer is (C)

Question Number: 9

Question Type: NAT

Let X be the number of distinct 16-bit integers in 2's complement representation. Let Y be the number of distinct 16-bit integers in sign magnitude representation. They $x - y$ is _____.

Solution:

X is number of distinct 16-bit integers in 2's complement representation.

The range is -2^{15} to $2^{15}-1$ i.e., there will be 65536 numbers.

Y is the number of distinct 16-bit integers in signed magnitude representation.

The range is $-(2^{15}-1)$ to $2^{15}-1$.

i.e., There will be 65535 numbers.

$$\therefore X - Y = 1.$$

Hence, the correct answer is (1)

Question Number: 10

Question Type: NAT

A processor has 40 distinct instructions and 24 general purpose registers. A 32-bit instruction word has an opcode, two register operands and an immediate operand. The number of bits available for the immediate operand field is _____.

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

N items are stored in a sorted doubly linked list. For a *delete* operation, a pointer is provided to the record to be deleted. For a *decrease - key* operation, a pointer is provided to the record on which the operation is to be performed.

An algorithm performs the following operations on the list in this order: $\Theta(N)$ *delete*, $O(\log N)$ *insert*, $O(\log N)$ *find*, and $\Theta(N)$ *decrease - key*. What is the time complexity of all these operations put together?

- (A) $O(\log^2 N)$
- (B) $O(N)$
- (C) $O(N^2)$
- (D) $\Theta(N^2 \log N)$

Solution:

– $\Theta(N)$ delete operations take 1 unit of time because a pointer is provided to the record to be deleted.

Time complexity = $\Theta(N)$

– $O(\log N)$ elements need to be inserted into a sorted array, for 1 element we need to find the correct position to place, which takes $O(N)$ comparisons, so for $(\log N)$ elements, we need $O(N \log N)$ time.

Time complexity = $O(N \log N)$

– For find also we need $O(n \log N)$ time.

– $q(N)$ decrease-key operations take because a pointer is provided to the record on which the operation is performed.

Time complexity = $O(N)$

Total time complexity = $(N + N \log N + N \log N + N)$

= $(2N + 2N \log N) = 2(N + N \log N)$

= $N + N \log N \leq C * N^2$

= $N + N \log N \in O(N^2)$

Hence, the correct option is (C)

Question Number: 16 **Question Type: NAT**

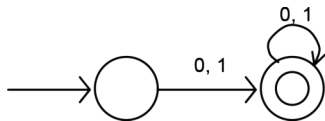
The number of states in the minimum sized DFA that accepts the language defined by the regular expression

$(0+1)^*(0+1)(0+1)^*$ is _____ .

Solution: Given regular expression,

$(0 + 1)^* (0 + 1) (0 + 1)^*$

The minimized DFA will be as below:



∴ Two states required

Hence, the correct answer is (2)

Question Number: 17 **Question Type: MCQ**

Language L_1 is defined by the grammar: $S_1 \rightarrow aS_1b | \epsilon$

Language L_2 is defined by the grammar: $S_2 \rightarrow abS_2 | \epsilon$

Consider the following statements:

$P: L_1$ is regular

$Q: L_2$ is regular

Which one of the following is TRUE?

- (A) Both P and Q are true
- (B) P is true and Q is false
- (C) P is false and Q is true
- (D) Both P and Q are false

Solution:

Given, L_1 is defined by the grammar

$S_1 \rightarrow a S_1 b | \epsilon$.

L_1 accepts strips which are in the form of

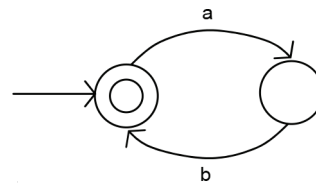
$\{a^n b^n | n \geq 0\}$

This is not regular.

L_2 is defined by the grammar:

$S_2 \rightarrow a b S_2 | \epsilon$.

The DFA for the language generated by this grammar is



∴ L_2 is regular.

∴ P is false & Q is true.

Hence, the correct option is (C)

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

Consider the following types of languages: L_1 : Regular, L_2 : Context - free, L_3 : Recursive, L_4 : Recursively enumerable.

Which of the following is /are TRUE?

- I. $\bar{L}_3 \cup L_4$ is recursively enumerable
- II. $\bar{L}_2 \cup L_3$ is recursive
- III. $L_1^* \cap L_2$ is context - free
- IV. $L_1 \cup \bar{L}_2$ is context - free

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

Solution:

Given,

L_1 : Regular

L_2 : Context-free

L_3 : Recursive

L_4 : Recursively enumerable

(i) $\bar{L}_3 \cup L_4$ is recursively enumerable. As L_3 is Recursive, \bar{L}_3 is also recursive. Every recursive language is recursively enumerable. Recursively enumerable languages are closed under union.

$\therefore \bar{L}_3 \cup L^4$ is recursively enumerable.

(ii) $\bar{L}_2 \cup L_3$ is recursive.

L_2 is CFL. \bar{L}_2 is not necessarily CFL but \bar{L}_2 is recursive.

As L_3 is recursive, $L_2 \cup L_3$ is recursive.

(\because recursive languages are closed under union).

(iii) $L_1^* \cap L_2$ is context-free

L_1^* is regular as regular languages are closed under closure.

L_2 is context-free.

Intersection of regular and CFL is CFL.

(iv) $L_1 \cup \bar{L}_2$ is context-free.

\bar{L}_2 may or may not be CFL.

So $L_1 \cup \bar{L}_2$ may or may not be context-free.

\therefore I, II and III are true.

Hence, the correct option is (D)

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

Match the following:

- | | |
|--|---------------------------|
| (P) Lexical analysis | (i) Leftmost derivation |
| (Q) Top down parsing | (ii) Type checking |
| (R) Semantic analysis | (iii) Regular expressions |
| (S) Runtime environments | (iv) Activation records |
| (A) $P \leftrightarrow i, Q \leftrightarrow ii, R \leftrightarrow iv, S \leftrightarrow iii$ | |
| (B) $P \leftrightarrow iii, Q \leftrightarrow i, R \leftrightarrow ii, S \leftrightarrow iv$ | |
| (C) $P \leftrightarrow ii, Q \leftrightarrow iii, R \leftrightarrow i, S \leftrightarrow iv$ | |
| (D) $P \leftrightarrow iv, Q \leftrightarrow i, R \leftrightarrow ii, S \leftrightarrow iii$ | |

Solution:

(1) Regular expressions are used for the construction of lexical analysis.

$P - iii$

(2) Top down parsing uses left most derivation for parsing the string.

$Q - i$

(3) Semantic analysis is used for type checking.

$R - ii$

(4) Runtime environments make use of activation records.

$S - iv$

Hence, the correct option is (B)

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

In which one of the following page replacement algorithms it is possible for the page fault rate to increase even when the number of allocated frames increases?

- (A) **LRU** (Least Recently Used)
 (B) **OPT** (Optimal Page Replacement)
 (C) **MRU** (Most Recently Used)
 (D) **FIFO** (First In First Out)

Solution: Given statement resembles the definition of Belady's anomaly. FIFO is affected with Belady's anomaly.

Hence, the correct option is (D)

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

B+ Trees are considered **BALANCED** because

- (A) The lengths of the paths from the root to all leaf nodes are all equal.
 (B) The lengths of the paths from the root to all leaf nodes differ from each other by at most 1.
 (C) The number of children of any two non - leaf sibling nodes differ by at most 1.
 (D) The number of records in any two leaf nodes differ by at most 1.

Solution: B+ trees has a constraint that makes the tree always balanced (The length of paths from root to all the leaf nodes is equal).

Hence, the correct option is (A)

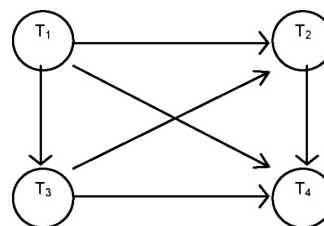
Question Number: 22 **Question Type: MCQ**

Suppose a database schedule S involves transactions T_1, \dots, T_n . Construct the precedence graph of S with vertices representing the transactions and edges representing the conflicts. If S is serializable, which one of the following orderings of the vertices of the precedence graph is guaranteed to yield a serial schedule?

- (A) Topological order (B) Depth - first order
 (C) Breadth - first order (D) Ascending order of transaction indices

Solution: S is serializable, means precedence graph should not contain any cycles.

Example: consider 4 transactions



Topological ordering:

T_1, T_3, T_2, T_4

Depth First order might give T_1, T_2, T_4, T_3

Breadth First order might give T_1, T_3, T_4, T_2

Ascending order of transaction indices T_1, T_2, T_3, T_4

\therefore Topological ordering is valid for any precedence graph.

Hence, the correct option is (A)

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

Anarkali digitally signs a message and sends it to Salim. Verification of the signature by Salim requires

- (A) Anarkali's public key.
 (B) Salim's public key.
 (C) Salim's private key.
 (D) Anarkali's private key.

Solution: Anarkali digitally signs a message and sends it to Salim. For this Anarkali uses her private key. To verify this Salim requires Anarkali's public key.

Hence, the correct option is (A)

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

In an Ethernet local area network, which one of the following statements is **TRUE**?

- (A) A station stops to sense the channel once it starts transmitting a frame.
- (B) The purpose of the jamming signal is to pad the frames that are smaller than the minimum frame size.
- (C) A station continues to transmit the packet even after the collision is detected
- (D) The exponential back off mechanism reduces the probability of collision on retransmissions.

Solution: The exponential backoff algorithm reduces the probability of collision on retransmission. (This is true).

A station stops transmitting packet if collision is detected.

Hence, the correct option is (D)

Question Number: 25 **Question Type: MCQ**

Identify the correct sequence in which the following packets are transmitted on the network by a host when a browser requests a webpage from a remote server, assuming that the host has just been restarted.

- (A) **HTTP GET** request, **DNS** query, **TCP SYN**
- (B) **DNS** query, **HTTP GET** request, **TCP SYN**
- (C) **DNS** query, **TCP SYN**, **HTTP GET** request
- (D) **TCP SYN**, **DNS** query, **HTTP GET** request

Solution: When a browser requests a web page from a remote server, the packets to be transmitted are

1. Client sends DNS query for remote server.
2. To get connection client will send TCP SYN packet.
3. After connection is established, the client requests data from server using HTTP GET request.

Hence, the correct option is (C)

Question Number: 26 **Question Type: MCQ**

Q.26 –Q.55 carry two marks each.

A binary relation R on $N \times N$ is defined as follows: $(a, b) R (c, d)$ if $a \leq c$ or $b \leq d$. consider the following propositions:

P : R is reflexive

Q : R is transitive

Which one of the following statements is **TRUE**?

- (A) Both P and Q are true.
- (B) P is true and Q is false
- (C) P is false and Q is true
- (D) Both P and Q are false.

Solution: Given binary relation R on $N \times N$ is $(a, b) R (c, d)$ if $a \leq c$ or $b \leq d$

We know that $a \leq a$ and $b \leq b$

$\Rightarrow (a, b) R (a, b), \forall (a, b) \in N \times N$

$\therefore R$ is reflexive

$\Rightarrow P$ is true ----- (1)

Counter example for Q :-

We know that $(4, 10) R (7, 6) (\because 4 \leq 7)$

and $(7, 6) R (3, 9) (\because 6 \leq 9)$

But $(4, 10) R (3, 9) (\because 4 \not\leq 3$ and $10 \not\leq 9)$

$\therefore R$ is not transitive

Hence Q is false ----- (2)

\therefore From (1) and (2), option (B) is correct.

Hence, the correct option is (B)

Question Number: 27 **Question Type: MCQ**

Which one of the following well - formed formulae in predicate calculus is **NOT** valid?

- (A) $(\forall x p(x) \Rightarrow \forall x q(x)) \Rightarrow (\exists x \neg p(x) \vee \forall x q(x))$
- (B) $(\exists x p(x) \vee \exists x q(x)) \Rightarrow \exists x (p(x) \vee q(x))$
- (C) $\exists x (p(x) \wedge q(x)) \Rightarrow (\exists x p(x) \wedge \exists x q(x))$
- (D) $\forall x (p(x) \vee q(x)) \Rightarrow (\forall x p(x) \vee \forall x q(x))$

Solution: Standard results.

Hence, the correct option is (D)

Question Number: 28 **Question Type: MCQ**

Consider a set U of 23 different compounds in a Chemistry lab. There is a subset S of U of 9 compounds, each of which reacts with exactly 3 compounds of U . Consider the following statements:

- I. Each compound in $U \setminus S$ reacts with an odd of compounds.
- II. At least one compound in $U \setminus S$ reacts with an odd number of compounds.
- III. Each compound in $U \setminus S$ reacts with an even number of compounds.

Which one of the above statements is **ALWAYS TRUE**?

- (A) Only I
- (B) Only II
- (C) Only III
- (D) None

Solution: Consider an undirected graph G with each of the 23 compounds as a vertex and if two compounds react then there will be an edge between the corresponding vertices.

As there are 9 compounds in $S \subseteq U$ such that each of the compounds of S reacts with exactly 3 compounds, the graph G will have atleast 9 odd vertices.

We know that in any undirected graph, there are an even number of odd vertices.

There exists atleast one compound in $U \setminus S$ that reacts with an odd number of compounds.

Hence, the correct option is (B)

Question Number: 29 **Question Type: MCQ**

The value of the expression $13^{99} \pmod{17}$, in the range 0 to 16, is _____ .

$$\Rightarrow \tau_1 = 0.25\text{nsec.}$$

$$\tau_2 = \frac{4\tau_1}{3} = 0.33\text{nsec}$$

$$\tau_3 = \frac{\tau_1}{2} = 0.125\text{nsec}$$

Now for a new processor, the longest stage delay is split into two equal stage delays. So new stage delays will be 0.25, 0.165, 0.165, 0.125nsec.

Maximum stage delay is 0.25

\Rightarrow cycle time = 0.25 nsec

$$\Rightarrow \text{frequency} = \frac{1}{0.25 \times 10^{-9}} = 4\text{GHz.}$$

Hence, the correct answer is 4

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

A complete binary min - heap is made by including each integer in [1,1023] exactly once. The depth of a node in the heap is the length of the path from the root of the heap to that node. Thus, the root is depth 0. The maximum depth at which integer 9 can appear is _____ .

Solution:

There are 1023 elements i.e., 1,,1023. The maximum number of elements at depth ‘d’ in complete binary tree is $2^{d+1} - 1$

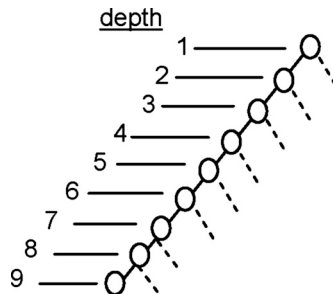
$$2^{d+1} - 1 = 1023$$

$$2^{d+1} = 1023 + 1$$

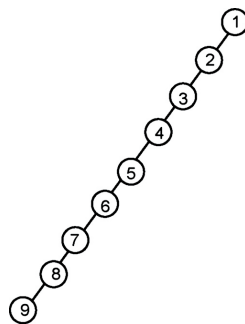
$$d+1 = 10$$

$$d = 9$$

There will be depth of 9 for min-heap of 1023 elements.



The longest path in min-heap is shown above, so the node 9 can be placed at depth 8.



Hence, the correct answer is 8

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

The following function computes X^Y for positive integers X and Y .

```
int exp (int X, int Y)
{
  int res = 1, a = X, b = Y;
  while (b! = 0)
  {
    if (b%2 == 0) {a = a*a; b = b/2;}
    else {res = res *a; b = b -1;}
  }
  return res;
}
```

Which one of the following conditions is **TRUE** before every iteration of the loop?

- (A) $X^Y = a^b$
- (B) $(res * a)^Y = (res * X)^b$
- (C) $X^Y = res * a^b$
- (D) $X^Y = (res * a)^b$

Solution:

$$X^Y = res * a^b$$

will be true before every iteration of the loop.

Hence, the correct answer is (C)

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

Consider the following New-order strategy for traversing a binary tree:

- Visit the root;
- Visit the right subtree using New - order;
- Visit the left subtree using New - order;

The New - order traversal of the expression tree corresponding to the reverse polish expression

$3\ 4\ * \ 5\ - \ 2\ ^ \ 6\ 7\ * \ 1\ + \ -$ is given by:

- (A) $+ - 1\ 6\ 7\ * \ 2\ ^ \ 5\ - \ 3\ 4\ *$
- (B) $- + 1\ * \ 6\ 7\ ^ \ 2\ - \ 5\ * \ 3\ 4$
- (C) $- + 1\ * \ 7\ 6\ ^ \ 2\ - \ 5\ * \ 4\ 3$
- (D) $1\ 7\ 6\ * \ + \ 2\ 5\ 4\ 3\ * \ - \ \wedge \ -$

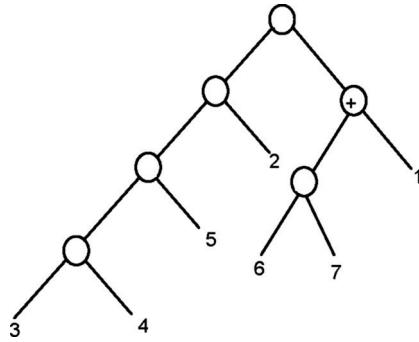
Solution:

Given post fix expression is

$$34 * 5 - 2 ^ 67 * 1 + -$$

The post fix expression is nothing but post order of the expression tree.

\therefore The expression tree of the above expression (given post order traversal) is



The new-order traversal for the above tree is
 $- + 1 * 7 6 ^ 2 - 5 * 4 3$

Hence, the correct option is (C)

Question Number: 37

Question Type: NAT

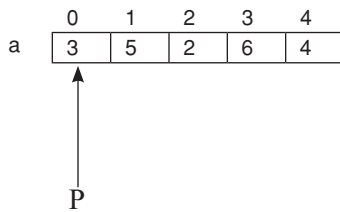
Consider the following program:

```
int f(int *p, int n)
{if (n <= 1) return 0;
else return max (f(p+1, n-1), p [0]-p [1] );
}
int main ()
{
int a[] = {3,5,2,6,4};
printf ("%d", f(a,5));
}
```

Note: $\max (x,y)$ returns the maximum of x and y .

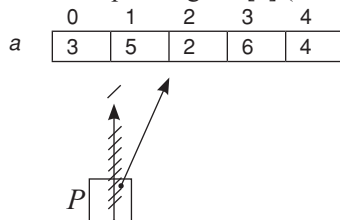
The value printed by this program is _____

Solution:



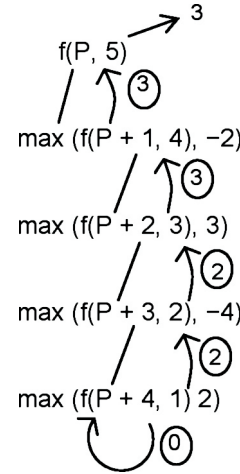
When P is pointing to a
 $P[0] = 3, P[1] = 5, P[2] = 2, P[3] = 6, P[4] = 4$

When P is pointing to $a[1]$ ($P \rightarrow P + 1$)



Then $P[0] = 5, P[1] = 2, P[2] = 6, P[3] = 4$
 $*P = P + 1$

Similarly, when $*P = P + 2$ and $*P = P + 3$



It prints 3.

Hence, the correct answer is 3

Question Number: 38

Question Type: MCQ

Let $A_1, A_2, A_3,$ and A_4 be four matrices of dimensions $10 \times 5, 5 \times 20, 20 \times 10,$ and $10 \times 5,$ respectively. The minimum number of scalar multiplications required to find the product $A_1 A_2 A_3 A_4$ using the basic matrix multiplication method is _____.

Solution:

- $A_1 = 10 \times 5$
- $A_2 = 5 \times 20$
- $A_3 = 20 \times 10$
- $A_4 = 10 \times 5$

Possible order of evaluation

- (i) $((A_1 \times A_2) \times A_3) \times A_4$
- (ii) $(A_1 \times A_2) \times (A_3 \times A_4)$
- (iii) $A_1 \times (A_2 \times (A_3 \times A_4))$
- (iv) $(A_1 \times (A_2 \times A_3)) \times A_4$
- (v) $A_1 \times ((A_2 \times A_3) \times A_4)$

(i) $A_1 \times A_2 = [\text{result 1}]_{10 \times 20} = 10 \times 5 \times 20 = 1000$
 $[\text{result 1}]_{10 \times 20} \times [A_3]_{20 \times 10} = [\text{result 2}]_{10 \times 10} = 10 \times 20 \times 10 = 2000$
 $[\text{result 2}]_{10 \times 10} \times [A_4]_{10 \times 5} = 10 \times 10 \times 5 = 500$

Total multiplications = $1000 + 2000 + 500 = 3500$

(ii) $A_1 \times A_2 = 1000$
 $A_3 \times A_4 = 20 \times 10 \times 5 = 1000$
 $[A_1 \times A_2]_{10 \times 20} * [A_3 \times A_4]_{20 \times 5} = 10 \times 20 \times 5 = 1000$
 Total multiplications = $1000 + 1000 + 1000 = 3000$

(iii) $A_3 \times A_4 = 1000$
 $[A_2]_{5 \times 20} \times [A_3 \times A_4]_{20 \times 5} = [\text{result 1}]_{5 \times 5} = 5 \times 20 \times 5 = 500$
 $[A_1]_{10 \times 5} \times [\text{result 1}]_{5 \times 5} = 10 \times 5 \times 5 = 250$
 Total multiplications = $1000 + 500 + 250 = 1750$

(iv) $A_2 \times A_3 = [\text{result 1}]_{5 \times 10} = 5 \times 20 \times 10 = 1000$
 $[\text{result 2}]_{10 \times 10} = [A_1]_{10 \times 5} \times [\text{result 1}]_{5 \times 10} = 10 \times 5 \times 10 = 500$

Question Number: 42 **Question Type: MCQ**

Consider the following two statements:

- I. If all states of an NFA are accepting states then the language accepted by the NFA is Σ^* .
- II. There exists a regular language A such that for all languages B, $A \cap B$ is regular.

Which one of the following is **CORRECT**?

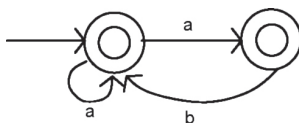
- (A) Only I is true
- (B) Only II is true
- (C) Both I and II are true
- (D) Both I and II are false

Solution:

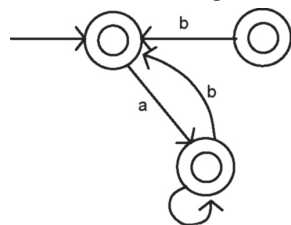
- I. If all the states of an NFA are accepting states then the language accepted by the NFA is Σ^* .

This is not always correct. (In some cases, where every transition is not included).

For example, consider below NFA.



The DFA equivalent to this NFA is given below:



This does not represent Σ^* .

\therefore I is false.

- II. There exists a regular language A such that for all languages B, $A \cap B$ is regular.

This statement is always correct.

Example: $A = \phi$ (A is regular)

$B = \{a^n b^n / n \geq 0\}$

$A \cap B = \phi$, which is regular.

For any B, $A \cap B = \phi$, which is regular.

\therefore II is correct.

Hence, the correct option is (B)

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

Consider the following languages:

$$L_1 = \{a^n b^m c^{n+m} : m, n \geq 1\}$$

$$L_2 = \{a^n b^n c^{2n} : n \geq 1\}$$

Which one of the following is TRUE?

- (A) Both L_1 and L_2 are context - free.
- (B) L_1 is context - free while L_2 is not context - free
- (C) L_2 is context - free while L_1 is not context - free.
- (D) Neither L_1 nor L_2 is context - free.

Solution:

Given languages:

$$L_1 = \{a^n b^m c^{n+m} : m, n \geq 1\}$$

$$L_2 = \{a^n b^n c^{2n} : n \geq 1\}$$

L_1 is context-free. The PDA can be designed which pushes a's, b's on stack and pops a's, b's for every c.

L_2 is not context-free.

$\{a^n b^n | n \geq 1\}$ is context-free.

But checking the equality of a's, b's with n c's is not possible with the stack memory of PDA.

Hence, the correct option is (B)

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

Consider the following languages.

$$L_1 = \{ \langle M \rangle \mid M \text{ takes at least 2016 steps on some input} \},$$

$$L_2 = \{ \langle M \rangle \mid M \text{ takes at least 2016 steps on all inputs} \} \text{ and}$$

$$L_3 = \{ \langle M \rangle \mid M \text{ accepts } \epsilon \}$$

where for each Turing machine M , $\langle M \rangle$ denotes a specific encoding of M . Which one of the following is TRUE?

- (A) L_1 is recursive and L_2, L_3 are not recursive
- (B) L_2 is recursive and L_1, L_3 are not recursive
- (C) L_1, L_2 are recursive L_3 is not recursive
- (D) L_1, L_2, L_3 are recursive

Solution: Given, $L_1 = \{ \langle M \rangle \mid M \}$ takes atleast 2016 steps on some input}.

L_1 is recursive. It is decidable. L_1 accepts strings which takes atleast 2016 steps on some input.

The machines says 'yes' for some input which has atleast 2016 steps, for other string it says 'no'.

$L_2 = \{ \langle M \rangle \mid M \}$ takes atleast 2016 steps on all inputs}

L_2 is decidable and so recursive.

Machines says 'yes' for all the strings which take atleast 2016 steps. And says 'no' for an input which has below 2016 steps.

L_3 is undecidable. Empty tape acceptance problem is undecidable, and so L_3 is not recursive.

Hence, the correct option is (C)

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

Which one of the following grammars is free from *left recursion*?

- (A) $S \rightarrow AB$
 $A \rightarrow Aa/b$
 $B \rightarrow c$
- (B) $S \rightarrow Ab/Bb/c$
 $A \rightarrow Bd/\epsilon$
 $B \rightarrow e$
- (C) $S \rightarrow Aa/B$
 $A \rightarrow Bb/Sc/\epsilon$
 $B \rightarrow d$
- (D) $S \rightarrow Aa/Bb/c$
 $A \rightarrow Bd/\epsilon$
 $B \rightarrow Ae/\epsilon$

Solution: The grammar is said to be left recursive if left most variable of right hand side of production is same as the variable at left hand side of production.

Hence, the correct option is (A)

$A \rightarrow Aa$ satisfies the definition of left recursion.

Option (C) and (D) Grammars simulates the definition of left recursive grammar.

Option (B) is free from left recursion.

Hence, the correct option is (B)

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

A student wrote two context - free grammars **G1** and **G2** for generating a single C-like array declaration. The dimension of the array is at least one.

For example, `int a [10] [3];`

The grammars use **D** as the start symbol, and use six terminal symbols `int`; `id [] num`.

Grammar **G1**

$D \rightarrow \text{int } L;$

$L \rightarrow \text{id } [E$

$E \rightarrow \text{num }]$

$E \rightarrow \text{num }] [E$

Grammar **G2**

$D \rightarrow \text{int}L;$

$L \rightarrow \text{id } E$

$E \rightarrow E [\text{num}$

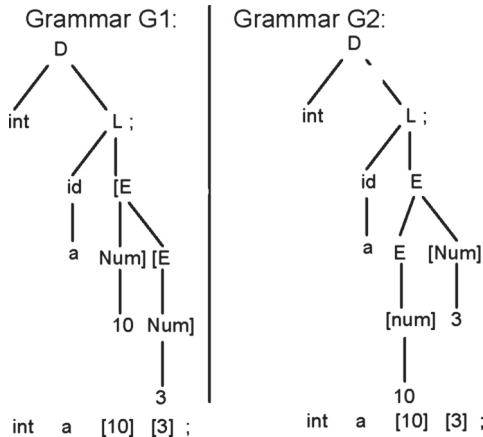
$E \rightarrow [\text{num}]$

Which of the grammars correctly generate the declaration mentioned above?

- (A) Both **G1** and **G2**
- (B) Only **G1**
- (C) Only **G2**
- (D) Neither **G1** nor **G2**

Solution:

`int a[10][3];`



Using both grammars G_1 and G_2 , we can generate the string `int a [10] [3] ;`

Hence, the correct option is (A)

Question Number: 47 **Question Type: MCQ**

Consider the following processes, with the arrival time and the length of the CPU burst given in milliseconds. The scheduling algorithm used is preemptive shortest remaining - time first.

| Process | Arrival Time | Burst Time |
|---------|--------------|------------|
| P_1 | 0 | 10 |

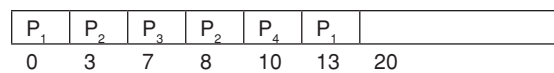
| | | |
|-------|---|---|
| P_2 | 3 | 6 |
| P_3 | 7 | 1 |
| P_4 | 8 | 3 |

The average turn around time of these processes is _____ milliseconds.

Solution:

| Process id | Arrival time | Burst time | Completion time | Turn around time |
|------------|--------------|------------|-----------------|------------------|
| P_1 | 0 | 10 | 20 | 20 |
| P_2 | 3 | 6 | 10 | 7 |
| P_3 | 7 | 1 | 8 | 1 |
| P_4 | 8 | 3 | 13 | 5 |

Gantt Chart:



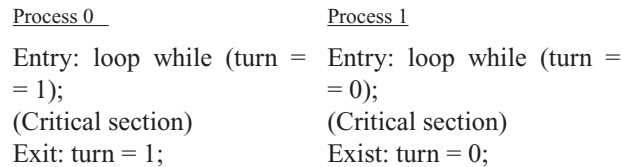
Turn around time (P_i) = Completion time (P_i) - Arrival time (P_i)

$$\text{Average T.A.T} = \frac{20+7+1+5}{4} = \frac{33}{4} = 8.25$$

Hence, the correct answer is (8.2 to 8.3)

Question Number: 48 **Question Type: MCQ**

Consider the following two - process synchronization Solution.



The shared variable `turn` is initialized to zero. Which one of the following is **TRUE**?

- (A) This is a correct two - process synchronization Solution.
- (B) This Solution violates mutual exclusion requirement.
- (C) This Solution violates progress requirement.
- (D) This Solution violates bounded wait requirement.

Solution:

Given processes are P_0 and P_1 . The above Solution guarantees the mutual exclusion principle. There can be only one process in critical section at any time (either process 0 or process 1). But it does not guarantee progress requirement.

Progress:
No process running outside the critical section should block the another process which is interested in executing critical section.

Let us consider the below scenario.

Initially turn = 0 (given in Solution) suppose P_0 and P_1 are in the system, now process P_0 is not interested in executing critical section (C.S), it is executing N.C.S (Non-Critical section).

Let P_1 is interested in executing C.S but it is not allowed in C.S as P_0 is blocking P_1 (\because turn = 0), Though C.S is free and P_0 is executing N.C.S.

P_1 gets chance only when P_0 complete its C.S and vice versa. The above Solution simulates strict alternation procedure. Therefore the above Solution doesn't guarantee progress.

Hence, the correct option is (C)

Question Number: 49 **Question Type: NAT**

Consider a non-negative counting semaphore S . The operation $P(S)$ decrements S , and $V(S)$ increments S . During an execution, 20 $P(S)$ operations and 12 $V(S)$ operations are issued in some order. The largest initial value of S for which at least one $P(S)$ operation will remain blocked is _____ .

Solution: During execution 20 $P(S)$ and 12 $V(S)$ operations are performed.

Counting semaphore:

After performing the $P(S)$ operations if the value of S is -1 then the process gets blocked

If $S = 0$ then the performing of down(S) ($P(S)$) operation by a process results in blocked state.

Let us consider the value of S as 0.

If 20 $P(S)$ and 12 $V(S)$ operations are performed on S in any order, it results in -8 .

We need to choose the value of S such that, the resulting value should be -1 (given atleast one process should be blocked after performing above operations)

So the value of S should be 7.

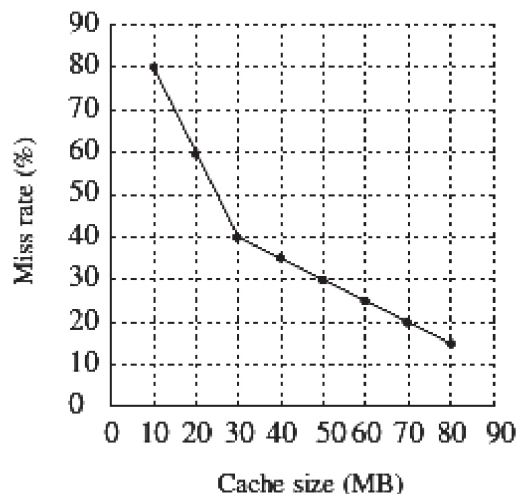
($\because -8 + 7 = -1$)

Hence, the correct answer is (7)

Question Number: 50 **Question Type: NAT**

A file system uses an in - memory cache to cache disk blocks. The miss rate of the cache is shown in the figure. The latency to read a block from the cache is 1 ms and to read a block from the disk is 10ms. Assume that the cost of checking whether a block exists in the cache is negligible. Available cache sizes are in multiples of 10MB.

The smallest cache size required to ensure an average read latency of less than 6 ms is _____ MB.



Solution:

Latency to read a block from cache = 1 ms

Latency to read a block from disk = 10ms

Checking whether a block exists in cache is negligible.

Required average read latency is less than 6ms.

Average access time = Hit ratio * cache access time + (1-Hit ratio) * (disk access time + cache access time)

Let, Hit ratio = H

$$6 = H * 1 + (1 - H) (10 + 1)$$

$$\Rightarrow 10H = 5$$

$$\Rightarrow H = \frac{1}{2} = 0.5 = 50\%$$

Hit ratio = 50%

$$\Rightarrow \text{Miss ratio} = 100\% - 50\% = 50\%$$

We need an average latency less than 6ms. So required miss rate will be 40%, whose cache size is 30MB.

Hence, the correct answer is (30)

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

Consider the following database schedule with two transactions T_1 and T_2 .

$$S = r_2(X); r_1(X); r_2(Y); w_1(X); r_1(Y); w_2(X); a_1; a_2$$

Where $r_i(Z)$ denotes a read operation by transaction T_i on a variable Z , $w_i(Z)$ denotes a write operation by T_i on a variable Z and a_i denotes an abort by transaction T_i .

Which one of the following statements about the above schedule is TRUE?

- (A) S is non - recoverable
- (B) S is recoverable, but has a cascading abort
- (C) S does not have a cascading abort
- (D) S is strict.

Solution:

| T1 | | T2 |
|----|----------|----------|
| 1. | | $r_2(X)$ |
| 2. | $r_1(X)$ | |

| | | |
|----|----------|----------|
| 3. | | $r_2(Y)$ |
| 4. | $w_1(X)$ | |
| 5. | $r_1(Y)$ | |
| 6. | | $w_2(X)$ |
| 7. | a_1 | |
| 8. | | a_2 |

There is no RW - conflict in the schedule, so it is recoverable.

- T_2 is not reading any data item which is updated by T_1 .
- Abort operation performed by T_1 does not give any effect to Abort operation performed by T_2 .
- So the abort operations are not cascading aborts.

Hence, the correct option is (C)

Question Number: 52 **Question Type: NAT**

Consider the following database table water_ schemes:

| water_ schemes | | |
|----------------|---------------|----------|
| scheme_no | District name | Capacity |
| 1 | Ajmer | 20 |
| 1 | Bikaner | 10 |
| 2 | Bikaner | 10 |
| 3 | Bikaner | 20 |
| 1 | Churu | 20 |
| 2 | Churu | 20 |
| 1 | Dungargarh | 10 |

The number of tuples returned by the following SQL query is _____ .

with total (name, capacity) as
select district _ name, **sum** (capacity)
from water _ schemes
group by district _ name
with total _ avg (capacity) as
select avg (capacity)
from total
select name
from total, total _ avg
where total . capacity \geq total_avg. capacity

Solution:

Total

| District-name | Sum(Capacity) |
|---------------|---------------|
| Ajmer | 20 |
| Bikaner | 40 |
| Churu | 30 |
| Dungargarh | 10 |

Total - avg:

| |
|----------------------|
| Avg(capacity) |
| 25 |

Select name

from total, total – avg

Where total . capacity \geq total - avg . capacity

| | |
|------------|----------------|
| Ajmer | $20 \geq 25$ ✗ |
| Bikaner | $40 \geq 25$ ✓ |
| Churu | $30 \geq 25$ ✓ |
| Dungargarh | $10 \geq 25$ ✓ |

Output:

| |
|-------------|
| Name |
| Bikaner |
| Churu |

Hence, the correct answer is (2)

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

A network has a data transmission bandwidth of 20×10^6 bits per second. It uses CSMA/CD in the MAC layer. The maximum signal propagation time from one node to another node is 40 microseconds. The minimum size of a frame in the network is ___ bytes.

Solution:

Given,

Transmission bandwidth of network

$$= 20 \times 10^6 \text{ bps}$$

Propagation time = 40 μ sec

Minimum size of frame in network = bandwidth * 2 * propagation delay

$$= 20 * 10^6 * 2 * 40 \times 10^{-6}$$

$$= 1600 \text{ bits}$$

$$= \frac{1600}{8} \text{ Bytes}$$

$$= 200 \text{ Bytes.}$$

Hence, the correct answer is (200)

Question Number: 54 **Question Type: MCQ**

For the IEEE 802.11 MAC protocol for wireless communication, which of the following statements is/ are **TRUE**?

- At least three non-overlapping channels are available for transmissions.
 - The RTS-CTS mechanism is used for collision detection.
 - Unicast frames are ACKed.
- (A) All I, II and III (B) I and III only
 (C) II and III only (D) II only

Solution:

For the IEEE 802.11 MAC protocol for wireless communication, atleast 3 non-overlapping channels are available.

RTS - CTS mechanism is used for collision avoidance, not for detection.

In 802.11, unicast frames are acknowledged.

\therefore Only I and III are true.

Hence, the correct option is (B)

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

Consider a 128×10^3 bits/second satellite communication link with one way propagation delay of 150 milliseconds. Selective retransmission (repeat) protocol is used on this link to send data with a frame size of 1 kilobyte. Neglect the transmission time of acknowledgement. The minimum number of bits required for the sequence number field to achieve 100% utilization is _____.

Solution:

Link bandwidth = $128 * 10^3$ bits/second

1-way propagation delay = 150 msec.

Frame size = 1KB

Link utilization = 100%

Link utilization of selective repeat protocol is

$$\text{Link utilization} = \frac{\text{window size}}{1 + 2 * a}$$

$$\text{Where } a = \frac{T_{\text{Propagation delay}}}{T_{\text{Transmission delay}}}$$

$$T_{\text{Propagation delay}} = 150 \text{ msec.}$$

$$128 * 10^3 \text{ bits} - 1 \text{ sec}$$

$$1 \times 1024 \times 8 \text{ bits} - \quad ?$$

$$T_{\text{Transmission delay}} = \frac{1024 \times 8}{128 \times 10^3} = 64 \text{ msec}$$

$$a = \frac{150}{64} = 2.34375$$

$$\text{Window size} = 1 * (1 + 2 * 2.34375) = 5.6875$$

In Selective Repeat, the sending and receiving window sizes must be equal and half the maximum sequence number.

$$2 * \text{window size} = \text{maximum sequence number}$$

$$\Rightarrow \text{Maximum sequence number} = 2 * 5.6875 = 11.375$$

\therefore Minimum number of bits required to generate this maximum sequence number is 4. ($\because 2^4 = 16 \approx 11.375$)

Hence, the correct answer is (4)