GATE 2023 [Forenoon Session] Computer Science Engineering

General Aptitude Part

Q.1 to Q.5 Carry One Mark Each

Question 1

We reached the station late, and _____ missed the train. **[Verbal Ability]**

(A) mostly (B) near

(C) utterly (D) nearly

Ans. (D)

Sol. **Given :** We reached the station late, and **nearly** missed the train.

Hence, the correct option is (D).

Question 2

Kind : _____ : : Often : Frequently **[Verbal Ability]**

(By word meaning)

(A) Type (B) Cruel

(C) Mean (D) Kindly

Ans. (A, D)

Sol. **Given :** Often is related with frequency. As often means, may times and frequently means continuously they both are related in same meaning with each other.

In the same way of relationship kind is related to type, as meaning of kind and type are same.

Option (B) cruel and option (C) mean cannot be related with kind according to the given relationship.

Option (D) kindly, cannot be related with kind as it does not satisfied the characteristics of given relationship.

Hence, the correct option is (A, D).

Question 3

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

(A) 4 (B) 8

(C) 5 (D) 9

Ans. (A)

Sol. **Given :**

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

Let $n = 2$,

$F_3 = F_2 + F_1$ …(i)

$F_4 = F_3 + F_2$ …(ii)

$F_5 = F_4 + F_3$ …(iii)

$F_6 = F_5 + F_4$ …(iv)

$F_7 = F_6 + F_5$ …(v)

For put the value of F_7 in equation (v), we get

$60 = 37 + F_s$

$F_s = 23$

Now, put the value of F_5 in equation (iv), we get

$F_6 = F_5 + F_4$

$37 = 23 + F_4$

$F_4 = 14$

Now, put value at F_4 is equation (iii), we get

$F_5 = F_4 + F_3$

$23 = 14 + F_3$

$F_3 = 9$

Now, put the value of F_3 in equation (ii), we get

$14 = 9 + F_2$

$F_2 = 5$

Now, put the value of F_2 in equation (i), we get

$F_3 = F_2 + F_1$

$9 = 5 + F_1$

$F_1 = 4$

Hence, the correct option is (A).

Question 4

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

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

[Numerical Ability]

(A) Less than half of pregnant women received medical care at least once from a doctor.

(B) More than half of pregnant women received medical care at least once from a doctor.

(C) Less than half of pregnant women received medical care at most once from a doctor.

(D) More than half of pregnant women received medical care at most once from a doctor.

Ans. (B)

Sol. **Given :** A survey for a certain year found that 90% of pregnant women received medical care at least once before giving birth of these women, 60% received medical from doctors.

With this given data option (A) can be inferred with certainty, as half of 90% will be 45% and from these 90%, 60% pregnant women received medical care from doctor, and 60% of 90% is 54% which is more then the percentage of half of pregnant women.

Hence, the correct option is (B).

Question 5

Looking at the surface of a smooth 3-dimensional object from the outside, which one of the following options is TRUE? **[Logical Reasoning]**

(A) The surface of the object may be concave in some places and convex in other places.

(B) The surface of object must be concave everywhere.

(C) The surface of object must be convex everywhere.

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

Ans. (A)

Sol. **Given :** We can combine the convex lens and the concave lens and the combined lens is called a convexo-concave or concavo-convex lens for which one side is convex and other side is concave. Since, convex and concave lenses are 3-dimensional object because each one is formed from two spheres (a three-dimensional object) and so the combined object is also a 3-dimensional object.

Hence, (B) and (C) are eliminated and (A) is correct.

Now, option (D), if you consider the edge as an straight line then for a finite three-dimensional object, option (D) is wrong because where at least two lines or straight edges meet, it creates a corner and according to the definition of smoothness, it should not have a sudden rise or fall and so it will not be a smooth object and so if edge means straight edges.

Hence, the correct option is (A).

Q.6 to Q.10 Carry Two Marks Each

Question 6

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

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

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

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

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

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

Ans. **(D)**

Sol. **Given :** The country of Zombieland is in distress since more than 75% of its working population is suffering from serious health issues.

Studies conducted by competent health experts conducted that a complete lack of physical exercise among its working population was one of the leading cause of their heath issues.

According to this information the government of Zombieland has to take action for the physical fitness of its working population.

So, they decided to provide monetary incentives to those who ride bicycles to work.

Therefore, we can say the government of Zombieland believes that riding bicycles is a form of physical exercise.

Hence, the correct option is (D).

Question 7

Consider two functions of time (t),

$f(t) = 0.01t^2$

$g(t) = 4t$

Where $0 < t < \infty$.

Now consider the following two statements :

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

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

Which one of the following options are TRUE?

[Engineering Mathmatics Calculus, Logical Reasoning]

(A) only (ii) is correct (B) both (i) and (ii) are correct

(C) neither (i) nor (ii) is correct (D) only (i) is correct

Ans. **(B)**

Sol. **Given :** Two functions of time (t),

$f(t) = 0.01t^2$

$g(t) = 4t$

Where $0 < t < \infty$.

Statements (i), for some $t > 0$, $g(t) > f(t)$ is true.

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

Hence, $g(t) > f(t)$ for some $t = 1$.

Statement (ii), there exists a T, such that $f(t) > g(t)$ for all $t > T$. There exist $T = 400$ such that $f(t) > g(t) \forall t > 400$, it is true.

Here, both statement (i) and (ii) are correct.

Hence, the correct option is (B).

Question 8

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

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

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

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

(iv) He was leaning against the parapet, watching the traffic below. **[Verbal Ability]**

(A) (iv), (ii), (i), (iii) (B) (iii), (ii), (i), (iv)

(C) (ii), (iii), (i), (iv) (D) (i), (ii), (iv), (iii)

Ans. (B)

Sol. **Given :**

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

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

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

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

We will make pair of two sentence for the sequences which creates a coherent narrative.

The pairs will be (iii) and (ii) which gives a meaningful narrative in the same way (i) and (iv).

According to the options, sequence in option (B) will give best coherent meaning.

Hence, the correct option is (B).

Question 9

$f(x)$ and $g(y)$ are functions of x and y, respectively, and $f(x)=g(y)$ for all real values of x and y.

Which one of the following options is necessarily TRUE for all x and y?

[Logical Reasoning, Engineering Mathematics Calculus]

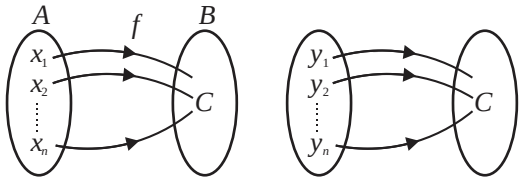
(A) $f(x)=0$ and $g(y)=0$ (B) $f(x)=g(y)=\text{constant}$

(C) $f(x)\neq$ constant and $g(y)\neq$ constant (D) $f(x)+g(y)=f(x)-g(y)$

Ans. (B)

Sol. **Given :** $f(x)$ and $g(x)$ are functions of x and y and $f(x)=g(y)$ for all real values of x and y.

Here, for all values of x and y it is necessary that image of 'x' under f is same as image at 'y' is same as image of 'y' using 'g' for all real values of x and y i.e. $f(x)=g(y)=\text{Constant}$.



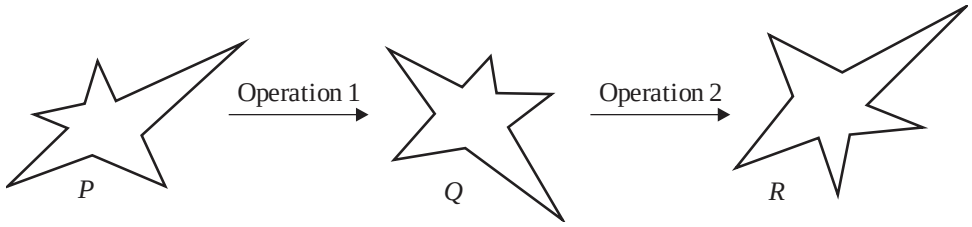
$f(x)=g(y)\forall y\in R$

Hence, the correct option is (B).

Question 10

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

[Spitial Aptitude]



(A) **Operation 1 :** A clockwise rotation by 90^0 about an axis perpendicular to the plane of the figure.
Operation 2 : A reflection along a vertical line.

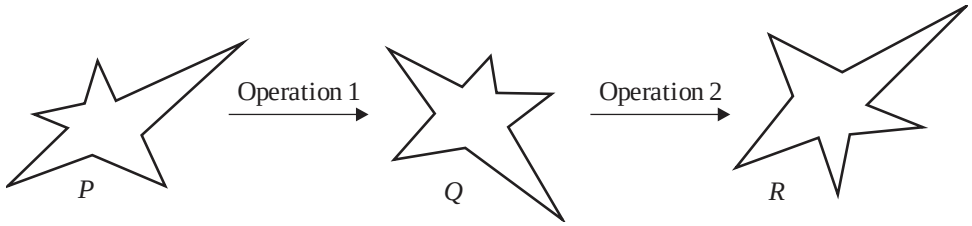
(B) **Operation 1 :** A clockwise rotation by 90^0 about an axis perpendicular to the plane of the figure
Operation 2 : A reflection along a horizontal line

(C) **Operation 1 :** A counter clockwise rotation by 90^0 about an axis perpendicular to the plane of the figure.
Operation 2 : A reflection along a horizontal line

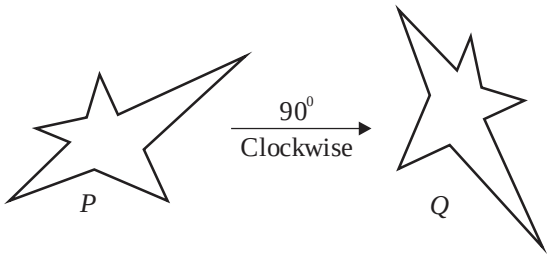
(D) **Operation 1 :** A counter clockwise rotation by 180^0 about an axis perpendicular to the plane of the figure.
Operation 2 : A reflection along a vertical line.

Ans. (B)

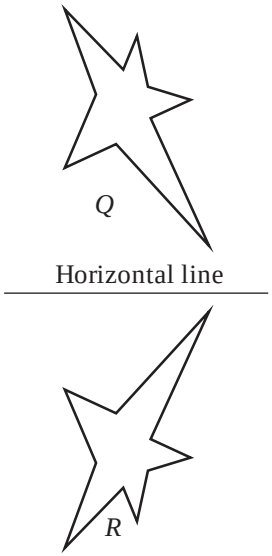
Sol. **Given :** The transformation of the 2-dimensional figure P to Q, and then to R as shown in below figure,



We can clearly see from P to Q, operation 1 is a clockwise rotation by 90^0 about an axis perpendicular to the plane of the figure.



Form Q to R, operation 2 is a reflection along a horizontal line.



Hence, the correct option is (B).

Technical Part

Q.1 to Q.25 Carry One Mark Each

Question 1

Consider the following statements regarding the front-end and back-end of a compiler. S1: The front-end includes phases that are independent of the target hardware.

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

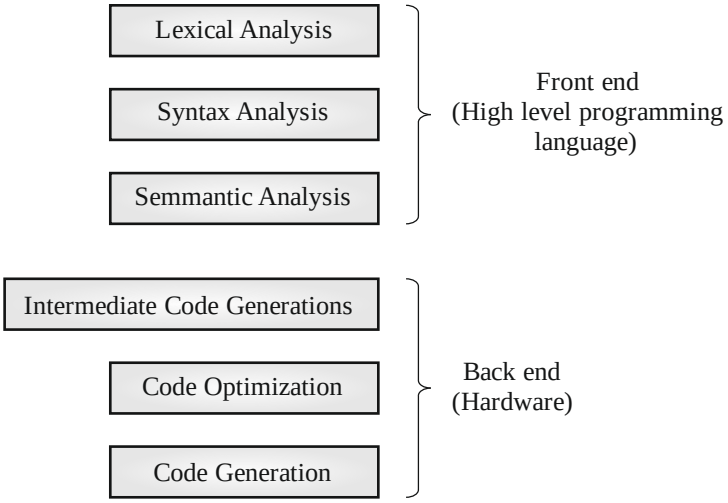
S3: The back-end includes phases that are specific to the programming language used in the source code.

Identify the CORRECT option **[Complier Design, Lexical Analysis]**

(A) Only S1 is TRUE.
(B) Only S1 and S2 are TRUE
(C) S1, S2, and S3 are all TRUE
(D) Only S1 and S3 are TRUE

Ans. (B)

Sol.



S1 : The front end or analysis phase consists of lexical, syntax and semantic analysis.

It takes source language and produces intermediate code representation. It is independent of target hardware. So, S1 is true.

S2 : The bock-end or synthesis phase consists of code optimization and target code generation phases which takes intermediate code and generates target code as output. It is dependent on target hardware. S2 is true.

S3 : Back-end phase is independent of source program as its task is to convert the intermediate code to target code. S3 is false.

Hence, the correct option is (B).

Question 2

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

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

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

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

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

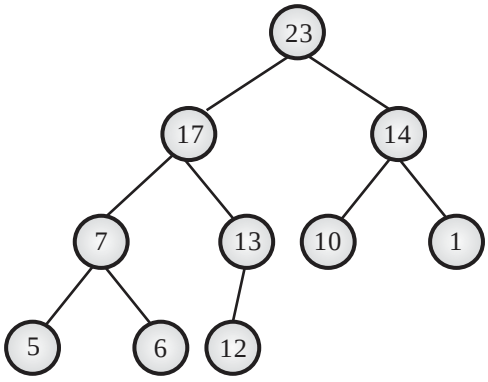
Ans. (B)

Sol. Here, we have to check all options for finding which one satisfies property of max-heap. i.e.

(i) Heap is a complete binary Tree

(ii) Parent element is always greater than child element value.

Upon checking only



Hence, the correct option is (B).

Question 3

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

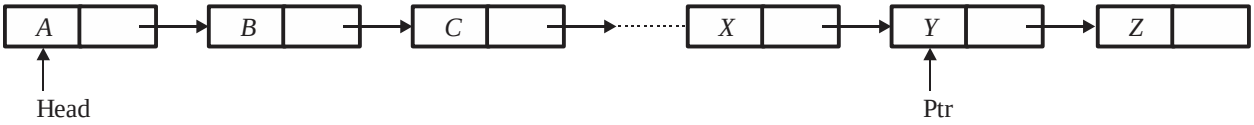
Let *n* denote the number of nodes in each of the linked lists. Which one of the following choices is TRUE about the worst-case time complexity of SLLdel and DLLdel ?

[Data Structure, Linked List]

(A) SLLdel is $O(1)$ and DLLdel is $O(n)$
(B) Both SLLdel and DLLdel are $O(\log(n))$
(C) Both SLLdel and DLLdel are $O(1)$
(D) SLLdel is $O(n)$ and DLLdel is $O(1)$

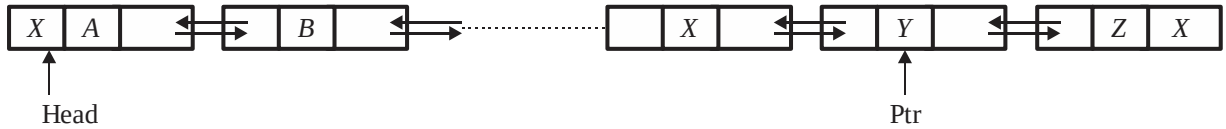
Ans. (D)

Sol. Given a single linked list SLL:



Here, were given head pointer and ptr pointer of the node to be deleted (Here y) We have to traverse from head node till node before the one pointed by ptr (here X) which take $O(n)$ time in worst case.

Given a doubly linked list DLL:



Simply we can do it as:

ptr $\rightarrow$prev $\rightarrow$next = ptr $\rightarrow$ next

ptr $\rightarrow$next $\rightarrow$prev= ptr $\rightarrow$prev

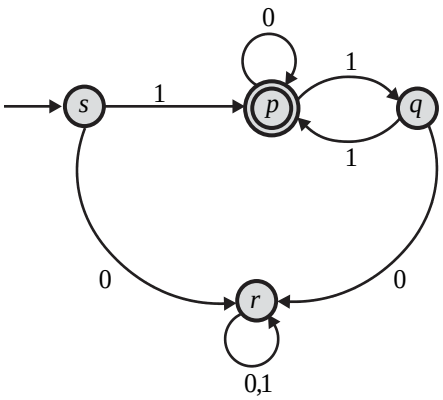
delete (ptr)

since it can be performed in $O(1)$ time:

Hence, the correct option is (D).

Question 4

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



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

[Theory of Computation & Finite Automata]

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

(C) $1(0+11)*$ (D) $1(110*)*$

Ans. (C)

Sol. **Method 1**

The given DFA generate strings like:

$\Sigma = \{1,10,110,100,1011,1000....\}$

So, start with 1 to reach final state from where wave two choices os $(0+11)^*$

Hence R.E. is $1(0+11)^*$.

Checking options:

(a) Dosen't generate 10

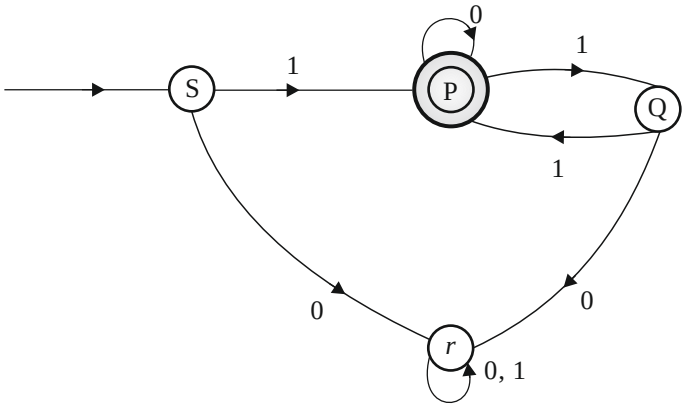
(b) Dosen't generate any os it starts with 0.

(d) Dosen't generate 10.

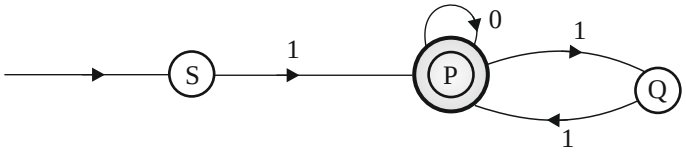
Hence, the correct option is (C).

Method 2

Given DFA shown below



Since state *r* is the dead state. So it can be removed.



Required Regular Expression

$= 1(0+11)*$

Question 5

The Lucas sequence L_n is defined by the recurrence relation :

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

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

Which one of the options given is TRUE? **[Discrete Mathematics & Combinatorics]**

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

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

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

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

Ans. **(A)**

Sol. **Method 1**

Lucas sequence

Put $n = 1$ in option we will get

$$l_1 = \frac{1+\sqrt{5}}{2} + \frac{1-\sqrt{5}}{2} = \frac{2}{2} = 1$$

given that $l_1 = 1$

Put $n = 2$ in option we will get

$$l_2 = \left(\frac{1+\sqrt{5}}{2}\right)^2 + \left(\frac{1-\sqrt{5}}{2}\right)^2 = 2\left(\frac{1}{4} + \frac{5}{4}\right) = 2\left(\frac{6}{4}\right) = 3$$

Given that $l_2 = 3$

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

Hence, the correct option is (A).

Method 2

Given that

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

By replacing 'n' by $(n+2)$ we have

$$L_{n+2} - L_{n+1} - L_n = 0 \qquad \ldots \text{(i)}$$

Characteristic Equation for Equation (i)

$$P^2 - P - 1 = 0$$

Characteristic ROOT

$$P = \frac{1 \pm \sqrt{5}}{2}$$

$\therefore$ Homogeneous function

$$c_1 p_1^n + c_2 p_2^n$$

$$L_n = c_1\left(\frac{1+\sqrt{5}}{2}\right)^n + c_2\left(\frac{1-\sqrt{5}}{2}\right)^n \quad \ldots \text{(ii)}$$

Put $n = 1$

$$L_1 = c_1\left(\frac{1+\sqrt{5}}{2}\right)^1 + c_2\left(\frac{1-\sqrt{5}}{2}\right)^1 \quad \ldots \text{(iii)}$$

$$1 = c_1\left(\frac{1+\sqrt{5}}{2}\right) + c_2\left(\frac{1-\sqrt{5}}{2}\right)$$

Put $n = 2$

$$L_2 = c_1\left(\frac{1+\sqrt{5}}{2}\right)^2 + c_2\left(\frac{1-\sqrt{5}}{2}\right)^2 \quad \ldots \text{(iii)}$$

$$3 = c_1\left(\frac{1+\sqrt{5}}{2}\right)^2 + c_2\left(\frac{1-\sqrt{5}}{2}\right)^2 \quad \ldots \text{(iv)}$$

Solving equation (iii) and equation (iv)

$$c_1 = 1, \quad c_2 = 1$$

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

Question 6

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

[Database, ER Model]

(A) Number of attributes of its relation schema.
(B) Number of tuples stored in the relation.
(C) Number of entries in the relation.
(D) Number of distinct domains of its relation schema.

Ans. (A)

Sol. By definition: " The degree of relation is the number of attributes it contains".
Hence, the correct option is (A).

Question 7

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

[Computer Network & Datalink Layer]

(A) Longer link length and lower transmission rate
(B) Longer link length and higher transmission rate
(C) Shorter link length and lower transmission rate
(D) Shorter link length and higher transmission rate

Ans. (B)

Sol. Transmission Time $(T_t) = \dfrac{\text{Length of Packet (L)}}{\text{Band width (B.W)}}$

Propagation Time $(T_p) = \dfrac{\text{Link Length (D)}}{\text{Speed (V)}}$

Link Utilisation = Efficiency $= \dfrac{T_t}{T_t + 2T_p} = \dfrac{L/Bw}{\dfrac{L}{Bw} + 2\left(\dfrac{D}{V}\right)} = \dfrac{L}{Bw\left(T_t + 2\dfrac{D}{V}\right)}$

So, Efficiency $\propto \dfrac{1}{D\,(\text{Link Length})}$

Also, Transmission rate = Band width and Efficiency $\propto \dfrac{1}{Bw}$

For low utilization, we need longer link length and higher transmission rate.
Hence, the correct option is (B).

Question 8

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

Let det(A) and det(B) denote the determinants of the matrices A and B, respectively.
Which one of the options given below is TRUE?

[Engineering Mathematics, Linear Algebra]

(A) det(A) = det(B)
(B) det(B) = −det(A)
(C) det(A)=0
(D) det(AB) = det(A) + det(B)

Ans. (B)

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

$R_1 \leftrightarrow R_3$

det B = – det A

Hence, the correct option is (B).

Question 9

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

Letter $\rightarrow [A-Za-z]$

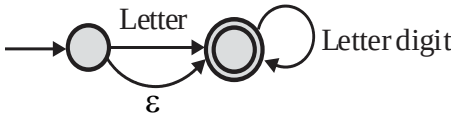
Digit $\rightarrow [0-9]$

id $\rightarrow$ letter (letter/digit)*

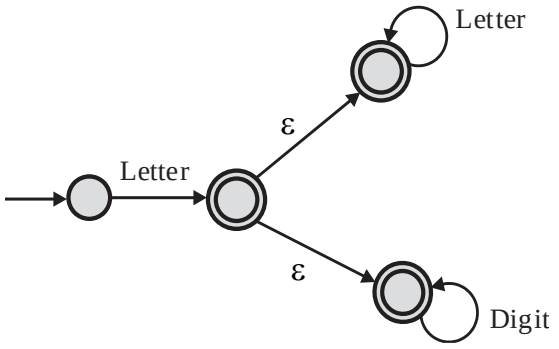
Which one of the following Non - deterministic. Finite - state Automate with $\in$- transitions accepts the set of valid identifiers? (A double-circle denotes a final state)

[Theory of Computation, Finite Automata]

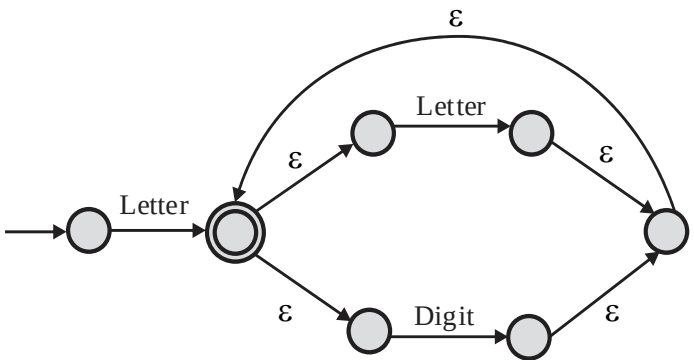
(A)



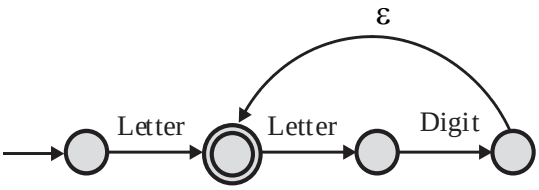
(B)



(C)



(D)



Ans. (C)

Sol. The regular expression is:

Letter (letter + digit)*.

Given : Grammar

Letter $\rightarrow$ [A-Z, a-z]

Digit $\rightarrow$ [0-9]

Id $\rightarrow$ Letter (letter/digit)*

Valid Identifier should start with letter and followed by either letter or digit

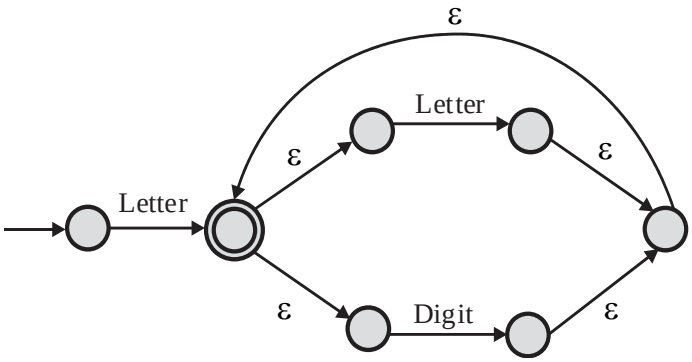
Regular expression (RE) = Letter (letter + digit)*

A. First option is wrong because as per NFA given identifier can be start with digit.

B. Second option is wrong because this NFA gives identifier as

Letter (letter)* OR Letter (digit)*

C. Third option is correct it gives correct Regular expression as per given grammar.



D. Fourth option is wrong because this NFA does not accept regular expression,

Letter (Letter)*

Hence, the correct option is (C).

Question 10

An algorithm has to store several keys generated by an adversary in a hash table. The adversary is malicious who tries to maximize the number of collisions. Let *k* be the number of keys, m be the number

of slots in the hash table, and $k > m$. Which one of the following is the best hashing strategy to counteract the adversary? **[Data Structure, Hashing]**

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

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

(C) Universal hashing method

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

Ans. (C)

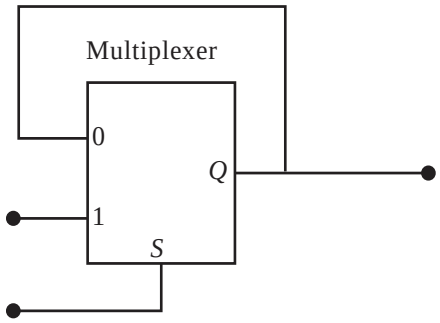
Sol. Here, the attacker is trying to maximize collision and to minimize it we have to use a method that randomly assigns keys to the slots. So option "C"- Universal hasting is best.

The only effective way to improve the situation is to choose the Hash function Randomly in such a way that is independent of the key that are actually going to be stored this approach is called universal hashing.

Hence, the correct option is (C).

Question 11 (Digital Electronics)

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



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

[Digital Logic, Combinational Circuits]

(A) D Flip-flop

(B) D Latch

(C) Half-adder

(D) Demultiplexer

Ans. (B)

Sol. **Method 1**

The output equation of above 2×1 mux is:

$V = \overline{S}\, I_0 + S.I_1$

So, when S = 0

$Y = I_0 = Q$, the previous state value

When S = 1

$Y = I_1$, (Output = Input)

Thus, it is D, Latch

Hence, the correct option is (B).

Method 2

$$Q_{n+1} = \overline{S}Q_n + SQ_n$$

$$Q_{n+1} = Q_n(\overline{S} + S)$$

$$Q_{n+1} = Q_n$$

Output is same as the input Q_{n+1} is generated after delay.

Hence, the correct option is (B).

Question 12

Which one or more of the following need to be saved on a context switch from one thread (T1) of a process to another thread (T2) of the same process? **[Operating System, Memory Management Virtual table]**

(A) Page table base register
(B) Stack pointer
(C) Program counter
(D) General purpose registers

Ans. (B), (C), (D)

Sol. (A) Page Table Base Register holds base address of page table for currently executing thread since, thread switch between same process so there's no need of updation:

(B) Each thread has its own stack. So stack painter needs to be saved.

(C) PC register contains address of next instruction to be executed by current thread. So it needs to be saved when switch occurs.

(D) These registers are used to store temporary data during thread execution and needs to be saved before thread switches.

Hence, the correct options are (B), (C) & (D).

Question 13

Which one or more of the following options guarantee that a computer system will transition from user mode to kernel mode? **[Operating System, Process Management I]**

(A) Function Call
(B) malloc Call
(C) Page Fault
(D) System Call

Ans. (C), (D)

Sol.
- Function calls and malloc calls do not necessarily result in transition to kernel mode.
- System call guarantees that computer system will transition from user mode to kernel mode as using system calls a user requests services from OS and transition from user mode to kernel mode.
- Page fault occures when program requests access of page not currently in memory (Physical memory) so, OS needs to handle page fault and may need to allocate physical memory.

Hence, the correct options are (C) & (D).

Question 14

Which of the following statements is/are CORRECT?

[Theory of Computation, Properties of Languages]

(A) The intersection of two regular languages is regular.
(B) The intersection of two context-free languages is context-free.
(C) The intersection of two recursive languages is recursive.

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

Ans. **(A), (C), (D)**

Sol. Intersection options are closed under Regular Language, Recursive Language and Recursively Enumerable Language.

For Context free Language

Let $L_1 = a^n b^n c^m / m,n \geq 0$ and $L_2 = a^m b^n c^n / m,n \geq 0$

Both L_1 and L_2 are CFL languages.

But $L_1 \cap L_2 = a^n b^n c^n / n \geq 0$ is a non-CFL language

So (B) is False

Hence, the correct options are (A), (C) & (D).

Question 15

Which of the following statements is/are INCORRECT about the OSPF (Open Shortest Path First) routing protocol used in the Internet? **[Algorithm, Greedy Algorithm]**

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

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

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

(D) OSPF implements hierarchical routing.

Ans. **(A), (C)**

Sol. OSPF uses Dijkstra's algorithm to compute the shortest path tree for each route, the cost of a route is calculated by gathering link state information from available routers.

Also, OSPF is hierarchical routing protocol, using are 0 (autonomous system) at top of hierarchy.

So, A and C are False.

Hence, the correct options are (A) & (C).

Question 16

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

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

where P is a statement about integers, and Q is a statement about pairs of integers. Which of the following (one or more) option(s) would imply Geetha's conjecture?

[Discrete Mathematics, Mathematical Logic]

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

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

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

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

Ans. **(B), (C)**

Sol. Here, domain is set of integers, So Elements

$x, y \, E\{\ldots.-3,-2,-1,0,1,2,\ldots..\}$

Expression $E = \forall x\{P(x) \Rightarrow \exists_y Q(x,y)\}$

Which says if x is P then ' always exists a y such such that Q (x,y).

Now, checking options.

For option (A) :

$$\text{Is} \frac{\exists[P(x)] \wedge \forall_y \theta(x,y)}{\text{LHS}} \rightarrow \frac{E}{\text{RHS}} \text{True?}$$

Here, for LHS to be true. Say there exists an $x = (6)$ for which $p(x) = p(c) =$ True and for all $y\theta(6, y)$ is True.

Now, RHS : $E = \forall x < \frac{p(x)}{A} \Rightarrow \frac{\exists y 2(x,y)}{B}$

$A =$ True for say $x = 7$, so $p(7) =$ True

For B, say there doesn't exist any y such that $Q(7, y) =$ True. Hence $A \Rightarrow B$

$T \Rightarrow F$ is false.

So, its case of True $\Rightarrow$ False as LHS is True and A

RHS is False

Therefore it becomes case of True $\rightarrow$ False and eventually its False:

For option (B) :

$$\frac{\forall x \forall y Q(x,y)}{LHS} \rightarrow \frac{E}{RHS} \text{ True?}$$

Here, LHS is True for all values of x and y.

Now Ans: $E = \forall x \frac{[P(x)]}{A} \Rightarrow \frac{\exists y Q(x,y)]}{B}$

Now, since,

$\forall x \forall y Q(x,y) =$ True.

$\exists y Q(x,y) =$ True too.

So, For $A \Rightarrow B$

A $\Rightarrow$ True is always True.

As RHS is True. Its case of

True $\rightarrow$ True which is true.

For option (C) :

$$\rightarrow \frac{\exists y \forall x[P(x) \Rightarrow Q(x,y)]}{\text{LHS}} \rightarrow \frac{E}{RHS} \text{ True?}$$

For LHS to be true, there exists some y say y = 2 for which for all x which are satisfying property p implies property Q (x,y)

Now, RHS: = $E = \forall x \left[\frac{P(x)}{A} \Rightarrow \frac{\exists y Q(x,y)}{B} \right]$

$B = \exists y Q(x,y)$ is always, true as there exists at least one y (we assumed y = 2) such that $\forall x Q(x,2)$ is True. So B is true

The case becomes $A \Rightarrow B$

$A \Rightarrow$ True which is true

So, L.H.S $\rightarrow$ R.H.S. is true.

For Option (D) :

$$\frac{\exists \times [P(x) \wedge \exists y 2(x,y)]}{\text{LHS}} \rightarrow \frac{E}{RHS} \text{ True?}$$

For LHS to be true, assume $x = 6$ for which properly $P(6)$ is true and there exists a y assume $y = 2$ such that $Q(6,2)$ is true.

Now, RHS $= E = Vx\left[\frac{P(x)}{A} \Rightarrow \frac{\exists y Q(x,y)}{B}\right]$

Say $x = 3$ and $P(x) =$ True

But there exists no y for $Q(3, y)$ to be true.

Hence, it becomes $A \Rightarrow B$

True $\Rightarrow$ False so RHS is False

Also, it becomes case of True $\rightarrow$ False which is false.

Hence, the correct options are (B) & (C).

Question 17

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

[Operating System, Process Management II]

(A) First-in First-Out
(B) Round Robin
(C) Priority Scheduling
(D) Shortest Job First

Ans. (A), (C), (D)

Sol.

- SJF and priority scheduling are prone to starvation as for SJF the shorter jobs might keep coming and longer burst time jobs have to keep waiting.
- Also, for priority scheduling the higher priority job might keep coming causing lower priority jobs to starve.
- Round Robin never cause starvation as every job gets a fixed time quantum to execute, which is finite and evry job get time for execution.
- For FCFS, in case of infinite loop like
  while (1);
  then it cause starvation
  so until there's special case of a task running forever there will be no starvation.

Hence, the correct options are (A), (C) & (D).

Question 18

Let $f(x) = x^3 + 15x^2 - 33x - 36$ be a real-valued function. Which of the following statements is/are TRUE?

[Engineering Mathematics, Calculus]

(A) $f(x)$ does not have a local maximum.
(B) $f(x)$ has a local maximum.
(C) $f(x)$ does not have a local minimum.
(D) $f(x)$ has a local minimum

Ans. **B, D**

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

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

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

$f'(x)=0$

$3x^2+30x-33=0$

$x^2+10x-11=0$

$(x+11)(x-1)=0$

$x=-11,\ x=1$

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

at $x=-11$

$f''(-11)=-66+30$

$=-36<0$

Local maxima

at $x=1$

$f''(1)=6+30$

$=36>0$

Local minima

$\therefore$ $f(x)$ has a local maximum.

$\therefore$ $f(x)$ has a local minimum.

Hence, the correct options are B and D.

Question 19

Let f and g be functions of natural numbers given by $f(n) = n$ and $g(n) = n^2$. Which of the following statements is/are TRUE? **[Algorithm, Complexity Analysis & Asymptotic notation]**

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

(C) $f \in o(g)$ (D) $f \in \theta(g)$

Ans. **(A), (C)**

Sol. Given, $F(n)=n$ and $g(n)=n^2$

(a) $F \in o(g)$ (Big$-oh$)

$F(n) \le c_1 g(n)$

$n \le c_1 n^2$ $\quad c_1 = 1$

$n \le n^2$ True

(b) $F \in \Omega(g)$ (omega)

$F(n) \ge c_2 g(n)$

$n \geq c_2 \cdot n^2$ False

Not any constant possible to bound variable functions.

(c) $F \in 0(g)$ (small-oh or little-oh)

$F(n) < c_3(g(n))$

$n < c_3 n^2$ $\quad c_3 = 1$

$n < n^2$ True

(d) $F \in \theta(g)$ (theta notation)

$F = \theta(g) \Leftrightarrow (F(n) \leq c_1 g(n))$ AND $(F(n) \geq c_2 g(n))$

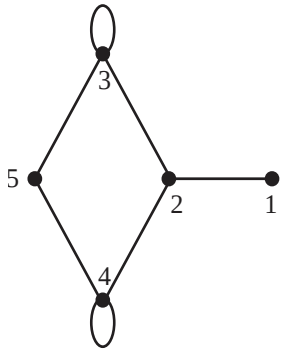
$(n \leq c_1 n^2)$ AND $(n \geq c_2 n^2)$

= True AND False = False

Hence, the correct options are (A) & (C).

Question 20

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



Let λ1, λ2, λ3, λ4, and λ5 be the five eigenvalues of A. Note that these eigenvalues need not be distinct. The value of λ1 + λ2 + λ3 + λ4 + λ5 = _____. **[Discrete Mathematics, Graph Theory]**

Ans. 2

Sol.

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

Sum of Eigen values,

$\lambda_1+\lambda_2+\lambda_3+\lambda_4+\lambda_5=T_r(A)$

= 0 + 0 + 1 + 1 +0

= 2

Hence, the correct answer is 2

Question 21

The value of the definite integral $\int_{-3}^{3}\int_{-2}^{2}\int_{-1}^{1}(4x^2y-z^3)\,dz\,dy\,dx$ is_____. (Rounded off to the nearest integer) **[Engineering Mathematics, Calculus]**

Ans. 0

Sol. $I=\int_{-3}^{3}\int_{-2}^{2}\int_{-1}^{1}(4x^2y-z^3)dz\,dy\,dx$

$I=\int_{-3}^{3}\int_{-2}^{2}\int_{-1}^{1}(4x^2ydzdydx)-\int_{-3}^{3}\int_{-2}^{2}\int_{-1}^{1}(z^3dz)dydx$

$I=\int_{-3}^{3}\int_{-2}^{2}4x^2y(z)_{-1}^{1}dydx-(0)$

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

$I=\int_{-3}^{3}8x^2\left(\int_{-2}^{2}ydy\right)dx$

$I=\int_{-3}^{3}8x^2(0)dx=0$

Hence, the correct answer is 0.

Question 22

A particular number is written as 132 in radix-4 representation. The same number in radix-5 representation is_____. **[Digital Logic, Number System]**

Ans. 110

Sol. **Given :** $(132)_4=(1\times4^2+3\times4'+2\times4^0)_{10}$

$=16+12+2=(30)_{10}$ (Power of 5)

5	30	
5	6	0
	1	1

$=(110)_5$

$=(110)_5$

Hence, the correct answer is 110.

Question 23

Consider a 3-stage pipelined processor having a delay of 10 ns (nanoseconds), 20 ns, and 14 ns, for the first, second, and the third stages, respectively. Assume that there is no other delay and the processor does not suffer from any pipeline hazards. Also assume that one instruction is fetched every cycle. The total execution time for executing 100 instructions on this processor is _____ ns.

[Computer Organization & Architecture, Instructions and Addressing Format]

Ans. 2040

Sol. Given delays 10ns, 20 ns, 14 ns

There's no buffer delay or hazard and one instruction is fetched every cycles.

Total instruction $(n)=100$

Pipeline delay $(T_p)=\max(10,20,14)=20\,\text{ns}$

Number of stages $(k)=3$

So, total execution time, $T=[k+(n-1)]\times T_p$

$=(3+100-1)\times 20$

$=2040$ ns

Hence, the correct answer is 2040.

Question 24

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

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

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

[Computer Organization & Architecture, Input Output Organization]

Ans. 10.2

Sol. Computer system polls keyboard every 10 ms.

In one second, it polls $\frac{1\text{s}}{10\,\text{ms}}=\frac{1000\,\text{ms}}{10\,\text{ms}}=100\,\text{times}$

Each poll take $100\,\mu s$

So, total polling time $=100\times 100\,\mu s=10\times 10^3\,\mu s=10\,\text{ms}$

Also, it takes $200\,\mu s$ for processing keystroke i.e. 0.2 ms

Total time spent in polling,

$T_1=(10+0.2)\,\text{ms}=10.2\,\text{ms}$

In interrupt system, when there's keystroke CPU executes corresponding interrupt service routine i.e. ISR taking 1 ms. so, $T_2 = 1\text{ms}$

Now, $\frac{T_1}{T_2} = \frac{10.2\,\text{ms}}{1\text{ms}} = 10.2$

Hence, the correct answer is 10.2.

Question 25

The integer value printed by the ANSI-C program given below is_____.

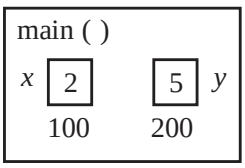
```
#include<stdio.h>
int funcp(){
    static int x = 1;
    x++;
    return x;
}
int main(){
    int x,y;
    x = funcp();
    y = funcp()+x;
    printf("%d\n", (x+y));
    return 0;
}
```

[C Program]

Ans. 7

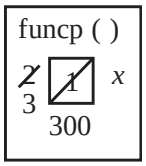
Sol. x in funcp( ) is static persists. It's value across the function call

i. $x = \text{funcp}()$



ii. $y = \text{funcp}( ) + x;$

$3 + 2 = 5$



iii. Printf ("%d\n", (x + y)); 2 + 5 = 7

Hence, the correct answer is 7.

Q.26 to Q.55 Carry Two Marks Each

Question 26

Consider the following program :

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

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

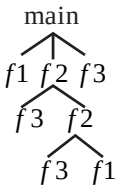
```
int f2(int X)
{
    f3();
    if (X==1)
        return f1();
    else
        return (X*f2(X-1));
}
```

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

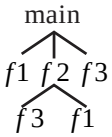
Which one of the following options represents the activation tree corresponding to the main function?

[Algorithm, Complexity Analysis & Asympotic]

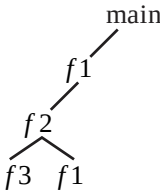
(A)



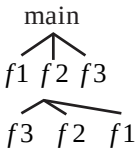
(B)



(C)

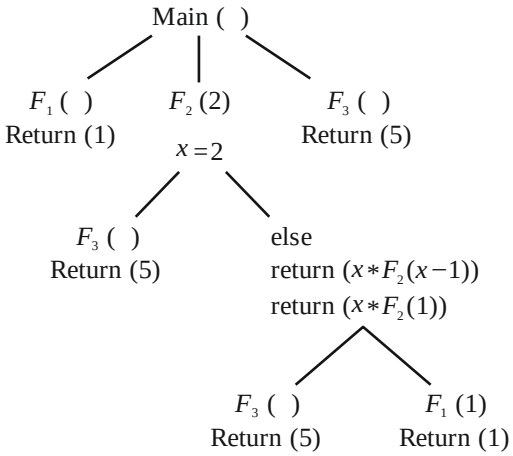


(D)



Ans. **(A)**

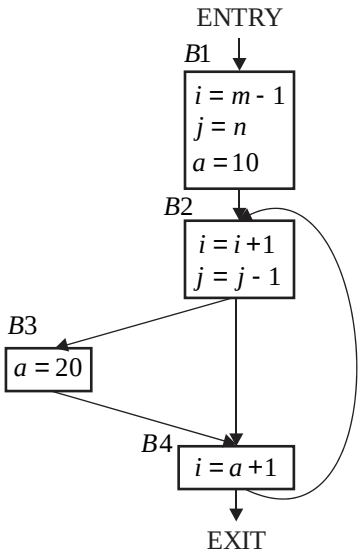
Sol. Following the execution sequence



Hence, the correct option is (A).

Question 27

Consider the control flow graph shown.



Which one of the following choices correctly lists the set of live variables at the exit point of each basic block? **[Compiler Design, Syntax Directed Translation]**

(A) B1: {}, B2: {a}, B3: {a}, B4: {a}

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

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

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

Ans. (D)

Sol. A variable 'V' is live (for statement b) if there exist a path from this statement to another statement is 'a' in CFG such that for each $b <= k < a$ and V is defined in any statement k in CFG.

For B_1 : There's path to B_2, B_3 and B_4.

In this path 'i' and 'J' are live as they're both used before modifying.

'a' is not live as it's used in B_3 before being used in B_4.

Another path is $B_2 \rightarrow B_4$

Where all 3 'a', 'i' and 'J' are live so live variable at exit of $B_1 = \{a, i, J\}$.

For B_2 : Similarly for path B_3, B_4 'J' is live for path B_4 'a' and 'J' are live.

For B_3 : Same as B_1 as path for exit is same.

So, live variable at exits of $B_4 = \{a, i, J\}$.

	i	j	m	n	a
B_1	Live	Live	Dead	Dead	Live
B_2	Dead	Live	Dead	Dead	Live
B_3	Dead	Live	Dead	Dead	Live
B_4	Live	Live	Dead	Dead	live

Hence, the correct option is (D).

Question 28

Consider the two functions incr and decr shown below.

[Operating System, Process Management II]

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

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

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

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

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

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

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

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

(A) 15, 7 (B) 7, 7

(C) 12, 7 (D) 12, 8

Ans. (C)

Sol. For implementation I_1 :

Binary semaphore $s=1$ and $incr()$ called 5 times and $decr()$ called 3 times by threads

So, it alternate as sequence.

$incr()$, $decr()$, $incr()$, $decr()$, $incr()$, $decr()$ which all make X as same value 10 and then two $incre()$ making $V_1=12$

For implementation I_2 :

Counting semaphore $s=2$.

So, one possible sequence is

```
decr()
{
wait(s);                    //s becomes '1'
read X;                     //X becomes/reads and stores value 10.
---------------
Run incr ( ) 5 times
--------------
X = 9                       //write X .
```

Two more decr ( ) so, $X=7$.

Value $V_2=7$.

Hence, the correct option is (C).

Question 29

Consider the context-free grammar G below

$S \rightarrow aSb \mid X$

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

where S and X are non-terminals, and a and b are terminal symbols. The starting non-terminal is S.
Which one of the following statements is CORRECT?

[Theory of Computation, Properties of Language]

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

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

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

(D) The language generated by G is not a regular language

Ans. **(B)**

Sol. **Method 1**

Option A : Since E can't be generated by G so, option (A) is false, which accept E.

Option C : Since $'ba'$ G but is accepted by $a^*b^*(a+b)$ $10(C)$ s false.

Option D : It is false since the language generated has satisfied all conditions of being regular language.

Option B : It is true as it accepts all strings generated by $a^*(a+b)b^*$.

Hence, the correct option is (B).

Method 2

$S \rightarrow asb \mid \times$

$\times \rightarrow a \times \mid xb \mid a \mid b$

$S \rightarrow a \quad s \quad b$

$\overset{*}{\Rightarrow} a^n \underline{s} b^n \mid n \geq 0$

$\Rightarrow a^n \underline{\times} b^n$

$\Rightarrow a^n a \underline{\times} bb^n$

$\Rightarrow a^n a^* \times b^* b^n$

$\overset{*}{\Rightarrow} a^n a^* \underline{\times} b^* b^n$

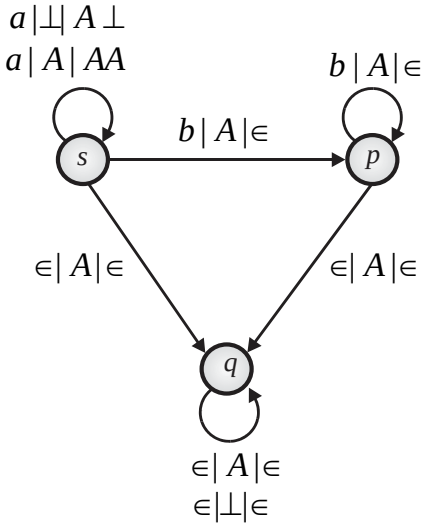
$\Rightarrow a^n a^* (a+b) b^* b^n$

$\Rightarrow a^* (a+b) b^*$

Question 30

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

The PDA accepts by empty stack.



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

[Theory of Computation, Pushdown Automata]

(A) $\{a^m b^n \mid 1 \le m \text{ and } n < m\}$

(B) $\{a^m b^n \mid 0 \le n \le m\}$

(C) $\{a^m b^n \mid 0 \le m \text{ and } 0 \le n\}$

(D) $\{a^m \mid 0 \le m\} \cup \{b^n \mid 0 \le n\}$

Ans. (A)

Sol.

Method 1

Option B : This option is not true since E is not accepted by P.

Option C : This option is false since E is not accepted by P.

Option D : This option is false since E is not accepted by P.

Option A : It accept all strings generated by P.

Hence, the correct option is (A).

Method 2

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

$$L = \{a^n \mid n \ge 1\}$$

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

$$L = \{a^m b^n \mid n < m\}$$

Language accepted by the PDA is

$$L = \{a^m \mid m \geq 1\} \cup \{a^m b^n \mid n < m\}$$

OR

$$L = \{a^m b^n \mid 1 \leq m \text{ and } n < m\}$$

Question 31

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

```
//C-code

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

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

L01: jeq r1, r2, end    ;if(r1==r2) goto end
L02: lw r5, 0(r4)       ;r5 <- Memory[r4+0]
L03: shl r5, r5, U1     ;r5 <- r5 << U1
L04: sw r5, 0(r3)       ;Memory[r3+0] <- r5
L05: add r3, r3, U2     ;r3 <- r3+U2
L06: add r4, r4, U3
L07: add r1, r1, 1
L08: jmp U4             ;goto U4
L09: end
```

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

[Computer Organisation & Architecture, Machine Instruction & Addressing Format]

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

Ans. **(B)**

Sol. **Method 1**

Here an analyzing code we can observe that. We are to shift value of r_5 left by u places. In code were multiplying element of b by 8. So, $u_1 = 3$, which is same as multiplying value by 8 or 2^3.

Also, r_3 and r_4 stores storing address of next element of arrays a and v. Since it's 32 bit system and size of int is 4B so well increment by 4 so, value of u_2 and u_3 s 4.

We have to jump to short of code i.e. $L01$ so that for-loop can be run.

So, u_4 is $L01$.

Hence, the correct option is (B).

Method 2

Since memory is byte addressable and integer is 32 bit means 4 byte.

So increment variables and byte needed to add.

LO5 : add r_3, r_3, U_2 $\qquad r_3 \leftarrow r_3 + u_2$

Here, $U2 = 4$

Similarly, $U3 = 4$

$LO8 = \text{JUMP U4; goto U4}$

This instruction move the control to comparison condition

So, $U4 = LO1$

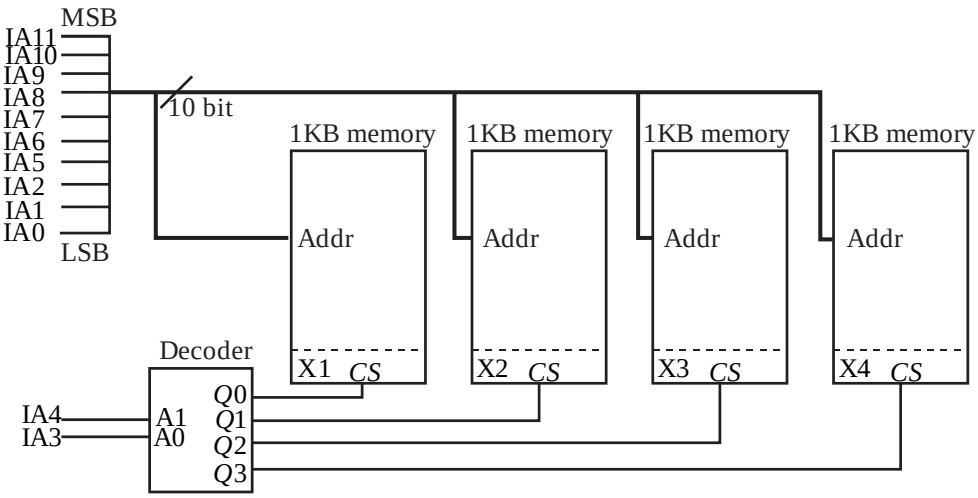
Hence, option B is correct.

$U1 = 3, U2 = 4, U3 = 4, U4 = LO1$

Question 32

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

[Computer Organisation & Architecture, Data Path & Control Unit]



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

(A) (0, 1, 2, 3)
(B) (0, 1024, 2048, 3072)
(C) (0, 8, 16, 24)
(D) (0, 0, 0, 0)

Ans. **(C)**

Sol. The addresses are of length 12 bits.

The 2:4 decoder with input IA_3 and IA_4 decides which chip is selected.

Possible values of IA_4IA_3 at 4.

For starting address the valued $I_{11}.....I_5$ remains '0' and we're focused on value from $I_4.....I_0$.

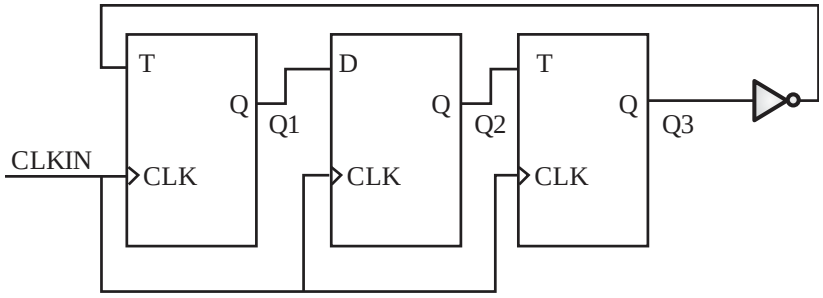
So,

I_4	I_2	Resulting value/Starting address
0	0 (X_0)	0(00000)
0	1 (X_1)	8(01000)
1	0 (X_2)	16(10000)
1	1 (X_3)	24(11000)

Hence, the correct option is (C).

Question 33 **(Digital Electronics)**

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



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

[Digital Logic, Sequential Circuit]

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

Ans. (A)

Sol. Given circuit is made from two T flip flops and one D flp-flop.

Here, $T_1 = \bar{Q}_3$

So, $Q_1^+ = T_1 \oplus Q_1 = \bar{Q}_3 \oplus Q_1 = Q_3 \odot Q_1$

Also, $D_2 = Q_1$

So, $Q_2^+ = Q_1$

Now, $T_3 = Q_2$

$Q_3^+ = T_3 \oplus Q_2 = Q_3 \oplus Q_2$

The state table looks like :

Q_1	Q_2	Q_3	$T_1 = Q_3 \odot Q_1$	$D_2 = Q_1$	$T_3 = Q_2 \oplus Q_3$
0	1	1	0	0	0
0	0	0	1	0	0
1	0	0	0	1	0
0	1	0	1	0	1
1	0	1	1	1	1
1	1	1	1	1	0
1	1	0	0	1	1

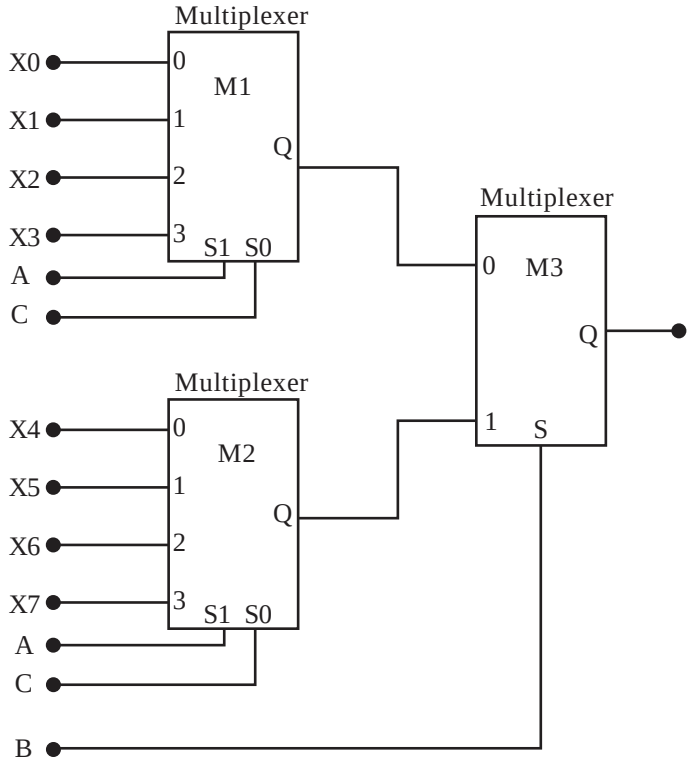
So, the missing state is 001.

Hence, the correct option is (A).

Question 34 **(Digital Electronics)**

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

[Digital Logic, Combination circuit]



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

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

Ans. **(C)**

Sol. **Given :**

$F=\bar{A}+\bar{A}\cdot\bar{C}+A\bar{B}C$.

Since final output is given by 2×1 mux m_3

So, MSB (most significant bit) is selection line of m_3 i.e. B.

Also we can observe from M_1 and M_2, that the selection lines $(S_1,S_0)=(A,C)$ so the function has C as LSB

The function $F(B,A,C)=\bar{A}+\bar{A}\bar{C}+A\bar{B}C$ is implemented using inputs as :

	B	***A***	***C***	
X_0	0	0	0	$1\rightarrow$Due to A'
X_1	0	0	1	$1\rightarrow$Due to A'
X_2	0	1	0	0
X_3	0	1	1	$1\rightarrow$Due to $AB'C$

X_4	1	0	0	$1 \rightarrow$ Due to A'
X_5	1	0	1	$1 \rightarrow$ Due to A'
X_6	1	1	0	0
X_7	1	1	1	0

So, $(X_0, X_1 \ldots\ldots X_7) = (11011100)$

Hence, the correct option is (C).

Question 35

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

[Computer Organization & Architecture, Machine Instruction & Addressing Format]

(A) 0x404C2EF4 (B) 0x405C2EF4

(C) 0xC15C2EF4 (D) 0xC14C2EF4

Ans. (C)

Sol. Here, $P = 0 \times 1800000 = 1100\ \ 0001\ \ 1000\ 0000\ \ 0000\ \ 0000\ 0000\ 0000$

In IEEE-754 single precision format.

$(S) \rightarrow$ Sign bit $= 1$

Biased exponent $= 131$

Actual exponent $= 131 - 127 = 4$

$(m) \rightarrow$ Mantissa = 0000 0000 0000 0000 0000 000

The number $= (-1)^s \times (1.m) \times 2^e = (-1)^1 \times 1.0 \times 2^4 = -16$

Similarity, $Q = 0x3F5C2EE4 =$ 0011 1111 0101 1100 0010 1110 1111 0100

Sign $= 0$

Biased exponent $= 126$

Actual exponent $= 126 - 127 = -1$

So, $Q = 1.10111000010111011110100 \times 2^{-1}$

$P * Q = -1.10111000010111011110100 \times 2^{-1} \times 2^4$

$P * Q = -1.10111000010111011110100 \times 2^3$

Sign $= 1$

Biased exponent $= 127 + 3 = 130 = 10000010$.

The number in IEEE-754 format is :

1	1000 0010	1011 1000 0101 1101 1110 100

↓ Sign bit ↓ Exponent ↓ Mostissa

0xC15C2EF4

Hence, the correct option is (C).

Question 36

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

When A contains n elements, which one of the following statements about the worst case running time of these two operations is TRUE? **[Data Structure, tree]**

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

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

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

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

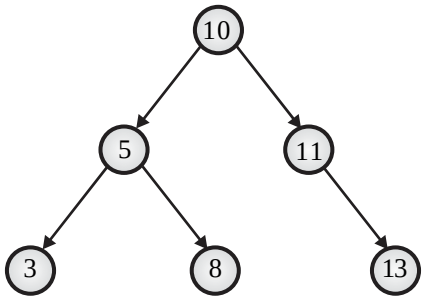
Ans. (B)

Sol. Since both extract-max (A) and Insert (A) needs to perform heapify ( ) operation, both take $0(\log(n))$ time.

Hence, the correct option is (B).

Question 37

Consider the C function foo and the binary tree shown.




```
typedef struct node {
        int val;
        struct node *left, *right;
} node;

int foo(node *p ) {
        int retval;
        if (p == NULL)
            return 0;
        else {
            retval = p->val + foo(p->left) + foo(p->right);
```

```
        printf("%d ", retval);
        return retval;
    }
}
```

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

[Data Structure, Tree]

(A) 3 8 5 13 11 10
(B) 3 5 8 10 11 13
(C) 3 8 16 13 24 50
(D) 3 16 8 50 24 13

Ans. (C)

Sol. **Method 1**

Given : Retval $= P \rightarrow val + foo(P \rightarrow \text{left}) + foo(P \rightarrow \text{right})$

Now, considering given tree with root 10.

Retval $= 10 + foo(P \rightarrow \text{left}) + foo(P \rightarrow \text{right})$

So, until we execute leaf node we won't get to return to root node.

Also child-Nodes 3, 8 and 13 will return value of leaf nodes, i.e. 3,8 and 13 only.

So, 5 node will return $5+3+8=16$.

11 node will return $11+13=24$

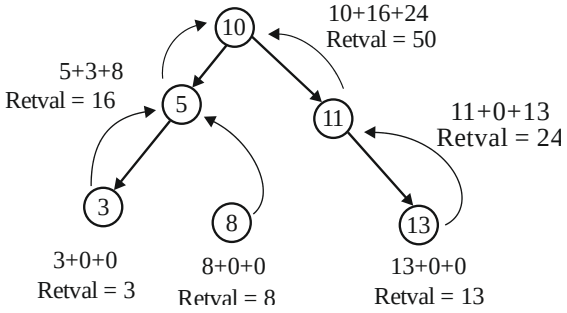
10 node will return $10+16+24=50$

Since there's no rule about evaluation order of parameters of '+' but considering/assuming left right rule by default we get output as : $3,8,16,13,24,50$.

Hence, the correct option is (C).

Method 2

Ret val $= P \rightarrow \text{val} + F00(P \rightarrow \text{Left}) + F00(P \rightarrow \text{Right})$



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

Question 38

Let U = {1, 2,...,n}, where n is a large positive integer U with $|A| = |B| = k$ and $A \cap B = \phi$. We say that a permutation of U separates A from B if one of the following is true.

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

How many permutations of U separate A from B? **[Discrete Mathematics, Combinatorics]**

(A) $n!$

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

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

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

Ans. **(D)**

Sol. $U=\{1,2,3,4,5,6\ldots n^2\}\ n>1000$

$A\subseteq U, B\subseteq U$ and $|A|=|B|=K$

$A\cap B=\phi$

Case 1 : If all element of A appear before the element of B then number of permutation

$$n_{c_{2K}} *(n-2K)!*K!*K!$$

$$n_{c_{2K}}(n-2K)!\,(K!)^2$$

Case 2 : If all element of B appears before the elements of A then number of permutation

$$n_{c_{2K}} *(n-2K)!*K!*K!$$

$$n_{c_{2K}}(n-2K)!\,(K!)^2$$

Total permutation

Case-1 + Case-2

$$n_{c_{2K}}(n-2K)!*(K!)^2+n_{c_{2K}}(n-2K)!*(K!)^2$$

$$2\binom{n}{2K}(n-2K)!*(K!)^2$$

Hence, the correct option is (D).

Question 39

Let $f:\ A\to B$ be an onto (or surjective) function, where A and B are nonempty sets. Define an equivalence relation $\sim$ on the set A as

$a\sim a_2$ if $f(a_1)=f(a_2)$,

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

$F(|x|)=f(x)$, for all the equivalence classes $[x]$ in ε.

Which of the following statements is/are TRUE?

[Discrete Mathematics & Graph theory, Set theory and Algebra]

(A) F is NOT well-defined.
(B) F is an onto (or surjective) function.
(C) F is a one-to-one (or injective) function.
(D) F is a bijective function.

Ans. **(B), (C), (D)**

Sol. The equivalence relation on set A is defined as :

$a_1 \sim a_2$ if $f(a_1) = f(a_2)$

Where $a_1, a_2 \ EA$.

Consider $a_i, b_i c_i .....EA$ and $\alpha, \beta, r.....EB$ and the mapping a_3 :

$a_1 \to \alpha,\ a_2 \to \alpha,\ a_3 \to \alpha.....a_n \to \alpha$

Similarity,

$b_1 \to \beta,\ b_2 \to \beta,\ b_3 \to .....b_n \to \beta$ and so on…….

According to equivalent, equivalent loss is :

$[a_1] = [a_2] = [a_3] = ... = [a_m]$

$[b_1] = [b_2] = [b_3] = ... = [b_n]$……and so on.

So, set of equivalence classes under relation is :

$\varepsilon = \{[a_1], [b_1], [c_1] .....\}$

Now, given new mapping $F = \varepsilon \to B$ as :

$F([x]) = F(x)$ for all $[x] \ E\varepsilon$

It means mapping will be :

$a_1 \to \alpha, b_1 \to \beta, c_1 \to r$ …….and so on.

Since, all distinct $a_1, b_1, c_1.....$ maps to different element of set B. SO F is injective.

We've considered $\{a_1, b_1, c_1.....\}$ as leaders of their equivalent class.

We can also consider $\{a_2, b_2, c_2.....\}$

Also, its cleared from mapping of F that all the elements of set B are

So, F is subjective.

Since F is both injective and subjective so F is bijective.

Also, we con observe that is well-defined function since its bijective.

Hence, the correct options are (B), (C), (D).

Question 40

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

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

[Computer Network, Transport Layer]

(A) 30 bits
(B) 32 bits
(C) 34 bits
(D) 36 bits

Ans. **(B), (C) (D)**

Sol. Given bandwidth (BW) = 100 Mbps

So, in 1 second we can send 100×10^6 bits

$=125\times10^3\ B$

In 120 seconds $=120\times125\times10^3 B$

$=15000\times10^5 B$

Since n lifetime of 120 seconds 15×10^8 bytes are generated, so

Sequence number bits $=\log_2(15\times10^8)$

≥ 30.48

≥ 31 bits

Hence, the correct options are (B), (C) & (D).

Question 41

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

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

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

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

[Discrete Mathematics Set theory & Algebra]

(A) H is a group.
(B) Every element in H has an inverse, but H is NOT a group.
(C) For every $A\in 2^X$, the inverse of A is the complement of A.
(D) For every $A\in 2^X$, the inverse of A is A.

Ans. **(A), (D)**

Sol. The symmetric difference is similar to EXOR operation in digital logic.

Now left check it for following properties :

1. Closure property : Operator Δ is defined as

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

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

   $\because$ 2^X is power set of X, so it contains all subset of X.

   So, $A\Delta B\in 2^X\ \forall A,B\in 2^X$.

2. Associativity : It's similar to XOR operation which is associative always, followed

3. Identity : $C\in 2^X$ is identity element.

   So, $A\Delta C=C\Delta A=A$ for $C\in 2^X$

   $A\Delta C=(A\cup C)-(A\cap C)=A$ which is possible when $C=\Phi$.

So, identity exists.

4. Inverse : $A\Delta B = B\Delta A = \Phi$ then $A\Delta B$ are inverse

ϕ each option given $A, B \in 2^X$.

So, $(A \cup B) - (A \cap B) = \Phi$

It's possible $(A \cup B) = (A \cap B)$

If $A = B$ then its possible.

Hence, every element of 2^X is it's own inverse and H is a group.

Hence, the correct options are (A) & (D).

Question 42

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

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

Which of the following statements is/are CORRECT about the minimum elapsed time between clicking on the URL and your browser fully rendering it? **[Computer Network & Transport Layer]**

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

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

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

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

Ans. (C), (D)

Sol. **Case I :**

Persistent HTTP : TCP connection is established once and multiple files are transmitted in single connection.

Pipelined : New HTTP request can be sent to server without receiving acknowledgement of previous.

a client request a page from server, following steps are followed in order before gets all data needed :

(i) There's 3-tier DNS hierarchy, it is done in iterative mode taking 3 RTT.

(ii) 1 RTT is used for TCP connection establishment.

(iii) 1 RTT is used to fetch HTML base file.

(iv) 1 RTT is for all other 10 objects.

So, total 6 RTT's are used.

Case-II : Non persistent HTTP with 5 parallel connections :

Non persistent : TCP connection is made for each HTTP request and closed.

5-parallel connections : 5 objects could be sent parallel at same time.

So, in this case the client have to wait for request to be fulfilled as following steps need to be completed.

(i) 3 RTT for DNS resolution.

(ii) 1 RTT for TCP connection establishment.

(iii) 1 RTT for fetch base HTML page.

(iv) 1 RTT for TCP connection establishment.

(v) 1 RTT to get 5 objects parallely (5 still test)

(vi) 1 RTT for TCP connection establishment

(viii) 1 RTT for getting remaining 5 objects.

In total it takes RTT's = 9

Hence, the correct options are (C) & (D).

Question 43

Consider a random experiment where two fair coins are tossed. Let *A* be the event that denotes HEAD on both the throws, *B* be the event that denotes HEAD on the first throw, and *C* be the event that denotes HEAD on the second throw. Which of the following statements is/are TRUE?

[Engineering Mathematics, Probability]

(A) *A* and *B* are independent. (B) *A* and *C* are independent.

(C) *B* and *C* are independent. (D) $\text{Prob}(B|C) = \text{Prob}(B)$

Ans. (C, D)

Sol. Let, ***A*** be the event that denotes HEAD on both the throws.

Let, *B* be the event that denotes HEAD on the first throw.

Let, *C* be the event that denotes HEAD on the second throw.

For, Event *A* (Head on both coins), only one case is feasible which is HH.

$$\therefore \quad P(A) = \frac{1}{4}$$

For, Event *B* (Head on first coins), only two cases are feasible which is HH, HT.

$$\therefore \quad P(B) = \frac{1}{2}$$

For, Event *C* (Head on second coins), only one case is feasible which is HH, TH.

$$\therefore \quad P(C) = \frac{1}{2}$$

NOTE : Two or more events are said to be independent, when the occurrence of one event does not affect the occurrence of other event.

In case of Independent Events : $P(A \cap B) = P(A).P(B)$

Let us check options one by one :

Option A : A and B are independent.

So, this will be true only when $P(A \cap B) = P(A).P(B)$

Here $A \cap B$ will have those cases having Head on first coin.

$$P(A \cap B) = \frac{1}{2}$$

$$P(A) = \frac{1}{4}$$

$$P(B) = \frac{1}{2}$$

$$P(A).P(B) = \frac{1}{8}$$

Clearly, $P(A \cap B) \neq P(A).P(B)$. So, **Option A is FALSE.**

Option B : A & C are independent.

So, this will be true only when $P(A \cap C) = P(A).P(C)$

Here $A \cap C$ will have those cases having Head on second coin.

$$P(A \cap C) = 1/2$$

$$P(A) = \frac{1}{4}$$

$$P(C) = 1/2$$

$$P(A).P(C) = 1/8$$

Clearly, $P(A \cap C) \neq P(A).P(C)$ .So, option B is False.

Option C : B & C are independent

So, this will be true only when $P(B \cap C) = P(B).P(C)$

Here $B \cap C$ will be have those cases having head on both coin.

$$P(B \cap C) = 1/4$$

$$P(B) = 1/2$$

$$P(C) = 1/2$$

$$P(B).P(C) = 1/4$$

Clearly, $P(B \cap C) = P(B).P(C)$. So, option C is TRUE.

Option D : $P(B/C) = P(B)$

$P(B/C) = P(B \cap C)/P(C)$

$P(B \cap C) = 1/4$ [See calculation in Option C]

$P(C) = 1/2$

$P(B/C) = (1/4)/(1/2) = 2/4 = 1/2$

$P(B) = 1/2$

Clearly, $P(B/C) = P(B)$. So option D is True

Hence, the correct options are (C) and (D).

Question 44

Consider functions Function 1 and Function 2 expressed in pseudocode as follows :

Function 1	Function 2
while $n > 1$ do	for $i = 1$ to $100 * n$ do
for $i = 1$ to n do	$x = x + 1$;
$x = x + 1$;	end for
end for	
$n = \lfloor n/2 \rfloor$;	
end while	

Let $f_1(n)$ and $f_2(n)$ denote the number of times the statement "$x = x + 1$" is executed in **Function 1** and **Function 2**, respectively.

Which of the following statements is/are TRUE?

[Algorithm, Complexity Analysis & Asymptotic Notation]

(A) $f_1(n) \in \Theta(f_2(n))$ (B) $f_1(n) \in o(f_2(n))$

(C) $f_1(n) \in \omega(f_2(n))$ (D) $f_1(n) \in O(n)$

Ans. **(A), (D)**

Sol. Analysing function 1 first, we observe the number of times inner loop run is halved every iteration

So, Number of times $n + \frac{n}{2} + \frac{n}{4} + \frac{n}{3} + ... + 1$

Inner loop runs $A(n) = n\left(1 + \frac{1}{2} + \frac{1}{4} + \frac{1}{3} + ... \frac{1}{n}\right)$

Say, it takes p timer, so

$$A(n)=n\left\{\frac{1-\left(\frac{1}{2}\right)^{p}}{1-\frac{1}{2}}\right\}$$

Since, for large p, we can say $1-\left(\frac{1}{2}\right)^{p}\approx 1$

So, $A(n)=\frac{n}{\frac{1}{2}}=2n$

So, $f_1(n)=0(n)$

Now, Function 2 runs for 100 n times.

So, $f_2(n)=0(100n)$

$=0(n)$

So, $f_1(n)\in\theta(f_2(n))$

Also, $f_1(n)\in 0(f_2(n))$ is true.

Hence, the correct options are (A) & (D).

Question 45

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

for $i=1,\ldots,n$

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

Which of the following statements is/are TRUE?

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

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

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

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

Ans. (A), (B)

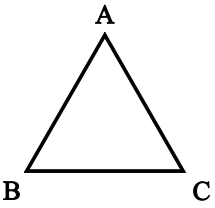
Sol. **For Option (A) :** Its, true as

"Color (V_i) $\leftarrow$ min < $J\in N$ = No neighbor of V_i is colored J >"

So, it ensures proper coloring.

For Option (B) : We can take example of a cycle of length 3.

Here, $\Delta G=2$



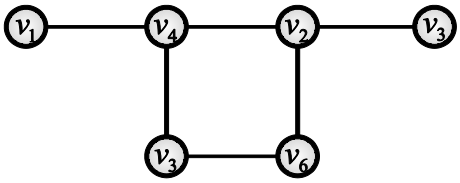
But we need 3 colours to color it also, number of neighbor's can't be more than the degree, i.e . ΔG .

So, at most $\Delta G+1$ colours needed.

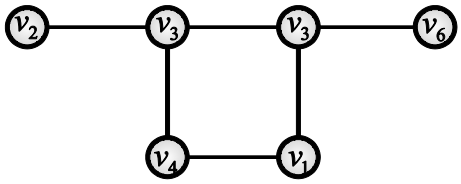
This option is true.

For Option (C) It's False as we have explained above.

For Option (D) It is not always the case as sometimes we might see that greedy coloring might not be giving optimal result. Consider example.



Uses 3 color and



Uses 3 color

When coloured greedily in order $(v_1, v_2 \ldots\ldots v_6)$. 90, number of color used $\neq$ Chromatic number of graph

Hence, the correct options are (A) & (B).

Question 46

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

If ϕ denotes the empty set, then the cardinality of $B(\phi)$ is _____.

[Discrete Mathematics, Graph theory]

Ans. 5040

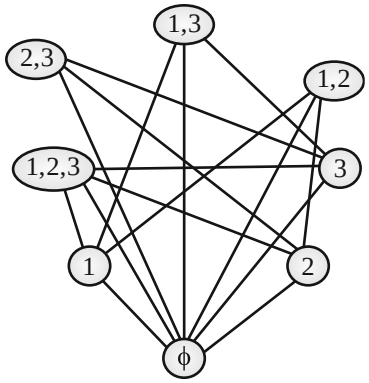
Sol. Here, given that U = <1, 2, 3>

Vertex set = Power set of $U = 2^U = \{\phi$, <1>, <2>, <3>, <1,2>, <1,3>, <2,3>, <1,2,3>$\}$

So, number of vertices $= 8$

Now, there's edge between A and B if either of them is proper subset of another.

Since, ϕ is proper subset of all other vertices except itself, so its' connected to all 7 vertices. Since it can be visited in any order.



So, cardinality of $B(\phi) = 7! = 5040$

Hence, the correct answer is 5040.

Question 47

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

int D[128][128];

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

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

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

[Operating System, Memory management Virtual Memory]

Ans. 4096

Sol. Given array D[128] [123] is stored in Row – major Order.

Number of physical frames available = 30

Number of elements in 1 frame = 512

So, number of pages to accommodate all element of array $D = \frac{123 \times 128}{512} = 32$.

Since we need 32 frames and were given only 30 so, collision will occur.

Also number of rows per frame $= \frac{512}{128} = 4$

So, in 30 frames we can per store 120 rows

Thus in 1st iteration, It' cause 32 page faults.

For 128 iterations it' cause $128 \times 32 = 4096$ faults.

Hence, the correct answer is 4096.

Question 48

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

The value of L is _____. **[Operating System, Memory Management Virtual Memory]**

Ans. 5

Sol. Virtual address is 57 bits, page size is 4kB $= 2^{12}$ B

Number of page $= \frac{2^{57}}{2^{12}} = 2^{45}$

Page Table Entry = 8kB

So, Each page can contain $\frac{4kB}{8B} = 2^9$ page entries

So, We need 9 bits to index page table.

So, number of levels $= \left\lceil \frac{45}{9} \right\rceil = 5$

Hence, the correct answer is 5.

Question 49

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

I : push the elements of *a* from a_0 to a_5 in that order into *S*.

II : enqueue the elements of a from a_0 to a_5 in that order into *Q*.

III : pop an element from *S*.

IV : dequeue an element from *Q*.

V : pop an element from *S*.

VI : dequeue an element from *Q*.

VII : dequeue an element from *Q* and push the same element into *S*.

VIII : Repeat operation VII three times.

IX : pop an element from *S*.

X : pop an element from *S*.

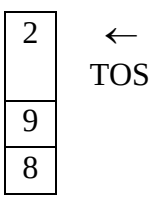
The top element of *S* after executing the above operations is _____.

[Data Structure, Stack & Queue]

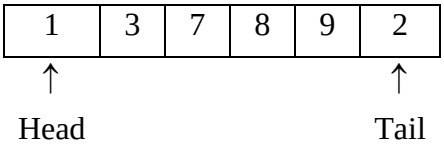
Ans. 8

Sol. Given Elements $(a_0, a_1, ...a_4) = (1, 5, 7, 8, 9, 2)$

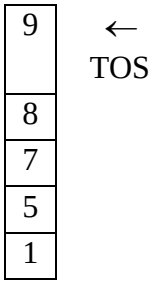
Step – 1 :



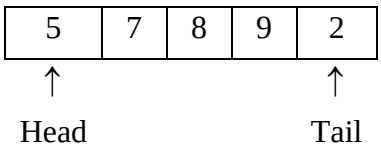
Step -2 :



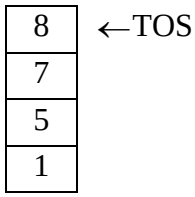
Step-3 :



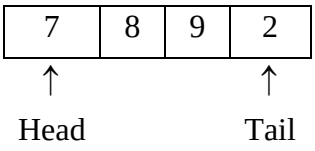
Step – 4 :



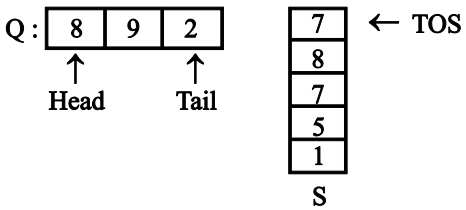
Step – 5 :



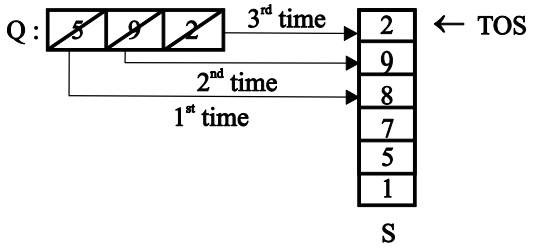
Step – 6 :



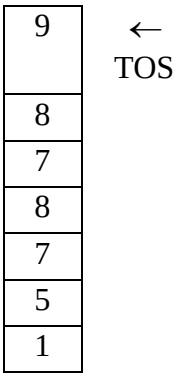
Step – 7 :



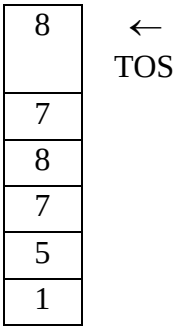
Step-8 :



Step – 9 :



Step – 10 :



$\therefore$ '8' in Top of stack So answer is 8.

Hence, the correct option is 8.

Question 50

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

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

$B \rightarrow 0$ $\quad B.val = \mathbf{0}.val$

$B \rightarrow \mathbf{1}$ $\quad B.val = \mathbf{1}.val$

The value computed by the translation scheme for the input string

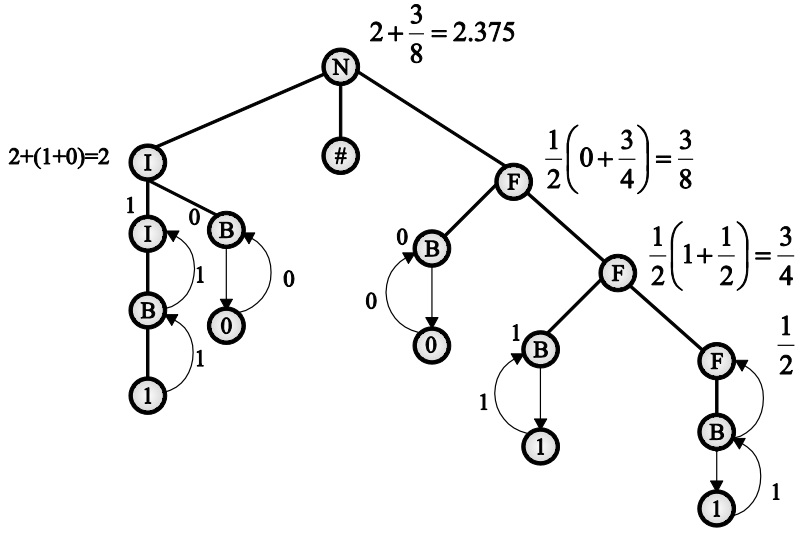
10 # 011

is _____. (Rounded off to three decimal places)

[Compiler Design, Syntax Directed Translation]

Ans. 2.375

Sol.



Hence, the correct answer is 2.375.

Question 51

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

Student :

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

The SQL query below is executed on this database.

SELECT *

FROM Student

WHERE gender = 'F' AND

marks > 65;

The number of rows returned by the query is _____.

[Database, Relational Model Relational Algebra]

Ans. **2**

Sol. Here to return female students with marks greater than 65.

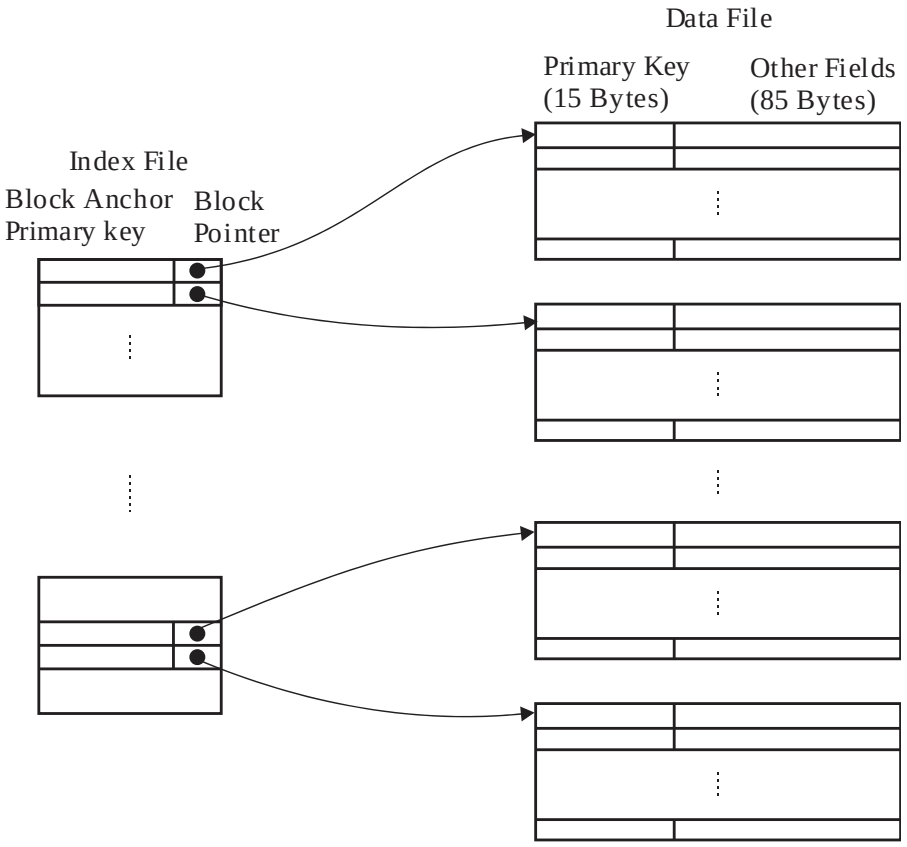
Output is :

Roll	Name	Gender	Marks
2	Aliya	F	70
3	Aliya	F	80

Hence, the correct answer is 2.

Question 52

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



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

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

[Database, File Structure]

Ans. **6**

Sol. Given database is stored as ordered file and indexed by primary index file

There're 25,000 records

100 B records size

15 B Primary key size

5 B Pointer size

1024 B Block size

It's stored in unspanned organization.

$$\text{So, Number of records per block} = \left\lfloor \frac{\text{Block size}}{\text{Record size}} \right\rfloor = \left\lfloor \frac{1024B}{100B} \right\rfloor = 10$$

$$\text{Number of data blocks needed} = \left\lceil \frac{\text{Number of records}}{\text{Number of records per block}} \right\rceil = \frac{25000}{10} = 2500$$

$$\text{No. of Index records per block} = \left\lfloor \frac{\text{Block size}}{\text{primany key size} + \text{Pointer size}} \right\rfloor = \left\lfloor \frac{1024}{15+5} \right\rfloor = \left\lfloor \frac{1024}{20} \right\rfloor = 51$$

$$\text{Number of index block needed} = \left\lceil \frac{2500}{51} \right\rceil = 50$$

Applying binary search, $\lceil \log_2(50) \rceil = 6$

Hence, the correct answer is 6.

Question 53

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

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

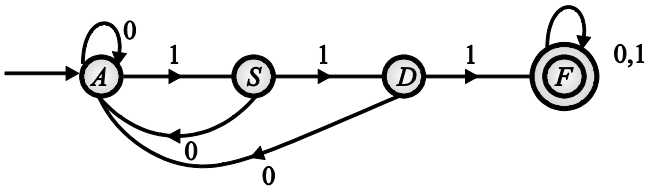
The minimum number of states in a Deterministic Finite-State Automaton (DFA) for L is _____.

[Theory of Computation, Finite Automata]

Ans. 4

Sol. Say L : set of strings containing 3 consecutive is.

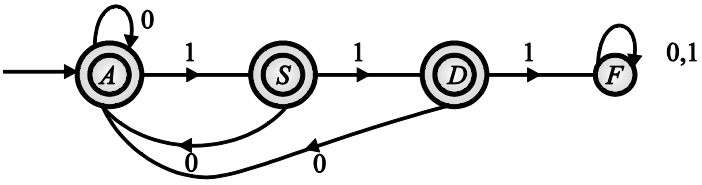
The MDFA for L →



I: set of strings not containing 3 consecutive

So, no. of state remains same i.e. 4

MDFA For I →



Hence, the correct answer is 4.

Question 54

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

The number of bits in the TAG is _____.

[Computer organization & Architecture, Memory Organization]

Ans. 19

Sol. **Given :** Cache Size $CS = 64\text{KB} = 2^6 \times 2^{10}\ B = 2^{16}\text{B}$

System use 32 bit address (A)

So, TAG = $A - \log_2(CS) + \log_2(P)$

$= 32 - \log_2(2^{16}) + \log_2(8)$

$= 32 - 16 + 3 = 19$

Hence, the correct option is 19.

Question 55

The forwarding table of a router is shown below.

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

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

[Computer Network, Concept of Layering and LAN Technologies]

Ans. 3

Sol. We will perform AND operation between IP and Subnet mask and see it we get same subnet –ID or not and well do longest prefix match.

So, checking subnet – 4.

IP $\wedge$ subnet = (200.150.68.118) $\wedge$ (255.255.255.224) = (200.150.68.96)

Subnet ID didn't match.

Checking subnet 3

(200.150.68.118) $\wedge$ (255.255.255.0) = 200.150.68.0

Subnet ID matches.

If will be forwarded to 3.

Hence, the correct answer is 3.

❑❑❑