3. $\varepsilon+0(10*1+10)*1$

4. $\varepsilon+0(10*1+10)*10*$

(A) $P-2, Q-1, R-3, S-4$

(B) $P-1, Q-3, R-2, S-4$

(C) $P-1, Q-2, R-3, S-4$

(D) $P-3, Q-2, R-1, S-4$

[GATE 2008 : IISc Bangalore]

Q. 12 Let $L=\{w\in(0+1)^*|w$ has even number of 1's}, i.e. L is the set of all bit strings with even number of 1's. Which one of the regular expressions below represents L?

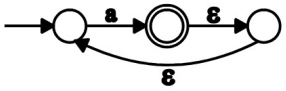
(A) $(0*10*1)*$ (B) 0*(10* 10*)*

(C) 0*(10*1)*0* (D) 0*1(10*1)*10*

[GATE 2010 : IIT Guwahati]

Q.13 What is the complement of the language accepted by the NFA shown below?

Assume $\Sigma=\{a\}$ and ε is the empty string.



(A) ϕ (B) $\{\varepsilon\}$

(C) a^* (D) $\{a,\varepsilon\}$

3. $(0+1)^*1$

(A) 1 and 2 only (B) 1 and 3 only

(C) 2 and 3 only (D) 1, 2, and 3

[GATE 2014 : IIT Kharagpur]

Q. 17 Let $L_1=\{w\in\{0,1\}^*|w$ has at least as many occurrences of (110)'s as (011)'s}. Let $L_2=\{w\in\{0,1\}^*|w$ has at least as many occurrences of (000)'s as (111)'s}. Which one of the following is TRUE?

(A) L_1 is regular but not L_2

(B) L_2 is regular but not L_1

(C) Both L_1 and L_2 are regular.

(D) Neither L_1 nor L_2 are regular

[GATE 2014 : IIT Kharagpur]

Q.18 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 $\overline{L}$ (complement of L)?

(A) 4 (B) 5

(C) 6 (D) 8

[GATE 2015 : IIT Kanpur]

Q.19 The number of states in the minimal deterministic finite automaton

corresponding to the regular expression (0 +1)* (10) is _____.

[GATE 2015 : IIT Kanpur]

Q.20 Consider the alphabet $\Sigma=\{0,1\}$, the null/empty string λ and the set 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.

$$X_0=1X_1$$

$$X_1=0X_1+1X_2$$

$$X_2=0X_1+\{\lambda\}$$

Which one of the following choices precisely represents the strings in X_0?

(A) 10(0* + (10)*)1

(B) 10(0*+(10*))*1

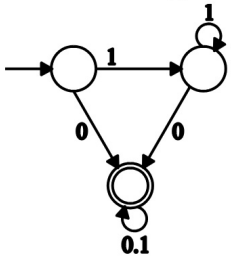
(C) 1(0+10)*1

(D) 10(0+10)*1+110(0+10)*1

[GATE 2015 : IIT Kanpur]

Q.21 Which one of the following regular expressions represents the language : the set of all binary strings having two

Q. 24 Consider the DFA A given below.



Which of the following are FALSE?

1. Complement of L(A) is context – free
2. L(A) = L((11*0+0)(0+1)*0*1*)
3. For the language accepted by A, A is the minimal DFA.
4. A accepts all strings over {0, 1} of length at least 2.

(A) 1 and 3 only (B) 2 and 4 only

(C) 2 and 3 only (D) 3 and 4 only

[GATE 2013 : IIT Bombay]

Q. 25 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

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) $(0+1)*(00(0+1)*11 + 11(0+1)*00)(1+1)*$

(C) $(0+1)*00(0+1)* + (0+1)*11(0+1)*$

(D) $00(0+1)*11 + 11(0+1)*00$

[GATE 2016 : IISc Bangalore]

Q.22 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 _____.

[GATE 2016 : IISc Bangalore]

Q.23 Consider the language L given by the regular expression (a+b)*b(a+b) over the alphabet {a, b}. The smallest number of states needed in a deterministic finite-state automaton (DFA) accepting L is _____.

[GATE 2017 : IIT Roorkee]

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

[GATE 2016 : IISc Bangalore]

Q. 26 For $\Sigma = \{a, b\}$, let us consider the regular language $L = \{x \mid x = a^{2+3k} \text{ or } x = b^{10+12k}, k \geq 0\}$. Which one of the following can be a pumping length (the constant guaranteed by the pumping lemma) for L?

(A) 3 (B) 5
(C) 9 (D) 24

[GATE 2019 : IIT Madras]

Q. 27 Consider the following statements.

I. If $L_1 \cup L_2$ is regular, then both L_1 and L_2 must be regular.

II. The class of regular languages is closed under infinite union.

Which of the above statements is/are TRUE?

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

[GATE 2020 : IIT Delhi]

Q.28 Which one of the following regular expressions represents the set of all binary strings with an odd number of 1's?

(A) $((0+1)*1(0+1)*1)*10*$

(B) $(0*10*10*)*0*1$

(C) $10*(0*10*10*)*$

(D) $(0*10*10*)*10*$

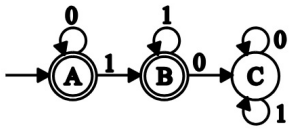
[GATE 2020 : IIT Delhi]

Q.29 Which of the following regular expression identities are true?

(A) r (*) = r*
(B) (r*s*)* = (r + s)*
(C) $(r+s)^* = r^*+s^*$
(D) $r^*s^* = r^*+s^*$

[GATE 1992 : IIT Delhi]

Q.30 The regular expression for the language recognized by the finite state automation of the below figure is _____.



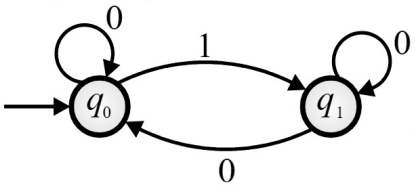
[GATE 2002 : IISc Bangalore]

Q.31 Which one of the following languages over the alphabet {0, 1} is described by the regular expression (0 +1)* 0(0+1)* 0(0+1)*

(A) The set of all strings containing the substring 00
(B) The set of all strings containing at most two 0's
(C) The set of all strings containing at least two 0's
(D) The set of all strings that begin and end with either 0 or 1

[GATE 2009 : IIT Roorkee]

Q.1 Which of the following options represents regular expression accepted by above DFA '*M*'?



(A) $(0+1)^*1$

(B) $0^*1(0+00^*1)^*$

(C) $(0+10^*0)^*10^*$

(D) $1(0+1)^*$

Q.2 Which of the following language is/are NOT regular?

(A) $L=\{WxW^R \mid W,x\in\{0,1\}^*\}$

(B) $L=\{WxW \mid W,x\in\{0,1\}^*\}$

(C) $L=\{WxW \mid W,x\in\{0,1\}^+\}$

(D) $L=\{WW \mid W\in\{0,1\}^*\}$

Q.3 $\text{R.E.}=(111+1111)^*$

Which of the following regular language represents above regular expression?

(A) $L=\{1^n \mid n\geq 0\}$

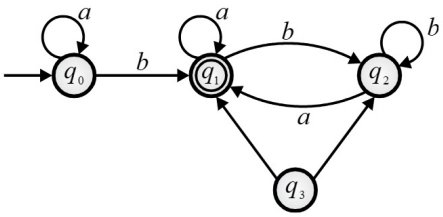
(B) $L=\{1^n \mid n\geq 0 \text{ and } n\neq 1,2\}$

(C) $L=\{1^n \mid n\geq 0 \text{ and } n\neq 1,2,5,7\}$

(D) $L=\{1^n \mid n\geq 0 \text{ and } n\neq 3,4\}$

Q.4 Regular expression $=(0+1)^*(0+1)(0+1)^*$ what is the minimum no. of states in DFA that accept above R.E. _____?

Q.5 The language accepted by above automaton is given by regular expression



(A) $a^*b(a+b)^*$

(B) $a^*ba^*bb^*aa^*$

(C) $a^*b(a+bb^*a)^*$

(D) $a^*b(bb+aa)^*$

Q.6 Which of the following two regular expression is/are equivalent?

(i) $(00)^*(0+\in)$ (ii) $(0+1)^*1$

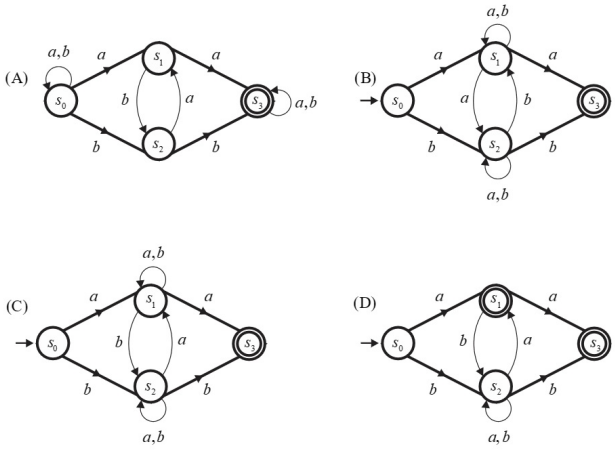
(ii) $(0^*1^*)^*$ (iv) $(0+1)^*$

(v) $0^*1(1+00^*1)^*$ (vi) $(0^*0^*)^*$

(A) (iii) and (iv) (B) (i) and (vi)

(C) (ii) and (v) (D) None

Q.7 Consider the regular expression. R=(a+b)*(aa+bb)(a+b)*. Which of the following non- deterministic finite automata recognizes the language defined by the regular expression R? Edges labeled λ denote transitions on the empty string.



Answer Key

Classroom Practice Questions									
1.	A	2.	C	3.	D	4.	D	5.	C,D
6.	C	7.	A	8.	D	9.	C	10.	B
11.	C	12.	B	13.	B	14.	C	15.	3
16.	B	17.	B	18.	B	19.	3	20.	C
21.	B	22.	2	23.	4	24.	D	25.	C

26.	D	27.	D	28.	D	29.	B	30.	0*1*
31.	C								
Practice Questions									
1.	A, B	2.	C, D	3.	B	4.	2	5.	C
6.	A, B, C	7.	A						

❑❑❑

3 Grammar, Language and it's Application

Classroom Questions

Q.1 If G is a context-free grammar and w is a string of length n in L(G), how long is derivation of w in G, if G is Chomsky normal form?

(A) 2n (B) 2n + 1

(C) 2n – 1 (D) n

[GATE 1992 : IIT Delhi]

Q.2 Which of the following definitions below generates the same language as L where $L = \{x^n y^n \mid n \geq 1\}$

(i) $E \rightarrow xEy \mid xy$

(ii) $xy \mid (x^+ xyy^+)$

(iii) $x^+ y^+$

(A) (i) only (B) (i) and (ii)

(C) (ii) and (iii) (D) (ii) only

[GATE 1995 : IIT Kanpur]

Q.3 Let L denote the language generated by the grammar $S \rightarrow 0S0 \mid 00$. Which of the following is true?

Which one of the following statements is **FALSE**?

(A) L_2 is context-free

(B) $L_1 \cap L_2$ is context-free

(C) Complement of L_2 is recursive

(D) Complement of L_1 is context-free but not regular

[GATE 2013 : IIT Bombay]

Q.6 Which of the following languages is /are regular?

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

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

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

(A) L_1 and L_3 only (B) L_2 only

(B) L_2 and L_3 only (D) L_3 only

[GATE 2015 : IIT Kanpur]

Q.7 Which of the following languages is

(A) L = 0^+
(B) L is regular but not 0^+
(C) L is context free but not regular
(D) L is not context free

[GATE 2000 : IIT Kharagpur]

Q.4 Let $L = L_1 \cap L_2$, where L_1 and L_1 are languages defined as follows,

$$L_1 = \{a^m b^m c\, a^n b^n \,|\, m, n \geq 0\}$$

$$L_2 = \{a^i b^j c^k \,|\, i, j, k \geq 0\}$$

Then L is
(A) Not recursive
(B) Regular
(C) Context free but not regular
(D) Recursively enumerable but not context free

[GATE 2009 : IIT Roorkee]

Q.5 Consider the following languages

$$L_1 = \{0^p 1^q 0^r \mid p, q, r \geq 0\}$$

$$L_2 = \{0^p 1^q 0^r \mid p, q, r \geq 0, p \neq r\}$$

generated by the given grammar?

$$S \rightarrow aS \,|\, bS \,|\, \varepsilon$$

(A) $\{a^n b^m \,|\, n, m \geq 0\}$
(B) $\{w \in \{a,b\}^* \,|\, w$ has equal number of a's and b's$\}$
(C) $\{a^n \,|\, n \geq 0\} \cup \{b^n \,|\, n \geq 0\} \cup \{a^n b^n \,|\, n \geq 0\}$
(D) $\{a,b\}^*$

[GATE 2016 : IISc Bangalore]

Q.8 Language L_1 is defined by the grammar:

$$S_1 \rightarrow aS_1 b \,|\, \varepsilon$$

Language L_2 is defined by the grammar:

$$S_2 \rightarrow abS_2 \,|\, \varepsilon$$

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

[GATE 2016 : IISc Bangalore]

Q.9 A context-free grammar is ambiguous if :
(A) The grammar contains useless non-terminals.
(B) It produces more than one parse tree for same sentence.
(C) Some production has two non-terminals side by side on the right-hand side.
(D) None of the above.

[GATE 1987 : IIT Bombay]

Q.10 FORTRAN is a :
(A) Regular language.
(B) Context free language.
(C) Context sensitive language.
(D) None of the above.

[GATE 1987 : IIT Bombay]

Q.11 Consider the following grammar G :

$$S \rightarrow bS \,|\, aA \,|\, b$$

$$A \rightarrow bA \,|\, aB$$

$$B \rightarrow bB \,|\, aS \,|\, a$$

Let $N_a(w)$ and $N_b(w)$ denote the number of a's and b's in a string w respectively. The language $L(G) \subseteq \{a,b\}^+$ generated

terminals and Y is a non-terminal), is always regular.
4. The derivation trees of strings generated by a context-free grammar in Chomsky Normal form are always binary trees.

(A) 1, 2, 3 and 4
(B) 2, 3 and 4 only
(C) 1, 3 and 4 only
(D) 1, 2 and 4 only

[GATE 2008 : IISc Bangalore]

Q.13 Match the following **List-I** with **List-II**

List-I

(E) Checking that identifiers are declared before their use
(F) Number of formal parameters in the declaration of a function agrees with the number of actual parameters in a use of that function
(G) Arithmetic expressions with matched pairs of parentheses
(H) Palindromes

List-II

(P) $L = \{a^n b^m c^n d^m \,|\, n \geq 1, m \geq 1\}$

(Q) $X \rightarrow XbX \,|\, XcX \,|\, dXf \,|\, g$

(R) $L = \{wcw \,|\, w \in (a|b)^*\}$ (S)

$X \rightarrow bXb \,|\, cXc \,|\, \varepsilon$

by G is

(A) $\{w|N_a(w) > 3N_b(w)\}$

(B) $\{w|N_b(w) > 3N_a(w)\}$

(C) $\{w|N_a(w) = 3k, k \in \{0,1,2,...\}\}$

(D) $\{w|N_b(w) = 3k, k \in \{0,1,2,...\}\}$

[GATE 2004 : IIT Delhi]

Q. 12 Which of the following statements are true?

1. Every left-recursive grammar can be converted to a right-recursive grammar and vice-versa.
2. All ε-productions can be removed from any context-free grammar by suitable transformations.
3. The language generated by a context-free grammar all of whose productions are of the form $X \to w$ or $X \to wY$ (where, w is a string of

Codes :

(A) $E-P, F-R, G-Q, H-S$

(B) $E-R, F-P, G-S, H-Q$

(C) $E-R, F-P, G-Q, H-S$

(D) $E-P, F-R, G-S, H-Q$

[GATE 2008 : IISc Bangalore]

Q. 14 $S \to aSa|bSb|a|b$

The language generated by the above grammar over the alphabets {a, b} is the set of

(A) All palindromes

(B) All odd length palindromes

(C) Strings that begin and end with the same symbol

(D) All even length palindromes

[GATE 2009 : IIT Roorkee]

Q.15 Consider the languages

$L_1 = \{0^i1^j | i \neq j\}, L_2 = \{0^i1^j | i = j\},$

$L_3 = \{0^i1^j | i = 2j+1\},$

$L_4 = \{0^i1^j | i \neq 2j\},$

Which one of the following statement is true?

(A) Only L_2 is context free

(B) Only L_2 and L_3 are context free

(C) Only L_1 and L_2 are context free

(D) All are context free

[GATE 2010 : IIT Guwahati]

Q.16 Which of the following languages are context-free?

$L_1 = \{a^m b^n a^n b^m | m, n \geq 1\}$

$L_2 = \{a^m b^n a^m b^n | m, n \geq 1\}$

$L_3 = \{a^m b^n | m = 2n+1\}$

(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

[GATE 2015 : IIT Kanpur]

Q.17 Consider the following context-free grammars :

$G_1 : S \to aS|B, B \to b|bB$

$G_2 : S \to aA|bB, A \to aA|B|\varepsilon, B \to bB|\varepsilon$

Which one of the following pairs of languages is generated by G_1 and G_2, respectively?

(A) $\{a^m b^n | m > 0 \text{ or } n > 0\}$ and

$\{a^m b^n | m > 0 \text{ and } n > 0\}$

(A) $\{(ab)^n (cb)^n | n \geq 1\}$

(B) $\{(ab)^n cb^{m_1} cb^{m_2} ... cb^{m_n} | n, m_1, m_2, ..., m_n \geq 1\}$

(C) $\{(ab)^n (cb^m)^n | m, n \geq 1\}$

(D) $\{(ab)^n (cb^n)^m | m, n \geq 1\}$

[GATE 2017 : IIT Roorkee]

Q.19 Identify the language generated by the following grammar, where S is the start variable.

$S \to XY$

$X \to aX|a$

$Y \to aYb|\varepsilon$

(A) $\{a^m b^n | m \geq n, n > 0\}$

(B) $\{a^m b^n | m \geq n, n \geq 0\}$

(C) $\{a^m b^n | m > n, n \geq 0\}$

(D) $\{a^m b^n | m > n, n > 0\}$

[GATE 2017 : IIT Roorkee]

Q. 20 If G is a grammar with productions

$S \to SaS|aSb|bSa|SS|\varepsilon$

Where S is the start variable, then which one of the following string is not generated by G?

(A) abab (B) aaab

(C) abbaa (D) babba

[GATE 2017 : IIT Roorkee]

Q.21 Consider the context-free grammar over the alphabet {a, b, c} given below

$\{a^m b^n \mid m>0$ and $n>0\}$

(B) $\{a^m b^n \mid m>0$ and $n>0\}$ and $\{a^m b^n \mid m>0$ or $n\geq 0\}$

(C) $\{a^m b^n \mid m\geq 0$ or $n>0\}$ and $\{a^m b^n \mid m>0$ and $n>0\}$

(D) $\{a^m b^n \mid m\geq 0$ and $n>0\}$ and $\{a^m b^n \mid m>0$ or $n>0\}$

[GATE 2016 : IISc Bangalore]

Q.18 Consider the following context-free grammar over the alphabet $\Sigma=\{a,b,c\}$ with S as the start symbol :

$S \rightarrow abScT \mid abcT$

$T \rightarrow bT \mid b$

Which one of the following represents the language generated by the above grammar?

over the alphabet {a, b, c} given below. S and T are non-terminals.

$G_1 : S \rightarrow aSb \mid T, T \rightarrow cT \mid \varepsilon$

$G_2 : S \rightarrow bSa \mid T, T \rightarrow cT \mid \varepsilon$

The language $L(G_1) \cap L(G_2)$ is

(A) Finite
(B) Not finite but regular
(C) Context free but not regular
(D) Recursive but not context free

[GATE 2017 : IIT Roorkee]

Q.22 Which one of following kinds of derivation is used by LR parsers?

(A) Leftmost
(B) Leftmost in reverse
(C) Rightmost
(D) Rightmost in reverse

[GATE 2019 : IIT Madras]

Q.23 Consider the grammar given below:

S → Aa

A → BD

B → b | ε

D → d | ε

Let a,b,d, and $ be indexed as follows:

a	b	d	$
3	2	1	0

Compute the FOLLOW set of the non-terminal B and write the index values for the symbols in the FOLLOW set in the descending order. (For example, if the FOLLOW set is {a, b, d,$}, then the answer should be 3210)

[GATE 2019 : IIT Madras]

Q.24 Consider the augmented grammar given below :

$S' \rightarrow S$

$S \rightarrow \langle L \rangle \mid \text{id}$

$L \rightarrow L, S \mid S$

Let $I_0 = \text{CLOSURE}(\{[S' \rightarrow \bullet S]\})$.

The number of items in the set GOTO $(I_0, \langle\ )$ is : _____.

[GATE 2019 : IIT Madras]

Q.25 The C language is

(A) A context free language
(B) A context sensitive language
(C) A regular language

Q.26 Consider the language $L = \{a^n \mid n \geq 0\} \cup \{a^n b^n \mid n \geq 0\}$ and the following statements.

I. L is deterministic context-free.
II. L is context-free but not deterministic context-free.
III. L is not LL(k) for any k.

Which of the above statements is/are TRUE?

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

[GATE 2002 : IISc Bangalore]

Q.27 Which of the following features cannot be captured by context-free grammar?

(A) Syntax of if-then-else statements
(B) Syntax of recursive procedures
(C) Whether a variable has been declared before its use
(D) Variable names of arbitrary length.

[GATE 2019 : IIT Madras]

Q.28 The lexical analysis for a modern computer language such as java needs the power of which one of the following machine models in a necessary and sufficient sense?

(A) Finite state automata
(B) Deterministic pushdown automata
(C) Non-deterministic pushdown automata
(D) Turing machine

[GATE 2011 : IIT Madras]

(D) Parsable fully only by a Turing machine

[GATE 2002 : IISc Bangalore]

Practice Questions

Q.1 $G: S \to aS|bA$

$A \to aA|bC|\in$

$C \to aC|bS$

Language accepted by above grammar is

(A) $L(G) = (a+b)^*$

(B) $L(G) = \{W \in \{a,b\}^* |$ Number of b's are odd$\}$

(C) $L(G) = \{W \in \{a,b\}^* | \#_b(W) \bmod 3 = 0\}$

(D) $L(G) = \{W \in \{a,b\}^* | \#_b(W) \bmod 3 = 1\}$

Q.2 $G: S \to AB|BC$

$B \to aAb|\in$

$A \to aA|a$

$C \to bC|a$

Language accepted by above grammar is

(A) $L(G) = \{a^n b^n | n \geq 1\}$

(B) $L(G) = \{a^n b^m | n > m\}$

(C) $L(G) = \{a^n b^m | m > n\}$

(D) $L(G) = \{a^n b^m | n \neq m\}$

Q.3 Which of the following CFLS is represented by following grammar?

$S \to AB / CD$

$C \to 0C / \in$

$A \to 0A1 / \in$

$D \to 1D2 / \in$

$B \to 0B / \in$

(A) $\{0^i 1^j 2^k | i = j < k \text{ OR } i > j = k\}$

(B) $\{0^i 1^j 2^k | i = j \text{ OR } j = k\}$

(C) $\{0^i 1^j 2^k | i = j = k \text{ OR } i > j = k\}$

(D) None.

Q.4 Consider the following grammar.

$G_1: S \to bA | aB$

$A \to aS | bAA | a$

$B \to bS | bBB | b$

$G_2: S \to aSbS | bSaS | \in$

Which one is /are TRUE?

(A) $L(G_1) = L(G_2)$

(B) $L(G_1) \subseteq L(G_2)$

(C) $L(G_1) \cap L(G_2) = \phi$

(D) $L(G_2) \cup \{\in\} = L(G_1)$

Q.5 Consider following grammar:-

$G: \{ \quad S \to aA,$

$A \to aA | bA$

(C) It is necessarily non- regular

(D) None of the above

Common Data for Q.7 & Q.8 Questions

Consider the context- free grammar

$E \to E + E$

$E \to (E * E)$

$E \to id$

Where E is the starting symbol, the set of terminals is $\{id, (, +,), *\}$, and the set of non-terminals is {E}.

Q.7 Which of the following terminal strings has more than one parse tree when parsed according to the above grammar?

(A) $id + id + id + id$

(B) $id + (id * (id * id))$

(C) $(id * (id * id)) + id$

(D) $((id * id + id) * id)$

Q.8 For the terminal string with more than one parse tree obtained as solution to Q. 8A. How many parse trees are possible?

(A) 5 (B) 4

(C) 3 (D) 2

Q.9 Let L be a context-free language and M a regular language. Then the language $L \cap M$ is

(A) Always regular

(B) Never regular

(C) Always a deterministic context-free language

(D) Always a context-free language

Q.10 Consider an ambiguous grammar G

$$B \to bB \mid cC \mid c$$
$$C \to cC \mid c \quad \}$$

The $L(G_1)$?

(A) $a^*b^*c^*$ (B) $aa^*b^*c^*$

(C) $aa^*bb^*cc^*$ (D) $(abc)^*$

Q.6 Let L be a regular language and M be a context free language, both over the alphabet Σ. Let L^c and M^c denote the complements of L and M respectively. Which of the following statements about the language $L^c \cup M^c$ is TRUE?

(A) It is necessarily regular but not necessarily context free

(B) It is necessarily context free

Q.10 Consider an ambiguous grammar G and its disambiguated version D. Let the language recognized by the two grammars be denoted by $L(G)$ and $L(D)$ respectively.

(A) $L(D) \subset L(G)$ (B) $L(D) \supset L(G)$

(C) $L(D) = L(G)$ (D) $L(D)$ is empty

Q.11 The two grammars given below generate a language over the alphabet $\{x, y, z\}$

$G1: S \to x \mid z \mid xS \mid zS \mid yB$

$B \to y \mid z \mid yB \mid zB$

$G1: S \to y \mid z \mid yS \mid zS \mid xB$

$B \to y \mid yS$

Which of the following choices describes the properties satisfied by the strings in these languages?

(A) G1: No y appears before any x
G2: Every x is followed by at least one y

(B) G1: No y appears before any x
G2: No x appears before any y

(C) G1: No y appears after any x
G2: Every x is followed by at least one y

(D) G1: No y appears after any x
G2: Every y is followed by at least one x

Q.12 Consider the grammar

$S \to ABCc \mid bc$

$BA \to AB$

$Bb \to bb$

$Ab \to ab$

$Aa \to aa$

Which of the following sentence can be derived by this grammar?

(A) abc (B) aab

(C) abcc (D) abbc

Answer Key

Classroom Practice Questions									
1.	C	2.	A	3.	B	4.	C	5.	D
6.	A	7.	D	8.	C	9.	B	10.	B
11.	C	12.	C	13.	C	14.	B	15.	D
16.	B	17.	D	18.	B	19.	C	20.	C
21.	B	22.	D	23.	31	24.	5	25.	B
26.	C	27.	C	28.	A				
Self - Practice Questions									
1.	D	2.	D	3.	A	4.	B	5.	C
6.	A	7.	A	8.	A	9.	D	10.	C
11.	A	12.	A						

❑❑❑

4 Push Down Automata

Classroom Questions

Q.1 Context free languages and regular languages are both closed under the operation(s) of :
(A) Union
(B) Intersection
(C) Concatenation
(D) Complementation

[GATE 1989 : IIT Kanpur]

Q.2 Context-free languages are
(A) Closed under union
(B) Closed under complementation
(C) Closed under intersection
(D) Closed under Kleene closure.

[GATE 1992 : IIT Delhi]

Q.3 If L_1 and L_2 are context free languages and R is a regular set, one of the languages below is not necessarily a context free language. Which one?
(A) L_1L_2 (B) $L_1 \cap L_2$
(C) $L_1 \cap R$ (D) $L_1 \cup L_2$

[GATE 1996 : IISc Bangalore]

Q.4 Which of the following languages over {a, b, c} is accepted by a deterministic push down automata?
(A) $\{wcw^R \mid w \in \{a,b\}^*\}$
(B) $\{ww^R \mid w \in \{a,b,c\}^*\}$
(C) $\{a^nb^nc^n \mid n \geq 0\}$
L_E the set of all languages accepted by empty stack. Which of the following is true?
(A) $L_D = L_E$
(B) $L_D \supset L_E$
(C) $L_D \subset L_E$
(D) None of the above

[GATE 1999 : IIT Bombay]

Q.7 If L_1 is a context free language and L_2 is a regular language which of the following is/are false?
(A) $L_1 - L_2$ is not context free
(B) $L_1 \cap L_2$ is context free
(C) $\sim L_1$ is context free
(D) $\sim L_2$ is regular

[GATE 1999 : IIT Bombay]

Q.8 Which of the following statement is true?
(A) If a language is context free it can always be accepted by deterministic pushdown automaton
(B) The union of two context free languages is context free
(C) The intersection of two context free languages is context free
(D) The complement of a context free

(D) $\{w|w$ is a palindrome over {a, b, c}$\}$

[GATE 1997 : IIT Madras]

Q.5 Context free languages are closed under :

(A) Union, intersection

(B) Union, Kleene closure

(C) Intersection, complement

(D) Complement, Kleene Closure

[GATE 1999 : IIT Bombay]

Q.6 Let L_D be the set of all languages accepted by a PDA by final state and language is context free

[GATE 2001 : IIT Kanpur]

Q.9 The language accepted by a Pushdown Automation in which the stack is limited to 10 items is best described as

(A) Context free

(B) Regular

(C) Deterministic Context Free

(D) Recursive

[GATE 2002 : IISc Bangalore]

Q.10 Let $G = (\{S\}, \{a, b\}, R, S)$ be a context free grammar where the rule set R is

$$S \to aSb | S\,S | \varepsilon$$

Which of the following statements is true?

(A) G is not ambiguous

(B) There exist $x, y \in L(G)$ such that $xy \notin L(G)$

(C) There is a deterministic pushdown automaton that accepts $L(G)$

(D) We can find a deterministic finite state automaton that accepts $L(G)$

[GATE 2003 : IIT Madras]

Q.11 The language $\{a^m b^n c^{m+n} | m, n \geq 1\}$ is

(A) Regular

(B) Context free but not regular

(C) Context sensitive but not context free

(D) Type-0 but not context sensitive

[GATE 2004 : IIT Delhi]

Q.12 Let $M = (K, \Sigma, F, \Delta, S, F)$ be a pushdown automaton.

Where, K= {s, f}, F = {f},

$\Sigma = \{a, b\}, F = \{a\}$ and

$$\Delta = \{((s, a, \varepsilon), (s, a)), ((s, b, \varepsilon), (s, a)), ((s, a, \varepsilon), (f, \varepsilon)), ((f, a, a), (f, \varepsilon)), ((f, b, a), (f, \varepsilon))\}.$$

Which one of the following strings is not a member of L(M) ?

(A) aaa (B) aabab

(C) baaba (D) bab

[GATE 2004 : IIT Delhi]

(B) $D_f \subset N_f$ *and* $D_p = N_P$

(C) $D_f = N_f$ *and* $D_p = N_P$

(D) $D_f = N_f$ *and* $D_p \subset N_P$

[GATE 2005 : IIT Bombay]

Q.14 Consider the languages :

$L_1 = \{a^n b^n c^m | n, m > 0\}$ and

$L_2 = \{a^n b^n c^m | n, m > 0\}$

Which one of the following statement is FALSE?

(A) $L_1 \cap L_2$ is a context-free language

(B) $L_1 \cup L_2$ is a context-free language

(C) L_1 and L_2 are context-free languages

(D) $L_1 \cap L_2$ is a context sensitive language

[GATE 2005 : IIT Bombay]

Q.15 Consider the languages :

$L_1 = \{w w^R | w \in \{0,1\}^*\}$

$L_2 = \{w \# w^R | w \in \{0,1\}^*\}$ where # is a special symbol

$L_3 = \{w w | w \in \{0,1\}^*\}$

Which one of the following is TRUE?

(A) L_1 is a deterministic CFL

(B) L_2 is a deterministic CFL

(C) L_3 is a CFL, but not a deterministic CFL

(D) L_3 is a deterministic CFL

[GATE 2005 : IIT Bombay]

Q.16 Let $L_1 = \{0^{n+m} 1^n 0^m | n, m \geq 0\}$,

$L_2 = \{0^{n+m} 1^{n+m} 0^m | n, m \geq 0\}$, and

$L_3 = \{0^{n+m} 1^{n+m} 0^{n+m} | n, m \geq 0\}$

Q.13 Let N_f and N_p denote the classes of languages accepted by non-deterministic finite automata and non-deterministic push-down automata, respectively. Let D_f and D_p denote the classes of languages accepted by deterministic finite automata and deterministic push-down automata, respectively. Which one of the following is TRUE?

(A) $D_f \subset N_f$ *and* $D_p \subset N_P$

Which of these languages are NOT context free?

(A) L_1 only (B) L_3 only

(C) L_1 *and* L_2 (D) L_2 *and* L_3

[GATE 2006 : IIT Kharagpur]

Q.17 Consider the following statements about the context-free grammar $G = \{S \to SS,\ S \to ab,\ S \to ba,\ S \to \varepsilon\}$

1. G is ambiguous
2. G produces all strings with equal number of a's and b's

3. G can be accepted by a deterministic PDA.

Which combination below expresses all the true statements about G?

(A) 1 only (B) 1 and 3 only

(C) 2 and 3 only (D) 1, 2 and 3

[GATE 2006 : IIT Kharagpur]

Q.18 The language $L = \{0^i 2^j 1^i \mid i \geq 0\}$ over the alphabet {0, 1, 2} is

(A) Not recursive.

(B) Is recursive and is a deterministic CFL.

(C) Is a regular language.

(D) None

[GATE 2007 : IIT Kanpur]

Q. 19 Which one of the following is FALSE?

(A) There is a unique minimal DFA for every regular language

(B) Every NFA can be converted to an equivalent PDA

(C) Complement of every context free language is recursive

(D) Every non deterministic PDA can be converted to an equivalent deterministic PDA

[GATE 2009 : IIT Roorkee]

Q.20 Consider the languages L_1, L_2 and L_3 as given below.

$L_1 = \{0^p 1^q \mid p, q \in N\}$

$L_2 = \{0^p 1^q \mid p, q \in N$ and $p = q\}$ and

$L_3 = \{0^p 1^q 0^r \mid p, q, r \in N$ and $p = q = r\}$

Which of the following statements is not TRUE?

(A) Pushdown automata (PDA) can be used to recognize L_1 and L_2

(B) L_1 is a regular language

(C) All the three languages are context free

Here, w^r is the reverse of the string w. Which of these language are deterministic context-free languages?

(A) None of the languages

(B) Only L_1

(C) Only L_1 and L_2

(D) All the three languages.

[GATE 2011 : IIT Madras]

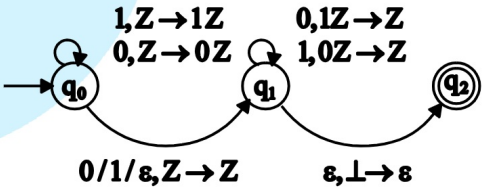
Q.22 Consider the NPDA

$(Q = \{q_0, q_1, q_2\}, \Sigma = \{0,1\},$

$\Gamma = \{0,1,\perp\}, \delta, q_0,$

$\perp, F = \{q_2\}),$

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 101100 so that the overall string is accepted by the automaton?

(A) 10110 (B) 10010

(C) 01010 (D) 01001

[GATE 2015 : IIT Kanpur]

Q.23 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

(D) Turing machines can be used to recognize all the languages.

[GATE 2011 : IIT Madras]

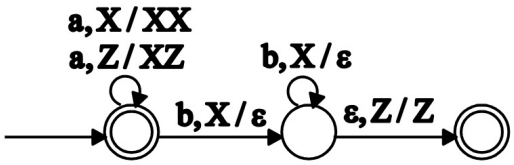
Q.21 Consider the following languages over the alphabet $\Sigma = \{0,1,c\}$:

$L_1 = \{0^n 1^n \mid n \geq 0\}$

$L_2 = \{wcw^r \mid w \in \{0,1\}^*\}$

$L_3 = \{ww^r \mid w \in \{0,1\}^*\}$

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 Turning 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

[GATE 2016 : IISc Bangalore]

Q.24 Consider the following languages :

$L_1 = \{a^n b^m c^{n+m} \mid m,n \geq 1\}$

$L_2 = \{a^n b^n c^{2n} \mid n \geq 1\}$

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.

[GATE 2016 : IISc Bangalore]

Q.25 Let L_1, L_2 be any two context-free languages and R be any regular language. Then which of the following is/are CORRECT?

(i) $L_1 \cup L_2$ is context free

(ii) $\overline{L_1}$ is context free

(iii) $L_1 - R$ is context free

(iv) $L_1 \cap L_2$ is context free

(A) (i), (ii) and (iv) only

(B) (i) and (iii) only

(C) (ii) and (iv) only

(D) (i) only

[GATE 2017 : IIT Roorkee]

Q.26 Consider the following language over the alphabet $\Sigma = \{a,b,c\}$.

Let $L_1 = \{a^n b^n c^m \mid m,n \geq 0\}$ and

$L_2 = \{a^m b^n c^n \mid m,n \geq 0\}$.

$L_1 = \{a^p \mid p \text{ is a prime number}\}$

$L_2 = \{a^n b^m c^{2m} \mid n \geq 0, m \geq 0\}$

$L_3 = \{a^n b^n c^{2n} \mid n \geq 0\}$

$L_4 = \{a^n b^n \mid n \geq 1\}$

Which of the following are CORRECT?

I. L_1 is context free but not regular

II. L_2 is not context –free.

III. L_3 is not context-free but recursive

IV. L_4 is deterministic context-free

(A) I, II and IV only

(B) II and III only

(C) I and IV only

(D) III and IV only

[GATE 2017 : IIT Roorkee]

Q.28 Consider the following languages :

I. $\left\{ a^m b^n c^p d^q \mid m+p = n+q, \text{ where } m,n,p,q \geq 0 \right\}$

II. $\left\{ a^m b^n c^p d^q \mid m = n \text{ and } p = q, \text{ where } m,n,p,q \geq 0 \right\}$

III. $\left\{ a^m b^n c^p d^q \mid m = n = p \text{ and } p \neq q, \text{ where } m,n,p,q \geq 0 \right\}$

IV. $\left\{ a^m b^n c^p d^q \mid mn = p+q, \text{ where } m,n,p,q \geq 0 \right\}$

Which of the languages above are context-free?

(A) I and IV only (B) I and II only

(C) II and III only (D) II and IV only

[GATE 2018 : IIT Guwahati]

Q.29 Which one of the following languages over $\Sigma = \{a,b\}$ is NOT context-free?

(A) $\{ww^R \mid w \varepsilon \{a,b\}^*\}$

(B) $\{wa^n b^n w^R \mid w \varepsilon \{a,b\}^*, n \geq 0\}$

(C) $\{wa^n w^R b^n \mid w \varepsilon \{a,b\}^*, n \geq 0\}$

Which of the following are context-free languages?

I. $L_1 \cup L_2$ II. $L_1 \cap L_2$

(A) I only (B) II only

(C) I and II (D) Neither I nor II

[GATE 2017 : IIT Roorkee]

Q.27 Consider the following languages.

(D) $\{a^n b^i \mid i \varepsilon \{n, 3n, 5n\}^*, n \geq 0\}$

[GATE 2019 : IIT Madras]

Q.30 Consider the following languages.

$L_1 = \{wxyx \mid w, x, y \in (0+1)^+\}$

$L_2 = \{xy \mid x, y \in (a+b)^*, |x| = |y|, x \neq y\}$

Which one of the following is TRUE?

(A) L_1 is regular and L_2 is context-free.

(B) L_1 is context-free but not regular and L_2 is context-free.

(C) Neither L_1 nor L_2 is context-free.

(D) L_1 is context-free but L_2 is not context-free.

[GATE 2020 : IIT Delhi]

Practice Questions

Q.1 Which of the following language can't be solved by deterministic PDA?

(A) $L = \{a^n b^n \mid n \geq 1\}$

(B) $L = \{a^n b^m c^m \mid n \geq 0 \text{ and } m \geq 1\}$

(C) $L = \{a^n b^n \mid n \geq 0\} \cup \{a^n b^{2n} \mid n \geq 0\}$

(D) $L = \{a^n b^m \mid n \neq m\}$

Q.2 Which of the following options OR statement is/ are correct/

$S1: \{a^n b^n c^m \mid n \leq m \leq 2n\}$ is CFL

$S1: \{a^i b^j \mid i = j \text{ OR } i = 2j\}$ is DCFL.

(A) $S1$ only (B) $S2$ only

(C) Both (D) None.

Q.3 Consider the following grammar:-

$G_1 : S \to aSa \mid a$

$G_2 : S \to aSa \mid b$

Which of the options is / are TRUE

(A) $L(G_1)$ and $L(G_2)$ are regular

(B) $L(G_1)$ is regular but $L(G_2)$ is CFL

(C) Both $L(G_1)$ and $L(G_2)$ are CFL

(D) $L(G_2)$ is regular but $L(G_1)$ is CFL

Q.4 Equivalent CFL for

$G = \{S \to aS \mid aSbS \mid \in\}$

(A) $L = \{X \mid X$ is a palindromes$\}$

(B) $L = \{X \mid X = a^n b^n \not\vdash n \geq 0\}$

(C) $L = \{X \mid$ each prefix oF 'X' has atleast as many a' s as b's$\}$

(D) $L = \{X \mid X$ has equal no. of a's and b's$\}$

Q.5 Which of the following options is/are

Q.6 Which of the following options is/are TURE?

(A) $L = \{a^i b^j \mid i \geq 0, j = n^2\}$ is not CFL

(B) For grammar $G = \{S \to aSb \mid SS \mid \in\}$ The $L(G)$ can be solved by DPDA.

(C) $L = \{wx^n w^R y^n \mid w \in \{x, y\}^*\}$ is CRL.

(D) For $L = \{ww \mid w \in \{a, b\}^*\}, \overline{L}$ is not CFL.

Q.7 Consider the regular grammar below

$S \to bS \mid aA \mid \varepsilon$

$A \to aS \mid bA$

The Myhill- Nerode equivalence classes for the language generated by the grammar are

(A) $\begin{Bmatrix} \{w \varepsilon (a+b)^* \mid \#_a(w) \text{ is even}\} \text{and} \\ \{w \varepsilon (a+b)^* \mid \#_a(w) \text{ is odd}\} \end{Bmatrix}$

(B) $\begin{Bmatrix} \{w \varepsilon (a+b)^* \mid \#_b(w) \text{ is even}\} \text{and} \\ \{w \varepsilon (a+b)^* \mid \#_b(w) \text{ is odd}\} \end{Bmatrix}$

(C) $\begin{Bmatrix} \{w \in (a+b)^* \mid \#_a(w) = \#_a(w)\} \\ \text{and } (w \in (a+b)^* \mid \#_a(w) \text{is even}\} \text{and} \\ \{w \varepsilon (a+b)^* \mid \#_a(w) \neq \#_b(w)\} \end{Bmatrix}$

(D) $\{\varepsilon\}, \begin{Bmatrix} wa \mid w \in (a+b)^* \text{and} \\ wb \mid w \in (a+b)^* \end{Bmatrix}$

Q.8 Consider the pushdown automaton (PDA) below which runs over the input alphabet (a, b, c). It has the stack alphabet $\{Z_0, X\}$ where Z_0 is the bottom-of-stack market. The set of states of the PDA is {s, t, u, f} where s is the start and f is the final state. The

Q.5 Which of the following options is/are CFL?

(A) $L=\{ww \mid w \in \{a,b\}^*\}$

(B) $L=\{w_1 w_2 \mid w_1 \neq w_2 \text{ and } w_1, w_2 \in \{a,b\}^*\}$

(C) $L=\{a^n b^m c^n d^m \mid n,m \geq 0\}$

(D) $L=\{x\,w\,y\,w \mid a,y,w \in \{a,b\}^+\}$

PDA accepts by final state. The transitions of the PDA given below are depicted in a standard manner. For example, the transition $(s,b,X) \rightarrow (t,XZ_0)$ means that if the PDA is in state a and the symbol on the top of the stack is X, then it can

read b from the input and move to state t after popping the top of stack and pushing the symbols Z_0 and X (in that order) on the stack.

$(s,a,Z_0) \rightarrow (s,XXZ_0)$

$(s,\varepsilon,Z_0) \rightarrow (f,\varepsilon)$

$(s,a,X) \rightarrow (s,XXX)$

$(s,b,X) \rightarrow (t,\varepsilon)$

$(t,b,X) \rightarrow (t,\varepsilon)$

$(t,c,X) \rightarrow (u,\varepsilon)$

$(u,c,X) \rightarrow (u,\varepsilon)$

$(u,\varepsilon,Z_0) \rightarrow (f,\varepsilon)$

The language accepted by the PDA is

(A) $\{a^\ell b^m c^n \mid \ell = m = n\}$

(B) $\{a^\ell b^m c^n \mid \ell = m\}$

(C) $\{a^\ell b^m c^n \mid 2\ell = m+n\}$

(D) $\{a^\ell b^m c^n \mid m = n\}$

Q.9 In the context-free grammar below, S is the start symbol, a and b are terminals, and ε denotes the empty string.

$S \rightarrow aSAb \mid \varepsilon$

$A \rightarrow bA \mid \varepsilon$

The grammar generates the language

(A) $\left((a+b)^* b\right)^*$ (B) $\{a^m b^n \mid m \leq n\}$

(C) $\{a^m b^n \mid m = n\}$ (D) $a^* b^*$

Q.10 Which of the following languages is accepted by a non-deterministic pushdown automaton (PDA) but NOT by a deterministic PDA?

(A) $\{a^n b^n c^n \mid n \geq 0\}$

(B) $\{a^\ell b^m c^n \mid \ell \neq m \text{ or } m \neq n\}$

(C) $\{a^n b^n \mid n \geq 0\}$

(D) $\{a^m b^n \mid m,n \geq 0\}$

Q.11 Consider the following languages.

$L_1 = \{a^i b^j c^k \mid i = j, k \geq 1\}$

$L_1 = \{a^i b^j \mid j = 2i, i \geq 0\}$

Which of the following is true?

(A) L_1 is not a CFL but L_2 is

(B) $L_1 \cap L_2 = \phi$ and L_1 is non-regular

(C) $L_1 \cup L_2$ is not a CFL but L_2

(D) There is a 4-state PDA that accepts L_1, but there is no DPDA that accepts L_2

Q.12 Which of the following languages is (are) non-regular?

$L_1 = \{0^m 1^n \mid 0 \leq m \leq n \leq 10000\}$

$L_2 = \{w \mid w$ reads the same forward and backward$\}$

$L_3 = \{w \in \{0,1\}^* \mid w$ contains an even number of 0's and an even number of 1's$\}$

(A) L_2 and L_3 only (B) L_1 and L_2 only

(C) L_3 only (D) L_2 only

Answer Key

Classroom Practice Questions									
1.	A, C	2.	A, D	3.	B	4.	A	5.	B
6.	A	7.	A	8.	B	9.	B	10.	C
11.	B	12.	B	13.	D	14.	A	15.	B
16.	D	17.	B	18.	D	19.	D	20.	D
21.	C	22.	B	23.	D	24.	B	25.	B
26.	A	27.	D	28.	B	29.	C	30.	A
Practice Questions									

1.	C	2.	D	3.	B	4.	C	5.	B, D
6.	A, C	7.	A	8.	C	9.	B	10.	B
11.	B	12.	D						

❑❑❑

5 TM and Un-Decidability

Classroom Questions

Q.1 Let L_1 be a recursive language. Let L_2 and L_3 be languages that are recursively enumerable but not recursive. Which of the following statement is not necessarily true?

(A) $L_2 - L_1$ is recursively enumerable

(B) $L_1 - L_3$ is recursively enumerable.

(C) $L_2 \cap L_3$ is recursively enumerable.

(D) $L_2 \cup L_3$ is recursively enumerable.

[GATE 2010 : IIT Guwahati]

Q.2 Consider the following decision problems :

P_1 : Does a given finite state machine accept a given string.

P_1 : Does a given context free grammar generate an infinite number of strings.

Which of the following statement is true?

(A) Both (P_1) and (P_2) are decidable

(B) Neither (P_1) nor (P_2) are decidable

(C) Only (P_1) is decidable

(D) Only (P_2) is decidable

[GATE 2000 : IIT Kharagpur]

Q. 3 Which of the following statement is false?

(A) Every NFA can be converted to an equivalent DFA.

(B) Every non-deterministic Turing machine can be converted to an equivalent deterministic Turing machine.

(C) Every regular language is also a context free language.

(D) Every subset of a recursively enumerable set is recursive.

(B) Always recognizable by pushdown automata.

(C) Also called type (0) languages.

(D) Recognizable by Turing machines.

[GATE 1990 : IISc Bangalore]

Q.5 In which of the cases stated below is the following statement true?

"For every nondeterministic machine M_1 there exists an equivalent deterministic machine M_2 recognizing the same language".

(A) M_1 is nondeterministic finite automation

(B) M_1 is a nondeterministic PDA

(C) M_1 is a nondeterministic Turing machine

(D) For no machine M_1 use the above statement true

[GATE 1992 : IIT Delhi]

Q.6 Which of the following conversions is not possible (algorithmically)?

(A) Regular grammar to context-free grammar

(B) Non-deterministic FSA to deterministic FSA

(C) Non-deterministic PDA to deterministic PDA

(D) Non-deterministic Turing machine to deterministic Turing machine.

[GATE 1994 : IIT Kharagpur]

Q.7 Which one of the following is not decidable?

(A) Given a Turing machine M, a string s and an integer k, M accepts s within k steps

(B) Equivalence of two given Turing machines

(C) Language accepted by a given finite state machine is non empty

[GATE 2007 : IIT Kanpur]

Q.4 Recursive languages are :

(A) A proper superset of context free languages.

(D) Language generated by a context free grammar is non empty

[GATE 1997 : IIT Madras]

Q.8 Regarding the power of recognition of languages, which of the following statement is false?

(A) The non-deterministic finite-state automata are equivalent to deterministic finite-state automata.

(B) Non- deterministic Push-down automata are equivalent to deterministic Push-down automata.

(C) Non-deterministic Turing machines are equivalent to deterministic Turing machines.

(D) Multi-tape Turing machines are equivalent to single-tape Turing machines.

[GATE 1998 : IIT Delhi]

Q.9 Which of the following is true?

(A) The complement of a recursive language is recursive.

(B) The complement of a recursively enumerable language is recursively enumerable.

(C) The complement of a recursive language is either recursive or recursively enumerable.

(D) The complement of a context-free language is context-free.

[GATE 2002 : IISc Bangalore]

Q.10 If the strings of a language L can be effectively enumerated in lexicographic (i.e. alphabetic) order, which of the following statements is true?

(A) L is necessarily finite

(B) L is regular but not necessarily finite

(C) L is context free but not necessarily regular

(D) L is recursive but not necessarily context free

[GATE 2003 : IIT Madras]

Q.11 A single tape Turing Machine M has two states q_0 and q_1 of which q_0 is the starting state. The tape alphabet of M is {0, 1, B} and its input alphabet is {0,1}. The symbol B is the blank symbol

	0	1	B
q_0	$q_1,1,R$	$q_1 1,R$	Halt
q_1	$q_1,1,R$	$q_1,1,R$	q_0,B,L

The table is interpreted as illustrated below.

The entry $(q_1,1,R)$ in row q_0 and column 1 signifies that if M is in state q_0 and reads 1 on the current tape square, then it writes 1 on the same tape square, moves its tape head one position to the right and transitions to state q_1. Which of the following statement is true about M?

(A) M does not halt on any string in $(0+1)^+$

(B) M does not halt on any string in (00 + 1)*

(C) M halts on all string ending in a 0

(D) M halts on all string ending in a 1

[GATE 2003 : IIT Madras]

Q.12 Let L_1 be a recursive language, and let L_2 be a recursive enumerable but not a recursive language. Which one of the following is TRUE?

(A) $\overline{L}_1$ is recursive and $\overline{L}_2$ is recursively enumerable

(B) $\overline{L}_1$ is recursive and $\overline{L}_2$ is not recursively enumerable

(C) $\overline{L}_1$ and $\overline{L}_2$ are recursively enumerable

(D) $\overline{L}_1$ is recursively enumerable and $\overline{L}_2$ is recursive

[GATE 2005 : IIT Bombay]

Q.13 For $s \in (0+1)^*$, let d(s) denote the decimal value of s (e. g. d (101) = 5)

Let L = {s $\in$(0 + 1)* | d(s) mod 5 = 2 and d(s) mod $7 \neq 4$}

Which one of the following statement is true?

(A) L is recursively enumerable, but not recursive

(B) L is recursive, but not context free

used to indicate end of an input string. The transition function of M is described in the following table.

(C) L is context free, but not regular
(D) L is regular

[GATE 2006 : IIT Kharagpur]

Q.14 Let L_1 be a regular language, L_2 be a deterministic context-free language and L_3 be a recursively enumerable, but not recursive language. Which one of the following statement is false?

(A) $L_1 \cap L_2$ is a deterministic CFL

(B) $L_3 \cap L_1$ is recursive

(C) $L_1 \cup L_2$ is context free

(D) $L_1 \cap L_2 \cap L_3$ is recursively enumerable

[GATE 2006 : IIT Kharagpur]

Q.15 Which of the following is true for the language $\{a^p \mid p \text{ is prime}\}$?

(A) It is not accepted by a Turing machine
(B) It is regular but not context-free
(C) It is context-free but not regular
(D) It is neither regular nor context-free, but accepted by a Turing machine

[GATE 2008 : IISc Bangalore]

Q.16 If L and $\overline{L}$ are recursively enumerable then L is

(A) Regular
(B) Context free
(C) Context sensitive
(D) Recursive

[GATE 2008 : IISc Bangalore]

Q.17 Which of the following statement is/are FALSE?

1. For every non-deterministic Turing machine, there exits an equivalent deterministic Turing machine
2. Turing recognizable languages are closed under union and complementation
3. Turing decidable languages are closed under intersection and complementation
4. Turing recognizable languages are closed under union and intersection

(A) 1 and 4 only (B) 1 and 3 only
(C) 2 only (D) 3 only

[GATE 2013 : IIT Bombay]

Q.18 Let L be a language and $\overline{L}$ be its complement. Which one of the following is NOT a viable possibility?

(A) Neither L nor $\overline{L}$ is recursively enumerable (r.e.).

(B) One of L and $\overline{L}$ is r.e. but not recursive; the other is not r.e.

(C) Both L and $\overline{L}$ are r.e. but not recursive.

(D) Both L and $\overline{L}$ are recursive.

[GATE 2014 : IIT Kharagpur]

Q.19 Let $<M>$ be the encoding of a Turing machines as a string over $\Sigma = \{0,1\}$.

Let $L=\{<M> \mid M \text{ is a Turing machine that accepts a string of length } \{2014\}.$ Then, L is

(A) Decidable and recursively enumerable
(B) Un-decidable but recursively enumerable
(C) Un-decidable and not recursively enumerable
(D) Decidable but not recursively enumerable

[GATE 2014 : IIT Kharagpur]

Q.20 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. $L_1 \cup L_2$ is recursively enumerable

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

[GATE 2015 : IIT Kanpur]

Q.21 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. $\overline{L}_3 \cup L_4$ is recursively enumerable

II. $\overline{L}_2 \cup L_3$ is recursive

III. $L_1^* \cap L_2$ is context-free

IV. $L_1 \cup \overline{L}_2$ is context-free

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

[GATE 2016 : IISc Bangalore]

Q.22 Consider the following languages.

$L_1 = \{<M> | M$ takes at least 2016 steps on some input$\}$,

$L_2 = \{<M> | M$ takes at least 2016 steps on all inputs$\}$ and

$L_3 = \{<M> | M$ accepts $\varepsilon\}$,

Where for each Turing machine M, <M> 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 and L_3 is not recursive
(D) L_1, L_2, L_3 are recursive

[GATE 2016 : IISc Bangalore]

Q.23 Let L(R) be the language represented by regular expression R. Let L(G) be the language generated by a context free grammar G. Let L(M) be the language accepted by a Turing machine M.

Which of the following decision problems are undecidable?

I. Given a regular expression R and a string w, is $w \in L(R)$?

II. Given a context free grammar G, is $L(G) = \phi$?

III. Given a context free grammar G, is $L(G) = \Sigma^*$ for some alphabet Σ?

IV. Given a Turing machine M and a string w, is $w \in L(M)$?

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

[GATE 2017 : IIT Roorkee]

Q.24 The set of all recursively enumerable languages is

(A) closed under complementation.
(B) closed under intersection.
(C) a subset of the set of all recursive languages.
(D) an uncountable set.

[GATE 2018 : IIT Guwahati]

Q.25 Consider the following problems. $L(G)$ denotes the language generated by a grammar *G*. $L(M)$ denotes the language accepted by a machine *M*.

(I) For an unrestricted grammar *G* and a string *w*, whether $w \in L(G)$

(II) Given a Turning machine *M*, whether $L(M)$ is regular

(III) Given two grammars G_1 and G_2, whether $L(G_1) = L(G_2)$

(IV) Given an NFA *N*, whether there is a deterministic PDA *P* such that *N* and *P* accept the same language.

Which one of the following statements is correct?

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

[GATE 2018 : IIT Guwahati]

Q.26 Which of the following problems are un-decidable?

(A) Membership problem in context-free languages.
(B) Whether a given context-free language is regular.
(C) Whether a finite state automation halts on all inputs.
(D) Membership problem for type 0 languages

[GATE 1989 : IIT Kanpur]

Q.27 It is undecidable whether :

(A) An arbitrary Turing machine halts after 100 steps.
(B) A Turing machine prints a specific letter.

(C) A Turing machine computes the product of two numbers.
(D) None of the above.

[GATE 1990 : IISc Bangalore]

Q.28 Which one of the following is the strongest correct statement about a finite language over some finite alphabet $\sum$?
(A) It could be un-decidable
(B) It is Turing-machine recognizable
(C) It is a regular language
(D) It is a context-sensitive language

[GATE 1991 : IIT Madras]

Q.29 Which of the following statements is false?
(A) The halting problem for Turing machines is un-decidable
(B) Determining whether a context free grammar is un-decidable
(C) Given two arbitrary context free grammars G_1 and G_2 it is undecidable whether $L(G_1) = L(G_2)$
(D) Given two regular grammars G_1 and G_2, it is un-decidable whether $L(G_1) = L(G_2)$

[GATE 1996 : IISc Bangalore]

Q.30 Which of the following are decidable?
1. Whether the intersection of two regular language is infinite
2. Whether a given context-free language is regular
3. Whether two push-down automata accept the same language
4. Whether a given grammar is context-free

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

[GATE 2008 : IISc Bangalore]

Q.31 Which of the following problems are decidable?
1. Does a given program ever produce an output?
2. If L is a context-free language, then, is $\overline{L}$ also context-free?
3. If L is a regular language, then, is $\overline{L}$ also regular?
4. If L is a recursive language, then is $\overline{L}$ also recursive?

(A) $1,2,3,4$ (B) $1,2$
(C) $2,3,4$ (D) $3,4$

[GATE 2012 : IIT Delhi]

Q.32 Which of the following is/are undecidable?
1. G is a CFG. Is $L(G) = \Phi$?
2. G is a CFG. Is $L(G) = \sum^*$?
3. M is a Turing machines. Is $L(M)$ regular?
4. A is a DFA and N is an NFA. Is $L(A) = L(N)$?

(A) 3 only (B) 3 and 4 only
(C) 1, 2 and 3 only (D) 2 and 3 only

[GATE 2013 : IIT Bombay]

Q.33 Which one of the following problems is un-decidable?
(A) Deciding if a given context-free grammar is ambiguous.
(B) Deciding if a given string is generated by a given context-free grammar.
(C) Deciding if the language generated by a given context-free grammar is empty.
(D) Deciding if the language generated by a given context-free grammar is finite.

[GATE 2014 : IIT Kharagpur]

Q.34 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 $G = (N, \sum, P, S)$ and a string $x \in \sum^*$, 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

[GATE 2016 : IISc Bangalore]

Q.35 Define languages L_0 and L_1 as follows
$L_0 = \{< M, w, 0> | M \text{ halts on } w\}$

$L_1 = \{< M, w, 1 > | M$ does not halts on w$\}$

Here <M, w, i > is a triplet, whose first component, M is an encoding of a Turing machine, second component, w, is a string, and third component, i, is a bit.

Let $L = L_0 \cup L_1$. Which of the following is true?

(A) L is recursively enumerable, but $\overline{L}$ is not

(B) $\overline{L}$ is recursively enumerable, but L is not

(C) Both L and $\overline{L}$ are recursive

(D) Neither L nor $\overline{L}$ is recursively enumerable

[GATE 2003 : IIT Madras]

Q.36 L_1 is recursively enumerable language over Σ. An algorithm A effectively enumerates its words as $w_1, w_2, w_3 ....$ Define another language L_2 over $\Sigma \cup \{\#\}$ as $\{w_i \# w_j : w_i, w_j \in L_1, i < j\}$. Here # is a new symbol. Consider the following assertions :

S_1: L_1 is recursive implies L_2 is recursive

S_2 : L_2 is recursive implies L_1 is recursive

Which of the following statements is TRUE?

(A) Both S_1 and S_2 are true

(B) S_1 is true but S_2 is not necessarily true

(C) S_2 is true but S_1 is not necessarily true

(D) Neither is necessarily true

[GATE 2004 : IIT Delhi]

Q.37 Let $A \leq_m B$ denotes that language A is mapping reducible (also known as many-to-one reducible) to language B. Which one of the following is FALSE?

(A) If $A \leq_m B$ and B is recursive then A is recursive.

(B) If $A \leq_m B$ and A is undecidable then B is un-decidable.

(C) If $A \leq_m B$ and B is recursively enumerable then A is recursively enumerable.

(D) If $A \leq_m B$ and B is not recursively enumerable then A is not recursively enumerable.

[GATE 2004 : IIT Delhi]

Q.38 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 $\overline{Y}$ reduce to W and Z reduces to $\overline{X}$ (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.

[GATE 2016 : IISc Bangalore]

Q.39 Let A and B be finite alphabets and let # be a symbol outside both A and B. Let f be a total function from A* to B* . We say f is computable if there exists a Turing machine M which given an input x in A*, always halts with f(x) on its tape. Let L_f denote the languages $\{x\#f(x) | x \in A^*\}$.

Which of the following statement is TRUE:

(A) f is computable if and only if L_f is recursive

(B) f is computable if and only if L_f is recursively enumerable

(C) If f is computable then if L_f is recursive, but not conversely

(D) If f is computable then if L_f is recursive, but not conversely

[GATE 2017 : IIT Roorkee]

Q.40 Consider the following sets:
S1. Set of all recursively enumerable languages over the alphabet {0, 1}
S2. Set of all synthetically valid C programs
S3. Set of all languages over the alphabet {0, 1}
S4. Set of all non – regular languages over the alphabet {0, 1}
Which of the above sets are uncountable?
(A) S1 and S2 (B) S3 and S4
(C) S2 and S3 (D) S1 and S4

[GATE 2019 : IIT Madras]

Q.41 Consider the following problem X. "Given a Turing machine M over the input alphabet Σ, any state q of M and a word $w \in \Sigma^*$, does the computation of M on w visit the state q"
Which of the following statements about X is correct?
(A) X is decidable
(B) X is un-decidable but partially decidable
(C) X is un-decidable and not even partially decidable
(D) X is not a decision problem

[GATE 2001 : IIT Kanpur]

Q.42 Consider three decision problems P_1, P_2 and P_3. It is known that P_1 is decidable and P_2 is un-decidable. Which of the following is TRUE?
(A) P_3 is decidable if P_1 is reducible to P_3
(B) P_3 is un-decidable if P_3 is reducible to P_2
(C) P_3 is un-decidable if P_2 is reducible to P_3
(D) P_3 is decidable if P_3 is reducible to P_2's complement

[GATE 2005 : IIT Bombay]

Q.43 Let Σ be a finite non-empty alphabet and let 2^{Σ^*} be the power set of Σ^*. Which one of the following is TRUE?
(A) Both 2^{Σ^*} and Σ^* are countable
(B) 2^{Σ^*} is countable and Σ^* is uncountable
(C) 2^{Σ^*} in uncountable and Σ^* is countable
(D) Both 2^{Σ^*} and Σ^* are uncountable

[GATE 2014 : IIT Kharagpur]

Q.44 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 in NP.
(D) Both Q_1 and Q_2 are NP hard.

[GATE 2015 : IIT Kanpur]

Practice Questions

Q.1 Which of the following statements is false?
(A) Every context-sensitive language is recursive
(B) The set of all languages that are not recursively enumerable is countable.
(C) The family of recursively enumerable languages is closed under union.
(D) The families of recursively enumerable and recursive languages are closed under reversal.

Q.2 Which of the following problems is undecidable?
(A) To determine if two finite automata are equivalent
(B) To determine if two finite automata are equivalent

(C) Finiteness problem for finite automata
(D) Ambiguity problem for context free grammar

Q.3 Let S be an NP-complete problem. Q and R are other two problems not known to be NP. Q is polynomial time reducible to S and S is polynomial time reducible to R. Which of the following statements is true?
(A) R is NP-complete
(B) R is NP-hard
(C) Q is NP-complete
(D) Q is NP-hard

Q.4 Let L(R) be the language represented by regular expression R. Let L(G) be the language generated by a context free grammar G. Let L(M) be the language accepted by a Turing machine M. Which of the following decision problems are decidable? I. Whether L(G) is deterministic context free language? II. Whether L(G1)∩L(G2) is a context free language, where G1 and G2 are deterministic grammar? III. Given a context-free grammar G, is $L(G)=\Sigma^*$ for some alphabet Σ? IV. Given a Turing machine M and a string w, is $w \in L(M)$?
(A) III and IV only
(B) II and IV only
(C) I and II only
(D) None of the above

Q.5 Which of the following statement is false?
(A) Checking the ambiguity of CFL is decidable.
(B) Checking whether a given context free language is regular is decidable.
(C) Checking whether a given context free language is empty is decidable.
(D) Both A and B

Q.6 Which of the following statement is false?
(A) Checking the ambiguity of CFL is decidable.
(B) Checking whether a given context free language is regular is decidable.
(C) Checking whether a given context free language is empty is decidable.
(D) Both A and B

Q.7 Given the following two statements: S_1:If L_1 and L_2 are recursively enumerable languages over ∑, then $L_1 \cup L_2$ and $L_2 \cap L_2$ are also recursively enumerable. S_2: The set of recursively enumerable languages is countable. Which of the following is correct ?
(A) S_1 is correct and S_2 is not correct
(B) S_1 is not correct and S_2 is correct
(C) Both S_1 and S_1 are not correct.
(D) Both S_1 and S_1 are correct.

Q.8 A problem whose language is recursive is called?
(A) Unified problem
(B) Boolean function
(C) Recursive problem
(D) Decidable

Q.9 Which of the following is FALSE with respect to possible outcomes of executing a Turing Machine over a given input?
(A) it may halt and accept the input
(B) it may halt by changing the input
(C) it may halt and reject the input
(D) it may never halt

Q.10 Which of the following pairs have different expressive power?
(A) Single-tape-turing machine and multi-dimensional turing machine.
(B) Multi-tape turing machine and multi-dimensional turing machine.
(C) Deterministic push down automata and non-deterministic pushdown automata.
(D) Deterministic finite automata and Non-deterministic finite automata

Q.11 What is the highest type number that can be assigned to the following grammar?
S → Aa
A → Ba

B → abc

(A) Type 0 (B) Type 1

(C) Type 2 (D) Type 3

Q.12 If L and P are two recursively enumerable languages, then they are not closed under

(A) Kleene Star L * of L

(B) Intersection L ∩ P

(C) Union L ∪ P

(D) Set Difference

Q.13 Which of the following statements is not correct?

(A) Every recursive language is recursively enumerable.

(B) L = $\{0^n1^n\ 0^n \mid n=1, 2, 3, ...\}$ is recursively enumerable.

(C) Recursive languages are closed under intersection.

(D) Recursive languages are not closed under intersection.

Q.14 Let L = $\{a^p \mid p \text{ is a prime}\}$. Then which of the following is true?

(A) It is not accepted by a Turing Machine

(B) It is regular but not context free

(C) It is context free but not regular

(D) It is neither regular nor context free, but accepted by a Turing Machine

Q.15 A language L is called Turing-decidable (or just decidable), if there exists a Turing Machine M such that on input x, M accepts if x ∈ L, and M rejects otherwise. L is called undecidable if it is not decidable. Which of following option is false?

(A) The class of decidable languages is closed under complement.

(B) The class of decidable languages is closed under union

(C) The class of decidable languages is closed under intersection

(D) None of these

Answer Key

Classroom Practice Questions									
1.	B	2.	C	3.	D	4.	D	5.	A, C
6.	C	7.	B	8.	B	9.	A, C	10.	D
11.	A	12.	B	13.	D	14.	B	15.	D
16.	D	17.	D	18.	B	19.	B	20.	D
21.	D	22.	C	23.	D	24.	B	25.	D
26.	B, D	27.	B	28.	C	29.	D	30.	B
31.	D	32.	D	33.	A	34.	C	35.	D
36.	A	37.	B	38.	C	39.	A	40.	B
41.	B	42.	C	43.	C	44.	A		
Practice Questions									
1.	B	2.	D	3.	B	4.	D	5.	D
6.	D	7.	D	8.	D	9.	B	10.	C
11.	D	12.	D	13.	D	14.	D	15.	D

❑❑❑

6 FSM with Output

Classroom Questions

Q.1 A finite state machine with the following state table has a single input X and a single output Z.

Present state	Next state Z	
	X= 1	X = 0
A	D,0	B,0
B	B,1	C,1
C	B,0	D,1
D	B,1	C,0

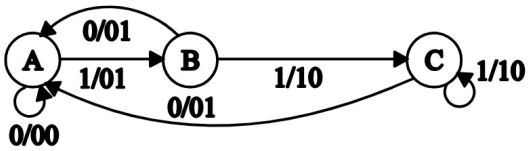
If the initial state is unknown, then the shortest input sequence to reach the final state C is

(A) 01 (B) 10

(C) 101 (D) 110

[GATE 1995 : IIT Kanpur]

Q.2 The finite state machine described by the following state diagram with A as starting state, where an arc label is x/y and x stands for 1-bit input and y stands for 2-bit output



(A) Outputs the sum of the present and the previous bits of the input

(B) Outputs 01 whenever the input sequence contains 11

(C) Outputs 00 whenever the input sequence contains 10

(D) None of the above

[GATE 2002 : IISc Bangalore]

Practice Questions

Q.1 Given the following state table of an FSM with two states A and B, one input and one output :

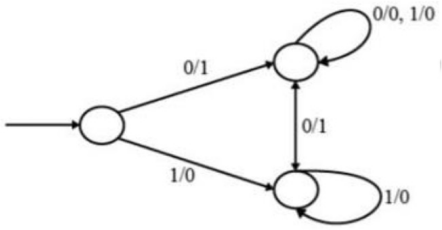
Present state A	Present state B	Input	Next state A	Next state B	Output
0	0	0	0	0	1
0	1	0	1	0	0
1	0	0	0	1	0
1	1	0	1	0	0
0	0	1	0	1	0
0	1	1	0	0	1
1	0	1	0	1	1
1	1	1	0	0	1

If the initial state is $A=0, B=0$, what is the minimum length of an input string which will take the machine to the state $A=0, B=1$ with Output = 1?

(A) 3 (B) 4

(C) 5 (D) 6

Q.2 The FSM (finite state machine) machine pictured in the figure above



(A) Complementsa given bit pattern

(B) Finds 2's complement of a given bit pattern

(C) Increments a given bit pattern by 1

(D) Changes the sign bit

Answer Key

Classroom Practice Questions									
1.	B	2.	A						
Practice Questions									
1.	A	2.	C						

❑❑❑

General Aptitude Part

Q.1 to Q.5 Carry ONE Mark Each

Question 1

The _____ is too high for it to be considered _____ .

(A) Fare/Fair (B) Fair/ Fare

(C) Faer/ Fair (D) Fare/fare

Ans. **A**

Sol. Fare : The amount of money you pay to travel by Bus, Train, Taxi, etc.

Fair : appropriate and acceptable in a particular situation.

The **fare** is too high for it to be considered **fair**.

Hence, the correct option is (A).

Question 2

A palindrome is a word that reads the same forward and backward. In a game of words, a player has the following two plates painted with letters

From the additional plates gives in the options, which one of the combinations of additional plates would allow the players to construct in five letter palindrome. The players should use all five plates exactly once. The plates can be rotated in their plane.

(A)  (B) 

C)  (D) 

Ans. **A**

Sol. **Given :**

A palindrome is a word that reads the same forward and backward.

In a game of words, a player has the two plates painted with letters

The player need to construct a five letter palindrome by using those given two letter plates.

The player should use all five plates exactly one and the plates can be rotated in their plane.

According to option A,

Can be used by rotating and combining with given letter plates.

The palindrome in a word will look live

That word will give same meaning either reads forward or backwards.

Hence, the correct option is (A).

Question 3

Let r be a root of the expression $x^2+2x+6=0$

Then the value of the expression $(r+2)(r+3)(r+4)(r+5)$ is

(A) – 51 (B) 126

(C) – 126 (D) 51

Ans. **C**

Sol. **Given :** r is a root of the expression $x^2+2x+6=0$

$r^2+2r+6=0$, $r^2+2r=-6$

$$=(r+2)(r+3)(r+4)(r+5)$$

$$=(r^2+5r+6)(r^2+9r+20)$$

$$=(r^2+2r+3r+6)(r^2+2r+7r+20)$$

$r^2+2r=-6$,

$$=(-6+3r+6)\ (-6+7r+20)$$

$$=3r(7r+14)$$

$$=21r(r+2)$$

$$=21(r^2+2r)=21\times(-6)=-126$$

Hence, the correct option is (C).

Question 4

A function $y(x)$ is defined in the interval $[0,1]$ on the x-axis as

$$y(x)=\begin{cases}2 & \text{if } 0\le x\le\frac{1}{3}\\ 3 & \text{if } \frac{1}{2}\le x\le\frac{3}{4}\end{cases}$$

Hence, the correct option is (A).

Question 5

Given below are four statements

Statement 1 : All students are inquisitive

$$\begin{cases} 1 \text{ if } \frac{3}{4} \le x \le 1 \end{cases}$$

Which one of the following is the area under the curve for the interval [0, 1] on the x –axis?

(A) $\frac{13}{6}$ (B) $\frac{6}{5}$

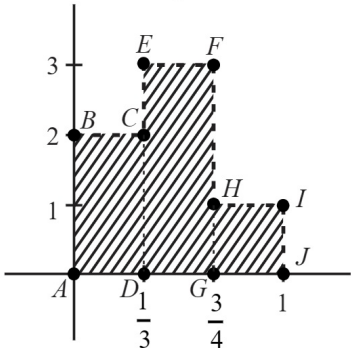
(C) $\frac{6}{13}$ (D) $\frac{5}{6}$

Ans. **A**

Sol. **Given :** A function $y(x)$ is defined in the interval [0, 1] on the x-axis as

$$y(x) = \begin{cases} 2 \text{ if } 0 \le x \le \frac{1}{3} \\ 3 \text{ if } \frac{1}{3} \le x \le \frac{3}{4} \\ 1 \text{ if } \frac{3}{4} \le x \le 1 \end{cases}$$

Graph of $y(x)$ vs x, is drawn as shown below figure,



The Area under the curve for the interval [0, 1] on the x-axis will be define as

= Area of *ABCD* + Area of *DEFG* + Area of *GHIJ*

Area of the rectangle = Length × Breadth

$$= 2 \times \frac{1}{3} + 3 \times \left(\frac{3}{4} - \frac{1}{3} \right) + 1 \left(1 - \frac{3}{4} \right)$$

$$= \frac{2}{3} + \frac{15}{12} + \frac{1}{4} = \frac{2}{3} + \frac{3}{2} = \frac{13}{6}$$

Statement 2 : Some students are inquisitive

Statement 3 : No students are inquisitive

Statement 4 : Some students are not inquisitive

For the given four statements, find the statements what cannot be true, simultaneously, assuming that there is at least one student in the class

(A) Statement 1 and Statement 3

(B) Statement 3 and Statement 4

(C) Statement 2 and Statement 4

(D) Statement 1 and Statement 2

Ans. **A**

Sol. **Given :**

Statement 1 : All student are inquisitive.

Statement 2 : some student are inquisitive

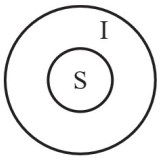
Statement 3 : No student are inquisitive.

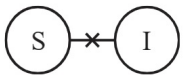
Statement 4 : Some student are not inquisitive

For finding the statement which cannot be true, simultaneously, we will go through with all options,

According to option (A).

Statement 1 and statement 3 can not be true simultaneously by the venn diagram of the statement

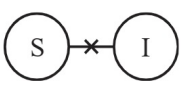


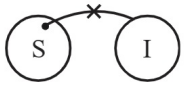


We can say that statement 1 and statement 3 cannot be true simultaneously.

According to option (B)

Statement 3 and Statement 4 can not be true simultaneously. By the venn diagram of the statements





We can say that both the statement can be true simultaneously. As when no student is inquisitive some students are also not inquisitive.

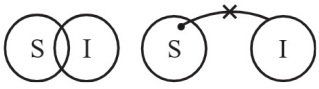
getting an orange ball in the next drawn?

(A) $\frac{23}{50}$ (B) $\frac{19}{50}$

(C) $\frac{8}{25}$ (D) $\frac{1}{2}$

According to option (C).

Statement 2 and statement 4 can not be true simultaneously by the venn diagram of the statements

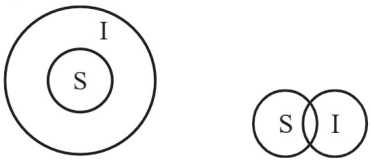


We can say that both the statement can be true simultaneously by that diagram.

By this diagram it is possible of the same time that some students are inquisitive and some students are not inquisitive.

According to option (D).

Statement 1 and statement 2 can be true simultaneously by the venn diagram of the statement.



By this diagram we can say that both the statement can be true simultaneously.

As, when all students are inquisitive then some students are already inquisitive.

Hence, the correct option is (A).

Question 6

A box contains five balls of same size and shape. Three of them are green coloured balls and two of them are orange coloured balls. Balls are drawn from the box one at a time. If a green ball is drawn it is not replaced. If an orange ball is drawn it is replaced with another orange ball. First ball is drawn. What is the probability of

Ans. **A**

Sol. **Given :**

A box contains five balls of same size and shape.

Three of them are green coloured balls and two of them are orange coloured balls.

Balls are drawn from the box one at a time.

If a green ball is drawn it is not replaced.

If an orange ball is drawn it is replaced with another orange ball.

For the probability of getting an orange ball in the next drawn we have two different cases.

Case I : One Green and one Orange

$$P(E)=\frac{3}{5}\times\frac{2}{4}=\frac{6}{20}$$

As we can't replace ball after getting green ball so when we are drawing orange ball as that time only 4 balls are remaining in box.

Case II : One Orange and one orange

$$P(E)=\frac{2}{5}\times\frac{2}{5}=\frac{4}{25}$$

As with orange we can replace ball so when we are drawing record orange ball at time 5 balls are present in box.

$P(E)=$ case 1 + case 2

$$P(E)=\frac{6}{20}+\frac{4}{25}=\frac{23}{50}$$

Hence, the correct option is (A).

Question 7

Some people believe that "what gets measured, improves". Some other believe that "what gets measured, gets gamed". One possible reason for the difference in the beliefs is the work culture in organization. In

organizations with good work culture, metrics help improve outcomes. However the same metrics are counterproductive in organizations with poor work culture.

Which one of the following is the correct logical inference based on the information in the above passage?

Which one of the following statements is correct based on the above information?

(A) P cannot be placed at a corner

(B) U cannot be placed at a mid point

(C) S cannot be placed at a corner

(D) R cannot be placed at a corner

Ans. **C**

information in the above passage?

(A) Metrics are useful in organization with poor work culture

(B) Metrics are always counterproductive in organizations with good work culture

(C) Metrics are never useful in organization with good work culture

(D) Metrics are useful in organizations with good work culture

Ans. **D**

Sol. According to the given information,

Option (A); can not be inferred as metrics are counterproductive in organization with poor work culture.

Option (B); can not be inferred as metrics are counterproductive in organization with poor work culture not good work culture.

Option (C); can not be inferred as metrics help improve outcomes, in organization with good work culture.

Option (D); can be inferred as metrics are useful in organization with good work culture, is mentioned.

Hence, the correct option is (D).

Question 8

The corners and the mid point of a triangle are name using distinct letters P, Q, R, S, T and U but not necessarily in the same order. Consider the following statements

- The line joining P and R is parallel to the line joining Q and S
- P is placed on the side opposite to the corner T
- S and U cannot be placed in the same side

Ans. **C**

Sol. **Given :**

The corners and midpoint of a triangle are name using distinct P, Q, R, S, T and U.

The line joining P and R is parallel to the line joining Q and S.

P is placed on the side opposite to the care T.

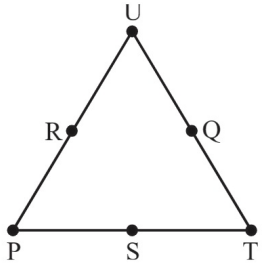
S and U cannot be placed in the same side.

with this given information we can draw multiple diagram which satisfy all the given conditions.

To prove given statement in the options which one is correct, we will draw different diagrams for each option.

According to option A,

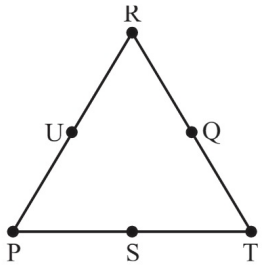
P cannot be placed at a corner but by the figure shown below,



P can be placed at a corner.

According to option B,

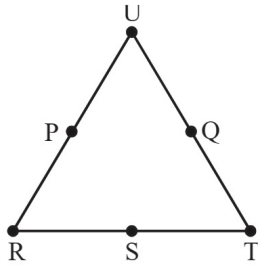
U cannot be placed at a mid point but by the figure shown below,

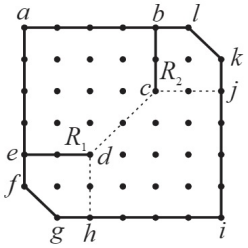


U can be placed at a midpoint.

According to option D,

R cannot be placed at a corner by but by the figure shown below,





In the figure shown above we can clearly see the least number of additional straight ropes shown by

R can be placed at a corner.

According to option C,

S cannot be placed at a corner

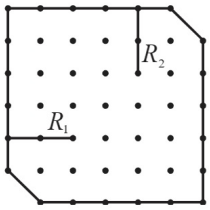
By all the possible diagram only that condition is not possible.

Hence, the correct option is (C).

Question 9

A plot of land must be divided between four families. They instant their individual plots to be similar in shape, not necessarily in area. The land has equally spaced placed marked as dots on the below figure. Two ropes R_1 and R_2 are already present and cannot be moved.

What is the least number of additional straight ropes needed to needs to divided plot? A straight rope can pass through three poles that are aligned in a straight line



(A) 2 (B) 3

(C) 4 (D) 5

Ans. **B**

Sol. **Given :**

A plot of land must be divided between four families.

Divided plots should be similar in shape not necessarily in area.

Two ropes R_1 and R_2 are already present in the plot and cannot be moved.

A straight rope can pass through three poles that are in a straight line.

dotted line needed to divided plot in four parts.

The plots are abcde, bcjkl, cdhij and efghd.

Which are same in shape but not in size.

Hence, the correct option is (B).

Question 10

In a currently conducted National Entrance Test, Boys constituted 65% of those who appeared for the test. Girls constituted the remaining candidates and they accounted for 60% of the qualified candidates. Which one of the following is the correct logical inference based on the information provided in the above passage?

(A) Equal number of boys and girls appeared for the test

(B) The number of boys who qualified the test is less than the number of girls who qualified.

(C) The number of boys who appeared for the test is less than the number of girls who appeared.

(D) Equal number of boys and girls qualified.

Ans. **B**

Sol. **Given :** In a currently conducted National Entrance Test,

Percentage of boys who appeared for the test is 65%

Percentage of girls who appeared for the test is 100% – 65% = 35%

Percentage of qualified girls is 60% of appeared girls

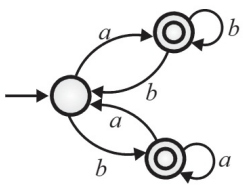
Accounted percentage of total qualified boys and girls is equals to appeared percentage of girls.

Let, the number of students is x,

Number of boys appeared for the test is $0.65x$

Number of girls appeared for the test is $0.35x$

Number of qualified girls $= 0.35x \times \frac{3}{5}$



(A) $ab*bab*+ba*aba*$

(B) $(ab*b)*ab*+(ba*a)*ba*$

(C) $(ab*b+ba*a)*(a*+b*)$

(D) $(ba*a+ab*b)*(ab*+ba*)$

Ans. **D**

$= 0.21x$

Number of qualified boys $= 0.35x - 0.21x = 0.14x$

So, the number of boys who qualified the test is less than the number of girls who qualified.

Hence, the correct option is (B).

Technical Part

Q.11 to Q.35 Carry ONE Mark Each

Question 11 **698808206**

Which one of the following statement is TRUE for all positive function $f(n)$?

(A) $f(n^2) = \theta(f(n)^2)$, when $f(n)$ is a polynomial

(B) $f(n^2) = o(f(n)^2)$

(C) $f(n^2) = O(f(n^2))$, when $f(n)$ is an exponential function

(D) $f(n^2) = \Omega(f(n)^2)$

Ans. **A**

Sol. A : It need not be true for a function which is decreasing.

B : An exponential function may be increasing or decreasing, so this condition may not always be true.

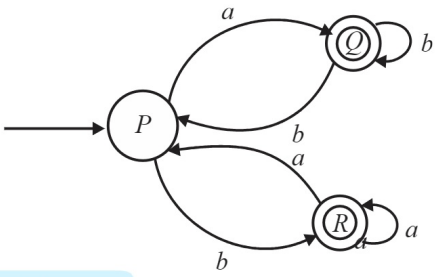
C : It always holds because if we square the input variable, then the highest order in the polynomial will also get squared.

D : It is not true in cases when $f(n)$ is a polynomial function.

Question 12 **698808207**

Which one of the following regular expression correctly represents the language of the finite automaton given below?

Sol. **Given : From**



Finite automata

We have two final state Q, R

First, find the regular expression for set of all strings that end up at the initial state P when running the given NFA.

Lets call P.

Note that, P is the initial state so NFA execution starts at P. Now to end up on state P at the end of the string we can do any of the following, in any order, any number of times:

1. Read "a" go to state Q then read any number of b's, then read b to come back to state P. so, 1 ab*b
2. Read "b" go to state R, them read any number of a's, then read a to come back

So, $P = (1+2)^*$

$= [(ab^*b) + (bc^*a)]^*$

Because we can do 1 or 2 in any order, any number of times:

Now, we want to find language of the given NFA if, Whose final states are Q,R

So,

$R\ \varepsilon\ (iV) = Q + R$

Where Q is the regular expression for set of all strings that end up at the state Q R is the regular expression for set of all strings.

$Q = P_{ab}^*$

$R = Pba$

So, $R\ \varepsilon\ (iv) = Q + R$

$= Pab^* + Pba^*$

$= P\ (ab^* + ba^*)$

$R\ \varepsilon\ (iv) = [(ab^*b) + (ba^*a)]^*\ (ab^* + ba^*)$

Statement C: Data flow analysis is necessary for run time memory management.

False, data flow analysis is used for the optimization of codes in control flow graph.

Statement D: LR (1) parsing is sufficient for Deterministic Context Free Language.

True, LR (1) parsing is sufficient for Deterministic Context Free Language.

Hence, the correct option is (D).

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

Hence, the correct option is (D).

Question 13 **698808208**

Which of the following statements is TRUE?

(A) The LALR (1) parser for a grammar G cannot have reduce – reduce conflict if the LR (1) parser for G does not have reduce – reduce conflict

(B) Symbol table is accessed only during the lexical analysis phase.

(C) Data flow analysis is necessary for run time memory management.

(D) LR (1) parsing is sufficient for Deterministic Context Free Language.

Ans. **D**

Sol. **Given statements are as follows :**

Statement A: The LALR (1) parser for a grammar G cannot have reduce – reduce conflict if the LR (1) parser for G does not have reduce – reduce conflict.

False, because the LALR (1) parser for a grammar G can have reduce-reduce conflict, even through LR (1) parser for G does not have reduce-reduce conflict.

Statement B: Symbol table is accessed only during the lexical analysis phase.

False, symbol table can be accessed by most of the phases of a compiler, like beginning with lexical analysis, and continuing through optimization.

Question 14 **698808209**

In relational data model which is true.

(A) A relation with only two attribute is always in BCNF

(B) BCNF decompositions preserve functional dependencies

(C) Every relation has at least one non prime attribute

(D) If all attributes of a relation are prime attributes, then relation is in BCNF.

Ans. **A**

Sol. **Given :**

In relational data model,

Following statements are as follows:

Statement A : Relation with only two attribute is always in BCNF

True,

$R(XY)$

$\{X \to Y\} \Rightarrow BCNF$

$\{Y \to X\} \Rightarrow BCNF$

$\{X \to Y, Y \to X\} \Rightarrow BCNF$

$\{\text{no non trival functional dependency}\}$

$\Rightarrow BCNF$

$\therefore$ A relation with two attributes is always in BCNF.

Statement B: BCNF decompositions preserve functional dependencies

False, BCNF can be used to obtain a lossless join decomposition into 3NF but does not ensure dependency preservation.

Statement C: Every relation has at least one non prime attribute

False, Let relation R with attributes (A, B, C) with functional dependency set

$\{AB \to C, C \to A\}$

In this relation all attributes are prime.

Statement D: If all attributes of a relation are prime attributes, then relation is in BCNF.

False, If all attributes of a relation are prime attributes, then relation is in 3NF, not in BCNF.

Hence, the correct option is (A).

Question 15 **698808210**

So, Best algorithm for the problem takes $\theta(n)$ time in worst case.

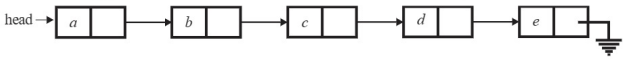
Hence, the correct option is (A).

Question 16 **698808211**

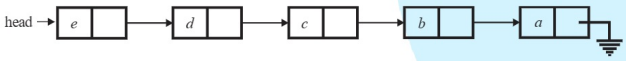
Suppose we are given n keys, m hash table slots and two simple uniform hash functions h_1 and h_2. Further suppose our hashing scheme uses h_1 for the odd keys and h_2 for the even keys. What is the expected no. of keys in a slot?

(A) $\frac{n}{\quad}$ (B) $\frac{m}{\quad}$

Consider the problem of reversing a singly linked list. To take an example, given the linked list below,



the reversed linked list should look like



Which one of the following statements is TRUE about the time complexity of algorithms that solve the above problem in $O(1)$ space?

(A) The best algorithm for the problem takes $\theta(n)$ time in the worst case.

(B) The best algorithm for the problem takes $\theta(n\log n)$ time in the worst case.

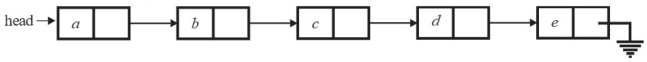
(C) The best algorithm for the problem takes $\theta(n^2)$ time in the worst case.

(D) It is not possible to reverse a singly linked list in O (1) space.

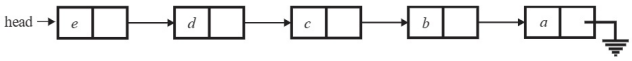
Ans. **A**

Sol. **Given :**

Single linked list



And the reversed linked list should look like



So, From given statements, statement A is suitable for the time complexity of algorithms that solve the given problem in O (1) space.

$\frac{m}{n}$

(C) $\frac{n}{2m}$ (D) $\frac{2n}{m}$

Ans. **A**

Sol. **Given :** n keys, m hash table slots, and two simple uniform hash functions h_1 and h_2.

Hashing scheme uses h_1 for the odd keys and h_2 for the even keys.

Uniform hash function definition:

$$Pr\left[h(x)=i\right]=1/\mathrm{m}$$

which means for every x, we have an equal probability of mapping to any of slot i.

The hash function given in the question is Uniform:

Take any slot i and calculate the probability of mapping some arbitrary x to i

i.e. $Pr\left[h(x)=i\right]=?$

Let the probability of choosing h_1 is p and choosing h_2 is 1–p then

$$Pr\left[h(x)=i\right]=pPr\left[h_1(x)=i\right]+(1-p)Pr\left[h_2(x)=i\right]$$

$\Rightarrow Pr\left[h(x)=i\right]=p/m+1-\mathrm{p/m}$ (since h_1 and h_2 both are uniform hash functions) =1/m

As you see, value of p does not matter but we can calculate p as = number of even keys / Total keys

Since h is uniform, we can say it will distribute all keys uniformly. This means if there are 50 keys and 10 slots then each slot will get 5 keys. i.e., n/m is answer.

But we can do this using probability.

Let X = the Number of items in slot 1. (Note that I am. only talking about some random slot, say slot 1)

X_i = {1 if i^{th} item maps to slot 1; otherwise, 0}

So, we can say $X=X_1+X_2+\ldots X_n$

They are asking E[X]

$$E\left[X\right]=E\left[X_1+X_2+\ldots X_n\right]$$

$E[X]=E[X_1]+E[X_2]+\ldots E[X_n]$

(D) R1 = 1001 and R2 = 1111

Ans. **B**

Sol. **Given :**

R1 and R2 are two 4 – bit registers and they stored numbers in 2's complement form.

We know that the range of 2's complement numbers representable with 4 bits are –8 to +7.

Then, if the result of the operation R1 + R2 is out of the range –8 to 7, then it is over flow

So, from given options,

Option (A) :

R1 = 1011 and R2 = 1110

$P(X_i = 1) = 1/m$ because whatever happens within the black box (h_1 or h_2), the overall hash function will be uniform.

$$E[X_i] = 1P(X_i = 1) + 0P(X_i = 0) = 1/m$$

So, $E[X] = n/m.$

Hence, the correct option is (A).

Question 17 **698808212**

Which one of the following facilitates transfer of bulk data from hard disk to main memory with the highest throughput?

(A) DMA based I/O transfer

(B) Interrupt driven I/O transfer

(C) Polling based I/O transfer

(D) Programmed I/O transfer

Ans. **A**

Sol. from the given options, option (A) DMA based input output transfer facilitates transfer of bulk data from secondary memory or hard disk to main memory without the use of CPU.

Hence, the correct option is (A).

Question 18 **698808213**

Let R1 and R2 be two 4-bit registers that store numbers in 2's complement form. For the operation R1+R2, which one of the following values of R1 and R2 gives an arithmetic overflow?

(A) R1 = 1011 and R2 = 1110

(B) R1 = 1100 and R2 = 1010

(C) R1 = 0011 and R2 = 0100

$R1 = -1\times2^3 + 0\times2^2 + 0\times2^1 + 1\times2^0 = -7$

$R2 = -1\times2^3 + 1\times2^2 + 1\times2^1 + 1\times2^0 = -1$

$R1 + R2 = -8(\text{no overflow})$

Option (B) :

$R1$ = 1100 and R2 = 1010

$R1 = -1\times2^3 + 1\times2^2 + 0\times2^1 + 0\times2^0 = -4$

$R2 = -1\times2^3 + 0\times2^2 + 1\times2^1 + 0\times2^0 = -6$

$R1 + R2 = -10(\text{over flow})$

Option (C) :

$R1$ = 0011 and R2 = 0100

$R1 = -1\times2^3 + 0\times2^2 + 1\times2^1 + 1\times2^0 = -5$

$R2 = -1\times2^3 + 1\times2^2 + 1\times2A1 + 0\times2^0 = -2$

$R1 + R2 = -7(\text{ no overflow})$

Option (D) :

$R1$ = 1001 and R2 = 1111

$R1 = 0\times2^3 + 0\times2^2 + 1\times2^1 + 1\times2^0 = 3$

$R2 = 0\times2^3 + 1\times2^2 + 0\times2^1 + 0\times2^0 = 4$

$R1 + R2 = 7(\text{no overflow})$

Hence, the correct option is (B).

Question 19 **698808214**

Consider the following threads, $T_1, T_2,$ and T3 executing on a single processor, synchronized using three binary semaphore variables, S_1, S_2 and S_3, operated upon using standard wait() and signal(). The threads can be context switched in any order and at any time.

T_1	T_2	T_3
while (true)	while (true)	while (true)
{	{	{
wait (S_3);	wait (S_1);	wait (S_2);
print ("C");	print ("B");	print ("A");
signal (S_2);	signal (S_3);	signal (S_1);
}	}	}

Which initialization of the semaphores would print the sequence BCABCABCA....?

(A) $S_1 = 1;\ S_2 = 1; S_3 = 1$

(B) $S_1 = 1; S_2 = 1; S_3 = 0$

(C) $S_1 = 1; S_2 = 0; S_3 = 0$

(D) $S_1 = 0; S_2 = 1; S_3 = 1$

After this Process P_3 can successfully execute wait (S_2): and then it executes print ("A");, after which it executes signal (S_1): and then gets stuck at wait (S_2);

Here A gets printed in this process.

After this Process P_2 can execute wait (S_1); successfully.

The process thus keeps repeating and the pattern printed is BCABCABCA...

Hence, the correct option is (C).

Question 20 **698808215**

Consider the following two statements with respect to matrices

Ans. **C**

Sol. **Given :**

A single processer in which three thread T_1, T_2 and T_3 are executing.

And they are synchronized by using three binary semaphore variables such that S_1, S_2 and S_3

They are operated by using standard wait ( ) & signal ( ) operation.

So, for checking that which initialization of semaphores would print the sequence of BCABCABCA...

Then, initially if $S_1 = 1, S_2 = 0, S_3 = 0,$

Process P_2 can successfully execute wait(S_1); while P_1 and P_3 remain stuck at wait(S_3); and wait(S_2); respectively.

After process P_2 prints B it executes signal(S_3); and gets stuck at wait(S_1);

Here B gets printed in this process.

After this Process P_1 can successfully execute wait(S_3); and then it executes print("C");, after which it executes signal (S_2); and then gets stuck at wait(S_3);

Here C gets printed in this process.

Since, eigen values are the same, thus the sum of eigen values (i.e. the trace) is also the same.

Hence, the correct option is (C).

Question 21 **698808216**

What is printed by ANSI C program?

```
#include <stdio.h>
int main (int argc, char *argv [])
{
int x = 1, z[2]={10,11};
int *p = NULL;
 p= &x;
*p = 10;
 p = &z[1];
*(& z [0]+1) +=3;
printf("%d, %d, %d\n", x , z [0], z [1]);
```

$A_{m\times n}, B_{n\times m}, C_{n\times n}$ and $D_{n\times n}$

Statement 1 : $Tr(AB) = Tr(BA)$

Statement 2 : $Tr(CD) = Tr(DC)$

Tr represents the trace of matrix, which one of the following holds _____.

(A) S1 is wrong and S2 is correct

(B) S1 is correct and S2 is wrong

(C) Both statements are correct

(D) Neither of the statements correct

Ans. **C**

Sol. **Given :** Two statements with respect to matrices $A_{m\times n}, B_{n\times m}, C_{n\times n}$ and $D_{n\times n}$

Statement 1 : $Tr(AB) = Tr(BA)$

Statement 2 : $Tr(CD) = Tr(DC)$

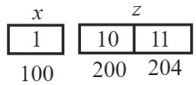
Then, from question.

The eigen values (counting multiplicity) of *AB* are the same as those of *BA*.

This is a corollary of theorem in second edition of matrix analysis by Horn and Johnson.

Paraphrasing from the cited theorem.

If *A* is an *m* by *n* matrix and *B* is an *n* by *m* matrix with $n > m$ then the characteristic polynomial P_{BA} of *BA* is related to the characteristic polynomial P_{AB} of *AB*.

$z[2] = \{10,11\};$ 

$p = \&x;$ 

$*p = 10;$ 

$p = \&z[1];$ 

* (& z [0]+1) +=3;

⇒ *(address of II[nd] element of array) + = 3;

⇒ i.e. add 3 to II[nd] element of array, therefore second elements becomes 14.

Hence, the correct option is (A).

Question 22 **698808217**

```
    return 0;
}
```

(A) 10, 10, 14 (B) 1, 10, 11

(C) 1, 10, 14 (D) 10, 14, 11

Ans. **A**

Sol. **Given :**

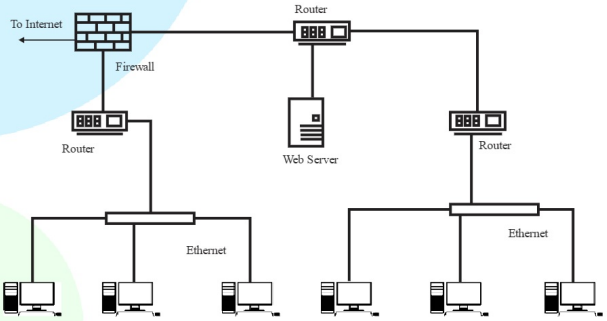
ANSI C program :

```
#include <stdio.h>
int main (int argc, char *argv [])
{
int x=1, z[2]={10,11};
int *p = NULL;
 p= &x;
*p = 10;

 p = &z[1];
*(& z [0]+1) +=3;
printf("%d, %d, %d\n", x , z [0], z [1]);
return 0;
}
```

Question 22 **698808217**

Consider an enterprise network with two Ethernet segments, a web server and a firewall, connected via three routers shown below :



What is the number of subnets in the enterprise network?

(A) 3 (B) 12

(C) 6 (D) 8

Ans. **C**

Sol. **Given :** A network which has Two Ethernet segments, a web server and a firewall.

And they are connected through three routers.

So, from given figure,

This is just like non equal sub netting where router 2 has the half of the addresses, Router 1 has other half, which is further divided into two subnets which is Web server and router 3, So total of 3 subnets possible.

Hence, the correct option is (C).

Question 23 **698808218**

Which of the following statements is/are true?

(A) Every subset of recursively enumerable Language is recursive

(B) If Language L & its complement $\overline{L}$ are both recursively enumerable then L must be recursive

(C) Complement of context free language must be recursive.

(D) If L_1 and L_2 are regular, then $L_1 \cap L_2$ must be Deterministic Context Free Language.

Ans. **B, C, D**

Sol. **Given :**

Statement A : Every subset of recursively enumerable Language is recursive

True, If L_1 and L_2 are regular then $L_1 \cap L_2$ is Regular thus also deterministic context free Language.

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

Question 24 **698808219**

Let WB and WT be 2 set associative cache organizations that use LRU algorithm for cache block replacement. WB is Write Back cache and WT is Write through cache. Which of the following statements are false?

(A) Each cache block in WB and WT has a dirty bit

(B) Every write hit in WB leads to a data transfer from cache to main memory

(C) Eviction of a block from WT will not lead to data transfer from

recursive

False, Since, $\sum^*$ is a recursively enumerable Language but there are many languages which are subset of $\sum^*$ which are not Recursive.

Statement B : If Language L & its complement $\overline{L}$ are both recursively enumerable then L must be recursive

True, If L is recursively enumerable Language, then for all member strings of L, the TM of L will halt within finite time. If $\overline{L}$ is recursively enumerable Language, then for all nonmember strings of L. The TM of $\overline{L}$ will halt within finite time. Thus for both member and nonmember strings of L and $\overline{L}$ we have a TM which halts within finite time. Thus L is a Recursive Language.

Statement C : Complement of context free language must be recursive.

True, Complement of CFL is a CSL in the worst case which is Recursive.

Statement D : If L_1 and L_2 are regular, then $L_1 \cap L_2$ must be Deterministic Context Free Language.

not lead to data transfer from cache to main memory

(D) A read miss in WB will never lead to eviction of a dirty block from WB

Ans. **A, B, D**

Sol. **Given :**

WB and WT is two set associative cache organization,

Where WB belongs to write back cache and WT belongs to write through cache.

LRU algorithm used for cache block replacement.

So, from given statements:

Statement A : Each cache block in WB and WT has a dirty bit

Statement B : Every write hit in WB leads to a data transfer from cache to main memory. False, for the hit operation no need to fetch the data from the main memory.

Statement C : Eviction of a block from WT will not lead to data transfer from cache to main memory

Statement D : A read miss in WB will never lead to eviction of a dirty block from WB

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

Question 25 **698808220**

Consider the following three relations in a relational database.

Employee (eId, Name)

Brand (bId, bName)

Own (eId, bId)

Which of the following relational algebra expressions return the set of eIds who own all the brands?

(A) $\pi_{eId}(\pi_{eId,bId}(\text{Own}) / \pi_{bId}(\text{Brand}))$

(B) $\pi_{eId}(\pi_{eId,bId}(\text{Own}) / \pi_{bId}(\text{Own}))$

(C) $\pi_{eId}(\text{Own}) - \pi_{eId} / \pi_{eId}(\text{Own}) \times \pi_{bId}(\text{Brand}) - \pi_{eId,bId}(\text{Own}))$

(D) $\pi_{eId}(\pi_{eId}(\text{Own}) \times \pi_{bId}(\text{Own})) / \pi_{bId}(\text{Brand})$

Ans. **A, C**

Sol. **Given :**

Three relations in relational database

assignment edge, then the system is not in deadlock state.

(C) Circular wait is a necessary condition for the formation of deadlock

(D) If the current allocation of resources to processes leads the system to unsafe state then deadlock will necessarily occur.

Ans. **B, C**

Sol. **Given :**

Statement A : In a system where each resource has more than one instance, a cycle in its wait-for-graph indicates the presence of a deadlock.

False, A cycle exist in the system but since P_1 does not need any more resources it will finish after some time and P_3 will get resource R_1 this even in the presence of cycle the deadlock

are as follows:

Employee (eId, ename)

Brand (bId, bname)

Own (eId, bId)

To find set of eIds who own all the brand we need to divide the table own by table brand like.

(A) $\pi_{eId}(\pi_{eId,bId}(\text{Own}) / \pi_{bId}(\text{Brand}))$ and the division operation can be represented using $(\times, -)$ operations like

(C) $\pi_{eId}(\text{Own}) - \pi_{eId} / \pi_{eId}(\text{Own})$

$\times \pi_{bId}(\text{Brand}) - \pi_{eId,bId}(\text{Own}))$

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

Question 26 **698808221**

Which of the following statements is/are TRUE with respect to deadlocks?

(A) In a system where each resource has more than one instance, a cycle in its wait-for-graph indicates the presence of a deadlock.

(B) In the resource-allocation graph of a system, if every edge is an assignment edge, then the system is not in deadlock state.

2. Hold and wait
3. No preemption
4. Circular wait

Statement D : If the current allocation of resources to processes leads the system to unsafe state then deadlock will necessarily occur.

False, Even if the allocation results in an unsafe state, some processes still may release the resources that are allocated to them for a while which may lead to elimination of deadlock from the system.

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

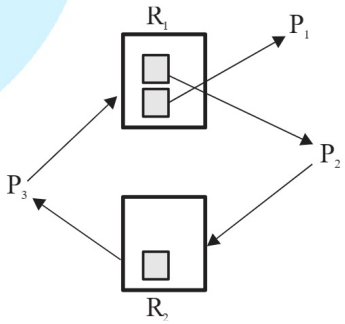
Question 27 **698808222**

Which of the following is /are true for group G?

(A) If for all $x, y \in G$, $(xy)^2 = x^2y^2$, then G is commutative.

(B) If for all $x \in G, x^2 = 1$, then G is commutative, here 1 is identity element of G

does not exist here



Statement B : In the resource-allocation graph of a system, if every edge is an assignment edge, then the system is not in deadlock state.

True, When every edge is the assignment edge, that is, no process needs any more resources than the ones that are already allocated, thus deadlock doesn't exist here.

Statement C: Circular wait is a necessary condition for the formation of deadlock

True, Circular wait is a necessary condition for Deadlock but it is not sufficient. There are following 4 necessary conditions for the occurrence of deadlock

1. Mutual exclusion

Theorem : All groups with less than 6 elements are abelian.

D. False

Theorem : Every subgroup of an abelian group has to be abelian.

Question 28 **698808223**

Suppose binary search tree with 1000 distinct elements is also complete binary tree. The tree is sorted using array representation of Binary Heap Tree. Assuming that the array indices start with 0, the 3rd largest element of tree is stoled at index _____?

Ans. **509**

Sol. **Given :**

Binary search tree which has 1000 distinct elements & it also work as complete binary tree.

Array representation of binary heap tree is used for sorting of tree,

So, the largest element in the BST is the right most element with index

element of G

(C) If the order of G is 2, then G is commutative

(D) If G is commutative then a subgroup of G need not to be commutative

Ans. **A, B, C**

Sol. **A. True**

Since $(ab)^2 = a^2b^2 \rightarrow (ab)(ab)=(aa)(bb)$

We know that in a group, left and right cancellation is allowed, so

ba = ab, Hence Commutative

B. True

Key Point: $x^2 = 1$ means each element is inverse of itself.

Let a,b be two elements in group G. Consider the element ab.

Now, $(ab)^2=1 \rightarrow ab.ab=1$

Now, multiply both sides on the right with b,

$abab = 1b \rightarrow aba = b$

Now, multiply both sides on the right with a,

$abaa = ba \rightarrow ab = ba$

Hence, G is abelian.

C. True

$510(2^9-2$ as the indexing of the array is starting with 0) its parent is the second-largest element and its left child is the third-largest element which is of the index $510-1=509$.

Hence, the correct Answer is 509.

Question 29 **698808224**

Consider the augmented grammar with $\{+,*,(,),id\}$ as the set of terminals.

$S' \rightarrow S$

$S \rightarrow S+R \mid R$

$R \rightarrow R*P \mid P$

$P \rightarrow (S) \mid id$

If I_0 is the set of two $LR(0)$ items $\{[S' \rightarrow S.], [S \rightarrow S.+R]\}$, then go to $(\text{Closure}(I_0),+)$ contains exactly _____ items.

Ans. **5**

Sol. **Given :**

Augmented grammar

$S' \rightarrow S$

$S \rightarrow S+R \mid R$

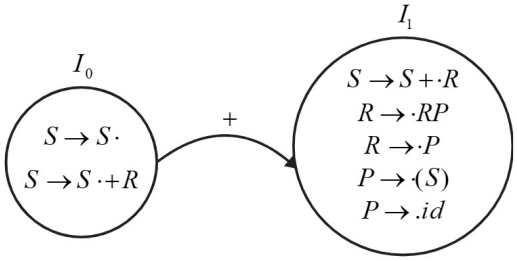
$R \rightarrow R*P \mid P$

$P \rightarrow (S) \mid id$

And set of terminals = $\{+,*,(,),id\}$

And there is a condition if I_0 is the set of two LR (0) Items such that $\{[S' \rightarrow S.], [S \rightarrow S.+R]\}$,

Then go to $(\text{Closure}(I_0),+)$ contains :



$\therefore$ 5 item

Hence, the correct answer is 5.

Question 30 **698808225**

Consider a simple undirected graph of 10 vertices if the graph is disconnected then the maximum number of edges it can have is

Consider a Relation R (A, B, C, D, E) with the following three functional dependencies.

$AB \rightarrow C,\ BC \rightarrow D,\ C \rightarrow E$

The number of super keys in the relation R is _____.

Ans. **8**

Sol. **Given :**

Relation R with attributes (A, B, C, D, E) and

There are three functional dependencies such that

$AB \rightarrow C$

$BC \rightarrow D$

$C \rightarrow E$

So, from these functional dependencies,

Candidate key = AB

$\therefore$ Number of super keys $2^{5-2} = 2^3 = 8$ super keys

Hence, the correct answer is 8.

Question 32 **698808227**

_____.

Ans. **36**

Sol. **Given :**

Undirected graph which has 10 vertices and we have to find the maximum number of edges when the graph is disconnected.

So, suppose we have 1 vertex on one side and other n-1 vertices on another side. To make it connected maximum possible edges (if consider it as complete graph) is

C_2^{n-1} which is $\frac{(n-1)(n-2)}{2}$

Thus to make it a disconnected graph we have 1 separate vertex on another side which is not connected. Thus the maximum possible edges is

$$C_2^{n-1} = {}^9C_2 = \frac{9\times 8}{2} = 36$$

Hence, the correct answer is 36.

Question 31 **698808226**

The number of arrangement of 6 identical ball in 3 identical bins_____.

Ans. **7**

Sol. **Given :**

6 identical balls

For which we have to find out the number of arrangement for these balls into three identical bins

Now, it is the case of distribution with identical objects and identical boxes.

We simply need to partition number 6 in to maximum 3 parts and count the partition.

(6,0,0), (5,1,0), (4,2,0), (4,1,1), (3,2,0), (3,1,1), (2,2,2).

Hence, the correct answer is 7.

Question 33 **698808228**

A cache memory that has a hit rate of 0.8 has an access latency 10 ns and miss penalty 100 ns. An optimization is done on the cache to reduce the miss rate. However the optimization results in an increase of cache access latency to 15 ns, whereas the miss penalty is

not affected. The minimum hit rate (rounded off to decimal two places) needed after the optimization such that it should not increase the average memory access time is _____.

Ans. **0.85**

Sol. **Given :**

a cache

which has,

Hit rate = 0.8

$\therefore$ miss rate = 0.2

Access latency = 10 ns

Miss penality = 100 ns

$\therefore$ $\text{AMAT}_{old} = 0.8(10) + 0.2(100)$

$= 8 + 20 = 28$

Where, AMAT is average memory access time.

For Optimized cache.

where access latency = 15 ns = hit time

Let x be the cache hit rate after optimization.

$\therefore$ $\text{AMAT}_{new} = x(15) + (1-x)100$

$= 15x + 100 - 100x = 100 - 85x$

$= \lim_{x\to 0^+}\left[\frac{1}{-e^{2\sqrt{x}}(2)}\right] = \lim_{x\to 0^+}\left[\frac{1}{-e^{2\sqrt{0}}(2)}\right]$

$= \frac{-1}{2} = -0.5$

Question 35 **698808230**

Consider the resolution of domain name www.gate.org.in by a DNS resolver. Assume that no resource records are cached anywhere across the DNS servers and that query resolution mechanism is used in the resolution. The number of DNS query response pairs involved in completely resolving the domain name is _____.

Ans. **4**

Sol. **Given :** Domain name www.gate.Org.in

There is no resource records are cached any where across the DNS servers,

In the iterative query the DNS resolver go to the these three servers which is root server, TLD DNS server, authoritative server. So there will be three pairs of request and response

$-15x+100=100x-100-85x$

$\text{AMAT}_{\text{Old}} \geq \text{AMAT}_{\text{new}}$

$\rightarrow 100-85x \leq 28$

$\rightarrow 72=85x$

$\rightarrow x=\frac{72}{85}=0.85$

The required hit rate = 0.85

Hence, the correct answer is 0.85.

Question 34 **698808229**

The value of following limit is _____.

$$\lim_{x\to 0^+}\frac{\sqrt{x}}{1-e^{2\sqrt{x}}}$$

Ans. **– 0.5**

Sol. **Given :**

$\lim_{x\to 0^+}\frac{\sqrt{x}}{1-e^{2\sqrt{x}}}$ is in the form of $\frac{0}{0}$ form at

If we apply L'Hopitals rule then

$$=\lim_{x\to 0^+}\left[\frac{\frac{d}{dx}(\sqrt{x})}{\frac{d}{dx}(1-e^{2\sqrt{x}})}\right]=\lim_{x\to 0^+}\left[\frac{\frac{1}{2\sqrt{x}}}{0-e^{2\sqrt{x}}\cdot\frac{2}{2\sqrt{x}}}\right]$$

here.

Hence, the correct answer is 4.

Q.36 to Q.65 Carry TWO Marks Each

Question 36 **698808231**

Which one of the following is closed form for the generating function of the sequence $\{a_n\}_{n\geq 0}$ defined below?

$$a_n=\begin{cases}n+1, & n=\text{odd}\\ 1, & \text{Otherwise}\end{cases}$$

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

(C) $\frac{2x}{(1-x^2)^2}+\frac{1}{1-x}$ (D) $\frac{x}{(1-x^2)^2}+\frac{1}{1-x}$

Ans. **A**

Sol. **Given :**

Generating function

$$a_n=\begin{cases}n+1, & n=\text{odd}\\ 1, & \text{otherwise}\end{cases}$$

Of the sequence $\{a_n\}_{n\geq 0}$

So, $G(x)=\sum_{r=0}^{\infty}a_r x^r$

$$G(x)=\sum_{r=0\,(\text{even})}^{\infty}a_r x^r+\sum_{r=1(\text{odd})}^{\infty}a_r x^r$$

$$G(x)=\sum_{r=0\,\text{even}}^{\infty}x^r+\sum_{r=1\,\text{odd}}^{\infty}(r+1)x^r$$

As we know,

$$\frac{1}{1-x}=1+x+x^2+x^3+x^4+x^5+.....$$

$$\frac{1}{1-x^2}=1+x^2+x^4+x^6+x^8+x^{10}+.....$$

...(i)

$$\frac{2x}{(1-x^2)^2}=2x+4x^3+6x^5+8x^7+10x^4.....$$

...(ii)

Add equation (i) and (ii)

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

$$+x^4+6x^5+x^6+.....$$

$$\frac{1+x-x}{1-x^2}+\frac{2x}{(1-x^2)^2}$$

(C) $\frac{A^3}{3}$ (D) $\frac{A^3}{6}$

Ans. **D**

Sol. **Given :**

An undirected unweighted graph which has atleast 3 vertices

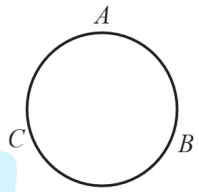
And A is adjacency matrix of graph.

So, as we know,

Diagonal element of A^3 gives number of paths of length 3,

From any vertex to itself (cycle of 3).

For each participating vertex, each cycle will be counted thrice. As given below (ABCA, BCAB and CABC).



Furthermore, since the graph is undirected, every cycle will be counted twice. So overall every cycle of length 3 in A^3 will be counted 6 times, so we divide by 6 also. Therefore, the number of Cycle is

$$= \sum_{r=0(\text{even})} x^r + \sum_{r=1(\text{odd})} (r+1)x^r$$

$$\Rightarrow \frac{1+x}{1-x^2} - \frac{x}{1-x^2} + \frac{2x}{\left(1-x^2\right)^2} = G(x)$$

$$\Rightarrow G(x) = \frac{1}{1-x} + \frac{x}{1-x^2}\left(-1 + \frac{2}{1-x^2}\right)$$

$$\Rightarrow \frac{1}{1-x} + \frac{x}{1-x^2}\left(\frac{-1+x^2+2}{1-x^2}\right)$$

$$\Rightarrow \frac{1}{1-x} + \frac{x\left(1+x^2\right)}{\left(1-x^2\right)^2}$$

Hence, the correct option is (A).

Question 37 **698808232**

Consider simple undirected unweighted graph with at least 3 vertices. If A is adjacency matrix of graph then the number of 3-cycle in the graph is given by trace of:

(A) A^3 (B) $\frac{A^3}{2}$

trace of $\frac{A^3}{6}$.

Hence, the correct option is (D).

Question 38 **698808233**

Which one of the following statements is False?

(A) The TLB performs an associative search in parallel on all its valid entries using page number of incoming virtual address

(B) If the virtual address of a word given by CPU has a TLB hit, but the subsequent search for the word results in cache miss, then the word will always be present in the main memory.

(C) In a system that uses hashed page tables, if two distinct virtual address VI and V2 map to the same value while hashing, then the memory access time of these addresses will not be the same

(D) The memory access time using a given inverted page table is always same for all incoming virtual addresses.

Ans. **D**

Sol. **Given :**

Statement A : The TLB performs an associative search in parallel on all its valid entries using page number of incoming virtual address.

True, TLB Lookups:

1. Sequential search of the TLB
2. Direct mapping: assigns each virtual page to a specific slot in the TLB e.g., use upper bits of VPA to index TLB (Translation lookaside buffer)
3. Set associativity: use N TLB banks to perform lookups in parallel
4. Fully associative cache: allows looking up all TLB entries in parallel
5. Typically :
   a. TLBs are small and fully associative
   b. Hardware caches use direct mapped or set-associative cache

True, a hashed page table lookup may require many memory references to search the desired virtual address and its corresponding frame number because there is no guarantee on the number of entries in the linked list.

Statement D : The memory access time using a given inverted page table is always same for all incoming virtual addresses.

False, when a memory reference takes place, this virtual address is matched by the memory-mapping unit and the Inverted Page table is searched for a match and the corresponding frame number is obtained.

If the match is found at the it entry then the physical address of the process is sent as the real address otherwise if no match is found then Segmentation Fault is generated. Finding a match requires searching the entire table. Depending on the match, the memory access time will vary.

Hence, the correct option is (D).

Question 39 **698808234**

Let $R_i(z)$ and $W_i(z)$ denote read and write operations on data element z by

Statement B : If the virtual address of a word given by CPU has a TLB hit, but the subsequent search for the word results in cache miss, then the word will always be present in the main memory.

True, a cache stores a copy of data from memory in a fast storage near the CPU. In case of TLB hit, we got the physical address (in main memory). We look into cache before accessing main memory. In case of a cache miss, we will definitely find the word in main memory as there was a TLB hit.

Statement C : In a system that uses hashed page tables, if two distinct virtual address VI and V2 map to the same value while hashing, then the memory access time of these addresses will not be the same

a transaction T_i, consider schedule S with four transactions

$S: R_4(x)\,R_2(x)\,R_3(x)\,R_1(y)\,W_1(y)\,W_2(x)\,W_3(y)\,R_4(y)$

Which one of the following serial schedules is conflict equivalent to S?

(A) $T_4 \to T_1 \to T_3 \to T_2$

(B) $T_1 \to T_4 \to T_3 \to T_2$

(C) $T_3 \to T_1 \to T_4 \to T_2$

(D) $T_1 \to T_3 \to T_4 \to T_2$

Ans. **D**

Sol. **Given :** A data element z.

In which transactions T_i occur by the operations read and write

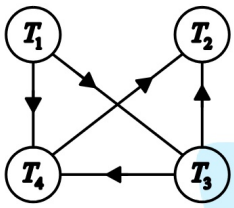
Where Read is denoted by $R_i(z)$ & write is denoted by $W_i(z)$

& there is schedule S for 4 transections i.e.,

$S: R_4(x)R_2(x)R_3(x)R_1(y)W_1(y)W_2(x)W_3(y)R_4(y)$

So, from given schedule :

T_1	T_2	T_3	T_4
			$R(x)$
	$R(x)$		
		$R(x)$	
$R(x)$			
$W(y)$			
	$W(x)$		
		$W(y)$	
			$R(y)$



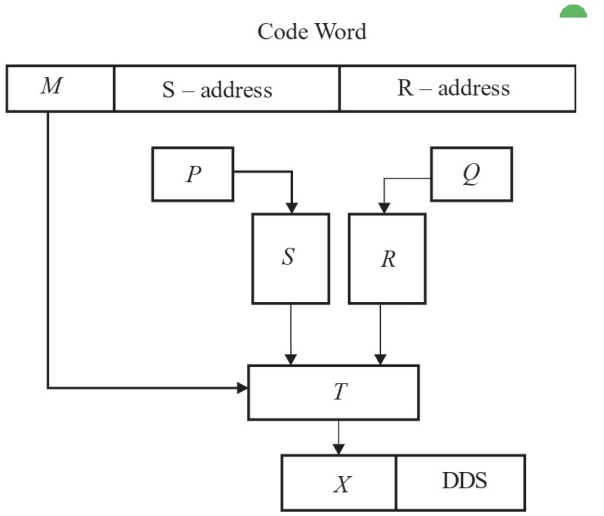
Now, Apply topological sort then the sequence is

$T_1T_3T_4T_2$

Hence, the correct option is (D).

Question 40 **698808235**

Consider a digital display system (DDS) shown in the figure that displays the contents of register X. A 16-bit



(A)	P is 10: 2^{10} decoder,	Q is 5: 2^5 decoder,	T is 2:1 Multiplexer
(B)	P is 10: 2^{10} decoder,	Q is 5: 2^5 decoder,	T is 2:1 encoder
(C)	P is 10: 1 Multiplexer,	Q is 5: 1 Multiplexer,	T is 2:1 Multiplexer
(D)	P is 1:10 de-multiplexer	Q is 1:5 de-multiplexer	T is 2:1 Multiplexer

Ans. **A**

Sol. **Given :** Digital display system (DDS).

Where, it show the contents of register X and length of data in register X = 16 bit

Where, S is 1024 word memory

code word is used to load a word in X, either from S or from R. S is a 1024-word memory segment and R is a 32-word register file. Based on the value of mode bit M, T selects an input word to load in X. P and Q interface with the corresponding bits in the code word to choose the addressed word. Which one of the following represents the functionality of P, Q, and T?

segment and R is 32 word register file.

Based on the value of M, T selects an input for loading in register X.

P & Q work as interface for choosing time addressed word.

So, based on the Address provided to P, one of the words of the memory unit S has to be selected. this function is performed by a Decoder r

To be able to address 1024 words, we need 10 bits , and to select one out of 2^{10} addresses , we need 1G: 2^{10} Decoder which is unit P.

Similarly to decoder Address R we need $5:2^5$ decoder.

Now one of the two inputs has to be selected to be loaded into X, selecting one input among many to

place in the output. This function is performed by a Multiplexer here we need a 2x1 MUX.

Hence, the correct answer is (A).

Question 41 **698808236**

Consider three floating point numbers A, B and C stored in registers R_A, R_B and R_C, respectively as per IEEE-754 single precision floating point format. The 32-bit content stored in these registers (in hexadecimal form) are as follows.

$R_A = 0xC1400000$	$R_B = 0x42100000$	$R_C = 0x41400000$

Which one of the following is false?

(A) $A+C=0$ (B) $B=3C$

(C) $C=A+B$ (D) $(B-C)>0$

Ans. **C**

Sol. **Given :**

Three registers which store three floating point numbers A, B & C in IEEE-754 single precision floating point format.

Size of register = 32 bit

$R_A = 0xC1400000$	$R_B = 0x42100000$	$R_C = 0x41400000$

$A = 1100 \quad 0001 \quad 0100 \quad 0000$

$\text{Biased Exponent} = 130,$

$\text{Exponent} = 130 - 127 = 3$

$\text{Decimal} = -1.1 \times 2^3 = -1100 = -12$

$B = 0100 \quad 0010 \quad 0001 \quad 0000$

units. The processes arrive in the order *P*, *Q*, *R*, *S* all at time $t = 0$. There is exactly one context switch from *S* to *Q*, exactly one context switch from *R* to *Q*. Exactly two context switches from *Q* to *R*. There is no context switch from *S* to *P*. Switching to a ready process after the termination of another process is also considered a context switch. Which one of the following is NOT possible a CPU burst time (in time units) of these process?

(A) $P=3, Q=7, R=7, S=3$

(B) $P=4, Q=10, R=6, S=2$

(C) $P=4, Q=12, R=5, S=4$

(D) $P=2, Q=9, R=5, S=1$

Ans. **A**

Sol. **Given :**

Four process P,Q,R,S which are schedule on a CPU by round robin algorithm

Where, time quantum = 4 units,

Process arrived in the order P, Q, R, S at time $t = 0$.

So, from given conditions we can draw gantt chart according to given options.

Valid Required Contexts switches are 1 – S to Q, 1 – R to Q, 2 – Q to R and no S to P.

Option (A) :

$B = 0100 \quad 0010 \quad 0001 \quad 0000$

Biased Exponent $= 132,$

Exponent $= 132 - 127 = 5$

Decimal $= +1.001 \times 2^5 = 100100 = 36$

$C = 0100 \quad 0001 \quad 0100 \quad 0000$

Biased Exponent $= 128 + 2 = 130,$

Exponent $= 130 - 122 = 3$

Decimal $= +1.1 \times 2^3 = 1100 = +12$

$A = -12$

$B = 36$

$C = +12$

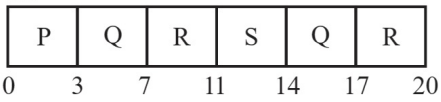
Hence, the correct option is (C).

Question 42 **698808237**

Consider four processes *P*, *Q*, *R* and *S* scheduled on a CPU as per round robin algorithm with a time quantum of 4

Option (A) :

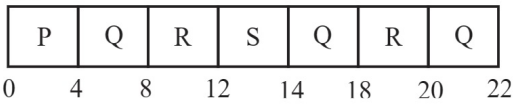
A :



Contexts switches are 1 – P to Q, 2 – Q to R, 1 – R to S and 1 – S to Q

Option (B) :

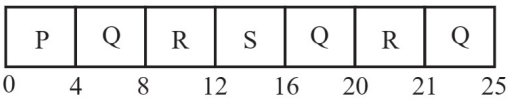
B :



Contexts switches are 1 – P to Q, 2 – Q to R, 1 – R to S, 1 S to Q and 1 – R to Q

Option (C) :

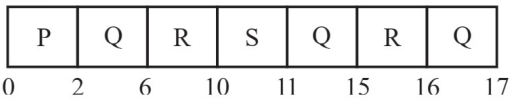
C :



Contexts switches are 1 – P to Q, 2 – Q to R, 1 – R to S, 1 S to Q and 1 – R to Q

Option (D) :

D :



Contexts switches are 1 – P to Q, 2 – Q to R, 1 – R to S, 1 S to Q and 1 – R to Q

So, from option B, C, D it satisfy all the condition given in the question,

So, the answer is option (A).

Hence, the correct option is (A).

Question 43 **698808238**

What is printed by ANSI C programme

```
#include<stdio.h>
int main (int argc, char * argv [])
{
int a [3][3][3]= {{1, 2, 3, 4, 5, 6, 7, 8,
 9}, {10, 11, 12, 13, 14, 15, 16, 17, 18},
 {19, 20, 21, 22, 23, 24, 25, 26, 27}};
int i= 0, j= 0, k=0;
for (i = 0; i< 3; i++) {
for(k = 0; k<3; k++)
printf("%d", a [i][j][k]);
printf("\n");
}
return 0;
}
```

(A) 1 2 3 (B) 1 4 7

$j = k = i = 0$

$a[3][3][3] = \{\{1, 2, 3, ...9\}, \rightarrow a[0]$

$\{10, 11, ...18\}, \rightarrow a[1]$

$\{19, ...27\}\} \rightarrow a[2]$

In short, there are total three 2–D arrays, and in the code we need to find first row of each 2D array i.e.

1, 2, 3 First row of first 2-D array

10, 11, 12 First row of second 2-D array

19, 20, 21 First row of third 2-D array

So, the output of the code is

1 2 3

10 11 12

19 20 21

Hence, the correct option is (A).

Question 44 **698808239**

What is printed by the following ANSI C program?

```
#include<stdio.h>
int main(int argc, char *argv[])
{
```

char $a = 'P';$

char $b = 'x';$

char $c = (a \,\&\, b) + '*';$

char $d = (a \mid b) - '-';$

char $e = (a \,\hat{}\, b) + '+';$

$printf("\%c\%c\%c\n", c, d, e);$

return 0;

10 11 12 | 10 13 16
19 20 21 | 19 22 25

(C) 1 2 3 | (D) 1 2 3
4 5 6 | 13 14 15
7 8 9 | 25 26 27

Ans. **A**

Sol. **Given :**

Code, in which

```
int a [3][3][3] = {{1, 2, 3, 4, 5, 6, 7, 8, 9},
{10, 11, 12, 13, 14, 15, 16, 17, 18},
{19, 20, 21, 22, 23, 24, 25, 26, 27}};
int i= 0, j= 0, k=0;
for (i = 0; i< 3; i++)
{
for(k = 0; k<3; k++)
```

So, from given code

}

ASCII encoding for relevant characters are given below :

A	B	C	...	Z
65	66	67	...	90
a	b	c	...	z
97	98	99	...	122

*	+	–
42	43	45

(A) z K S | (B) 122 75 83

(C) * – + | (D) P × +

Ans. **A**

Sol. **Given :**

ANSI C program :


```
#include<stdio.h>
int main(int argc, char *argv[])
{
    char a = 'P';
    char b = 'x';
    char c = (a & b) + '*';
    char d = (a | b) - '-';
    char e = (a ^ b) + '+';
    print f("%c%c%c\n",c,d,e);
    return 0;
}
```

ASCII value of P = 80 and $x = 120$

$c = \underbrace{a \& b}_{\downarrow} + \underbrace{'*'}_{\downarrow}$

$80 \quad 42 \quad \rightarrow 122 \Rightarrow z$

$d = \underbrace{a/b}_{\downarrow} - \underbrace{'-'}_{\downarrow}$

$120 \quad 45 \quad \rightarrow 75 \Rightarrow K$

$e = \underbrace{a \hat{} b}_{\downarrow} + \underbrace{'+'}_{\downarrow}$

$40 \quad 43 \quad \rightarrow 83 \Rightarrow S$

Hence, the correct option is (A).

Question 45 **698808240**

Consider solving the following system of simultaneous equations using LU decomposition.

$x_1 + x_2 - 2x_3 = 4, \quad x_1 + 3x_2 - x_3 = 7$ and $2x_1 + x_2 - 5x_3 = 7$

where L and U are denoted as

$\begin{pmatrix} L_{11} & 0 & 0 \end{pmatrix}$

(C) $L_{32} = -\frac{1}{2}, U_{33} = 2, x_1 = 0$

(D) $L_{32} = -\frac{1}{2}, U_{33} = -\frac{1}{2}, x_1 = 0$

Ans. **D**

Sol. **Given :**

Simultaneous equations :

$x_1 + x_2 - 2x_3 = 4$

$x_1 + 3x_2 - x_3 = 7$

$2x_1 + x_2 - 5x_3 = 7$

and L and U Which is denoted by

$$L = \begin{pmatrix} L_{11} & 0 & 0 \\ L_{21} & L_{22} & 0 \\ L_{31} & L_{32} & L_{33} \end{pmatrix}$$

and $U = \begin{pmatrix} U_{11} & U_{12} & U_{13} \\ 0 & U_{22} & U_{23} \\ 0 & 0 & U_{33} \end{pmatrix}$.

So, $LU = A$

$$\begin{bmatrix} 1 & 0 & 0 \\ L_{21} & 1 & 0 \\ L_{31} & L_{32} & 1 \end{bmatrix} \begin{bmatrix} U_{11} & U_{12} & U_{13} \\ 0 & U_{22} & U_{23} \\ 0 & 0 & U_{33} \end{bmatrix} = \begin{bmatrix} 1 & 1 & -2 \\ 1 & 3 & -1 \\ 2 & 1 & -5 \end{bmatrix}$$

$$\begin{bmatrix} U_{11} & U_{12} & U_{13} \\ L_{21}U_{11} & L_{21}U_{12} + U_{22} & L_{21}U_{13} + U_{23} \\ L_{31}U_{11} & L_{31}U_{12} + L_{32}U_{22} & L_{31}U_{13} + L_{32}U_{23} + U_{33} \end{bmatrix}$$

$$= \begin{bmatrix} 1 & 1 & -2 \\ 1 & 3 & -1 \\ 2 & 1 & -5 \end{bmatrix}$$

$$L=\begin{pmatrix} L_{21} & L_{22} & 0 \\ L_{31} & L_{32} & L_{33} \end{pmatrix},$$

$$U=\begin{pmatrix} U_{11} & U_{12} & U_{13} \\ 0 & U_{22} & U_{23} \\ 0 & 0 & U_{33} \end{pmatrix}$$

Which one of the following is the correct combination of values for L_{32}, U_{33}, and x_1?

(A) $L_{32}=2, U_{33}=-\frac{1}{2}, x_1=-1$

(B) $L_{32}=2, U_{33}=2, x_1=-1$

Comparing A_{11}, A_{12} and A_{13}

$U_{11}=1$

$U_{12}=1$

$U_{13}=-2$

Comparing A_{21},

$L_2.U_{11}=1$

Putting value of U_{11}

$L_{21}\times 1=1$

$L_{21}=1$

Comparing A_{22}

$L_{21}U_{12}+U_{22}=3$

Putting value of L_{21} and U_{12}

$1\times 1+U_{22}=3$

$U_{22}=2$

Comparing A_{23}

$L_{21}U_{13}+U_{23}=-1$

Putting value of L_{21} and U_{13}

$1\times -2+U_{23}=-1$

$U_{23}=1$

Comparing A_{31}

$L_{31}U_{11}=2$

Putting value of U_{11}

$L_{31}\times 1=2$

$L_{31}=2$

Comparing A_{32}

$L_{31}U_{12}+L_{32}U_{22}=1$

Putting value of L_{31}, U_{12} and U_{22}

$2\times 1+L_{32}\times 2=1$

$L_{32}\times 2=-1$

$L_{32}=\frac{-1}{2}$

Comparing A_{33}

$L_{31}U_{13}+L_{32}U_{23}+U_{33}=-5$

$2\times -2+\frac{-1}{2}\times 1+U_{33}=-5$

$-4-\frac{1}{2}+U_{33}=-5$

$\boxed{U_{33}=-\frac{1}{2}}$

(D) Given a Turing machine, M decide if M takes more than 1073 steps on every string.

Ans. **A, C, B**

Sol. For a given Turing machine, M decide that m takes more than 1073 steps on every string is decidabe only.

Remaining are undecidable

(A), (C) and (B) are undecidable.

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

Question 47 **698808242**

Consider language

$$L_1=\{a^n\omega a^n \mid \omega\in\{a,b\}^*\}$$

$$L_2=\{\omega x\omega^R \mid \omega, x\in\{a,b\}^*, |\omega|, |x|>0\}$$

Note ω^R is reversal of string ω which one of the following is true?

(A) L_1, L_2 are regular

(B) L_1 and L_2 are context free language

(C) L_1 is regular and L_2 is context free language

(D) L_1 and L_2 are context free language but not regular

Ans. **A, B, C**

Sol. **Given :**

Languages L_1 & L_2

and w^R is reversal of string w

$L_1=\{a^n w a^n \mid w\in(a,b)^*\}$ is regular

$L_2=\{wxw^R \mid w,x\in(a,b)^*, |w|, |x|>0\}$ is

$\boxed{2}$

Hence, the correct option is (D).

Question 46 **698808241**

Which of the following statements is / are undecidable?

(A) Given two Turing machines M_1 and M_2 decide of $L(M_1)=L(M_2)$.

(B) Given a Turing machine M, decide if $L(M)$ is regular.

(C) Given a Turing machine M, decide if M accepts all strings.

also regular

So, now from language L_1

L_1 is regular, because when we put the value of n is 0, then it will create a subset $\{w \mid w \in \{ab\}^*\}$

Which contains all possible strings.

So, if the subset of L_1 is $(a+b)^*$ then, $L_1=(a+b)^*$.

Now, from language L_2, L_2 is also regular, because when we put "a"and "b"in place of w, then we get

the expression which is regular such that $a(a+b)^+a+b(a+b)^*b$, which covers all the other string which can be obtained by putting w as "aa", "ab","bb","ba".

$\therefore$ Both L_1 and L_2 are regular

Any language which is regular is context free language as well.

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

Question 48 **698808243**

Consider the following languages

$L_1=\{ww \mid w \in (a, b)^*\}$,

$L_2=\{a^n b^n c^m \mid m, n \geq 0\}$

and $L_3=\{a^m b^n c^n \mid m, n \geq 0\}$

Which of the following statements are false?

(A) L_1 is not Context Free Language but L_2 and L_3 are Deterministic Context Free Language.

(B) Neither L_1 nor L_2 is Context Free Language.

(C) L_2, L_3 and $L_2 \cap L_3$ all are Context Free Language.

(D) Neither L_1 nor its complement is Context Free Language.

Ans. **B, C, D**

Sol. **Given :**

Languages

$L_1=\{ww \mid w \in (a, b)^*\}$

$L_2=\{a^n b^n c^m \mid m, n \geq 0\}$

L_2 & L_3 they both are CFL because they both have only 1 comparison.

$L_2 \cap L_3$ is not CFL.

$\therefore$ from these conditions,

(B), (C) and (D) are false

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

Question 49 **698808244**

Consider a simple undirected weighted graph G, all of whose edge weights are distinct. Which of the following statements about the Minimum Spanning Tree of G is/are true?

(A) Suppose $S \subseteq V$ be such that $S \neq \phi$ and $S \neq V$. Consider the edge with minimum weight such that one of its vertices is in S and the other in V\S. Such an edge will always be part of any Minimum Spanning Tree of G.

(B) G can have multiple Minimum Spanning Tree.

(C) One or both of the edges with the third smallest and the fourth-smallest weight are part of any MST of G.

(D) The edge with the second-smallest weight is always part of any Minimum Spanning Tree of G.

Ans. **A, C, D**

Sol. **Given :**

Undirected weighted graph G

Where, edge weights are distinct.

So, from given statements,

$L_3 = \{a^m b^n c^n \mid m, n \geq 0\}$

Now, from given languages:

$L_1 = \{ww \mid w \in \{a, b\}^*\}$ this language is not CFL, because it has the strings which has straight order.

but complement of $\overline{L_1}$ is CFL.

$L_2 = \{a^n b^n c^m \mid nm \geq 0\}$ is CFL

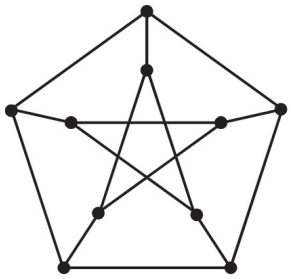
$L_3 = \{a^n b^m c^m \mid n, m \geq 0\}$ is CFL

The smallest edge is always part of the MST. The graph does not have multiple spanning trees, as all the edge weights are unique. The second and third-smallest edge will be part of the MST if the number of vertices are greater than $n > 3$ and 4 respectively.

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

Question 50 **698808245**

The following simple undirected graph is referred to as the Peterson graph.

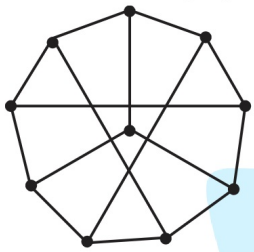


Which of the following statements is/are TRUE?

(A) The chromatic number of the graph is 3.

(B) The graph has a Hamiltonian path.

(C) The following graph is isomorphic to the Peterson graph.



(D) The size of the largest independent set of the given graph is 3. (A subset of vertices of a graph form an independent set if no two vertices of the subset are adjacent.)

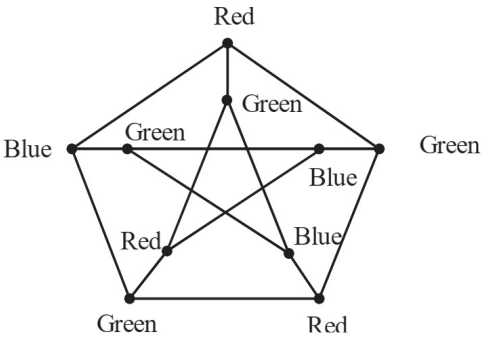
Ans. **A, B, C**

Sol. **Given :**

Undirected graph which is referred as the Peterson graph, then from

Statement A : The chromatic number of the graph is 3.

True,



Statement C : The size of the largest independent set of the given graph is 3. (A subset of vertices of a graph form an independent set if no two vertices of the subset are adjacent.)

False,

A set of vertices I is called an independent set if no two vertices in set I are adjacent to each other or in other words the set of non-adjacent vertices is called an independent set.

It is 4. From option B by simply keeping all the green vertices together we can simply observe that largest independent set contains 4 vertices.

Statement D : The following graph is isomorphic to the Peterson graph.

True,

We can say given graphs are isomorphic if they have :

1. Equal number of vertices
2. Equal number of edges
3. Same degree sequence
4. Same number of circuit of particular length

Note : In most graphs checking the first three conditions is enough.

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

Statement B : The graph has a Hamiltonian path.

True,

Question 51 **698808246**

Consider the following recurrence :

$f(1)=1$

$f(2n)=2f(n)-1, \text{for } n\geq 1;$

$f(2n+1)=2f(n)+1, \text{for } n\geq 1;$

Then, which of the following statement is/are TRUE?

(A) $f(2^n+1)=2^n+1$

(B) $f(5.2^n)=2^{n+1}+1$

(C) $f(2^n-1)=2^n-1$

(D) $f(2^n)=1$

Ans. **B, C, D**

Sol. **Given :**

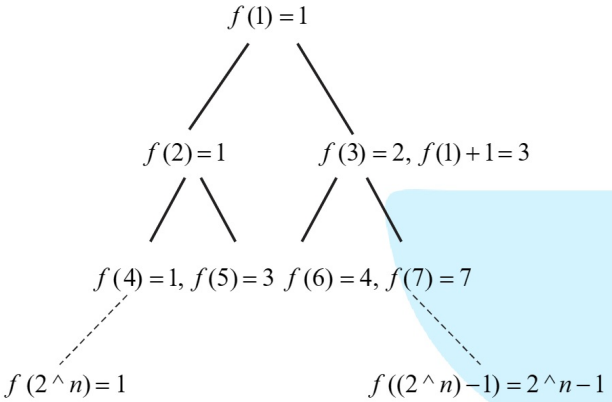
Recurrence function :

$f(1)=1$

$f(2n)=2f(n)-1, \text{for } n\geq 1;$ {i.e. for even input to function f}

$f(2n+1)=2f(n)+1, \text{for } n\geq 1;$ {i.e. for odd input to function f}

Options (C) and (D) are true as given in the following diagram.



For option (A) :

$2^n+1=\text{definitly odd}$

$\therefore \quad f(2^n+1)=2f(2^{n-1})+1=2(1)+1$

$\{\text{As we know } f(2^{n-1})=1\}$

$=3$

Therefore, option (A) is false.

For option (B) :

5.2^n = Definitely even number for all $n\geq 1$

$f(5\cdot 2^n)=2f(5\cdot 2^{n-1})-1$

$=2\left(2f(5\cdot 2^{n-2})-1\right)-1$

$=2^2 f(5\cdot 2^{n-2})-2-1$

$=2^{n+1}+2^n-2^n+1$

$=2^{n+1}+1$

Therefore, option (B) is false.

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

Question 52 **698808247**

Which of the properties hold for the adjacency matrix A of a simple undirected unweighted graph having n vertices?

(A) The diagonal entries of A^2 are the degrees of the vertices of the graph

(B) If the graph is connected then none of the entries of $A^{n-1}+I_n$ can be zero

(C) If the sum of all the elements of A is at most $2(n-1)$ then the graph must be acyclic

(D) If there is at least a 1 in each of A's rows and columns, then the graph must be connected

Ans. **A**

Sol. **Option (A) : True.**

Let's think about what $(A^2)_{i,i}$, the $i-th$ term on the diagonal is. We have

$(A^2)_{ii}=(A\times A)_{ii}=\sum jA_i,\ {}_jA_{j,i}$

But $A_{ij}=A_{j,i,}$ assuming that the graph is undirected, and $A_{ji}=1(i\sim j), i.e.$ is 1 is i and j are adjacent and 0 otherwise. Thus $A_{ij}A_{j,i}=A^2{}_{i,j}=A_{i,j}=1(i\sim j)$. So the sum is just the number of j such that $i\sim j$, which precisely the degree is.

This work if vertices in your graph may

$$= 2^2\left(2f(5\cdot 2^{n-3})-1\right)-2-1$$
$$= 2^3 f(5\cdot 2^{n-3})-2^2-2-1$$
$$= 2^n f(5\cdot 2^0)-2^{n-1}-2^{n-2}-2^{n-3}\ldots-2-1$$
$$= 2^n\left(f(5)\right)-\left(1+2+2^2+\ldots 2^{n-2}+2^{n-1}\right)$$
$$= 2^n(3)-(2^n-1)$$
$$= 2^n(2+1)-(2^n-1)$$

have a single self-loop, provided you count that as 1 (not 2) for the degree. Indeed, the term in the sum when $j=i$ is just $A^2_{i,i,}$ but you need this to be equal to $A_{i,i}$. Thus it needs to be 0 or 1.

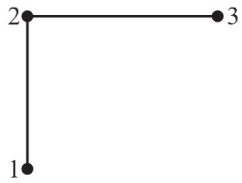
It does not work more generally, however, as $A^2_{ii} \neq A_{i,j}$ if $A_{i,j} > 1$.

$$(A^T A)_{i,j} = \sum_i A^2_{i,j} = \deg_{\text{out}}(i),$$

even for an undirected graph, provided the graph is simple.

Option (B) : False.

Take following connected graph with $n=3$,



Adjacency matrix, $(A)=\begin{bmatrix}0&1&0\\1&0&1\\0&1&0\end{bmatrix}$

$$A^{n-1} = A^{3-1} = A^2$$
$$= \begin{bmatrix}0&1&0\\1&0&1\\0&1&0\end{bmatrix}\begin{bmatrix}0&1&0\\1&0&1\\0&1&0\end{bmatrix} = \begin{bmatrix}1&0&1\\0&2&0\\1&0&1\end{bmatrix}$$
$$A^{n-1}+I_n = A^2+I_3$$
$$= \begin{bmatrix}1&0&1\\0&2&0\\1&0&1\end{bmatrix}+\begin{bmatrix}1&0&0\\0&1&0\\0&0&1\end{bmatrix} = \begin{bmatrix}2&0&1\\0&3&0\\1&0&2\end{bmatrix}$$

We can see that $A^{n-1}+I_n$ have some entries as zero. So option (B) false.

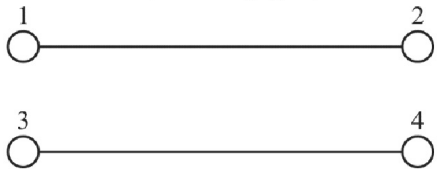
Option (C) : False.

A cyclic graph is a graph containing at least one graph cycle. Consider a graph with 10 vertices where only three vertices form a cycle while reset are isolated vertices (that is a disconnected graph)

In such a case, sum of all the elements of A is $(1+1+1)=3$ and 3 is less than $2(10-1)=2*9=18$. But the graph is

	1	2	3	4
1	0	1	0	0
2	1	0	0	0
3	0	0	0	1
4	0	0	1	0

The corresponding graph is :



The graph is not connected.

Hence, the correct option is (A).

Question 53 **698808248**

Which is /are eigen vector for given matrix $\begin{pmatrix}-9&-6&-2&-4\\-8&-6&-3&-1\\20&15&8&5\\32&21&7&12\end{pmatrix}$

(A) $\begin{pmatrix}-1\\1\\0\\1\end{pmatrix}$ (B) $\begin{pmatrix}1\\0\\-1\\0\end{pmatrix}$

(C) $\begin{pmatrix}-1\\0\\2\\2\end{pmatrix}$ (D) $\begin{pmatrix}0\\1\\-3\\0\end{pmatrix}$

Ans. **A, C, D**

Sol. **Given :**

Matrix $\begin{pmatrix}-9&-6&-2&-4\\-8&-6&-3&-1\\20&15&8&5\\32&21&7&12\end{pmatrix}$

Then from given options :

Option (A) :

$$\begin{bmatrix}-9&-6&-2&-4\end{bmatrix}\begin{bmatrix}-1\end{bmatrix}\quad\begin{bmatrix}-3\end{bmatrix}\quad\begin{bmatrix}-1\end{bmatrix}$$

still cyclic.

Option (D) : False.

Considering the following adjacency matrix :

$$\begin{bmatrix} -8 & -6 & -3 & -1 \\ 20 & 15 & 8 & 5 \\ 32 & 21 & 7 & 12 \end{bmatrix} \begin{bmatrix} 0 \\ 2 \\ 2 \end{bmatrix} = \begin{bmatrix} 0 \\ 6 \\ 6 \end{bmatrix} = 3 \begin{bmatrix} 0 \\ 2 \\ 2 \end{bmatrix}$$

Option (B) :

$$\begin{bmatrix} -9 & -6 & -2 & -4 \\ -8 & -6 & -3 & -1 \\ 20 & 15 & 8 & 5 \\ 32 & 21 & 7 & 12 \end{bmatrix} \begin{bmatrix} 0 \\ 1 \\ -3 \\ 0 \end{bmatrix} = \begin{bmatrix} 0 \\ 3 \\ -9 \\ 0 \end{bmatrix} = 3 \begin{bmatrix} 0 \\ 1 \\ -3 \\ 0 \end{bmatrix}$$

Option (C) :

$$\begin{bmatrix} -9 & -6 & -2 & -4 \\ -8 & -6 & -3 & -1 \\ 20 & 15 & 8 & 5 \\ 32 & 21 & 7 & 12 \end{bmatrix} \begin{bmatrix} -1 \\ 1 \\ 0 \\ 1 \end{bmatrix} = \begin{bmatrix} -1 \\ 1 \\ 0 \\ 1 \end{bmatrix} = 1 \begin{bmatrix} -1 \\ 1 \\ 0 \\ 1 \end{bmatrix}$$

Option (D) :

$$\begin{bmatrix} -9 & -6 & -2 & -4 \\ -8 & -6 & -3 & -1 \\ 20 & 15 & 8 & 5 \\ 32 & 21 & 7 & 12 \end{bmatrix} \begin{bmatrix} 1 \\ 0 \\ -1 \\ 0 \end{bmatrix} = \begin{bmatrix} -7 \\ -5 \\ 12 \\ 25 \end{bmatrix}$$

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

Question 54 **698808249**

Consider a system with 2 KB direct mapped data cache with a block size of 64 bytes. The system has a physical address space of 64 KB and a word length of 16 bits. During the execution of a program, four data words P, Q, R, and S are accessed in that order 10 times (i.e., PQRSPQRS...). Hence, there are 40 accesses to data cache altogether. Assume that the data cache is initially empty and no other data words are accessed by the program. The addresses of the first bytes of P, Q, R, and S are 0xA248, 0xC28A, 0xCA8A, and 0xA262, respectively. For the execution of the above program, which of the following statements is/are TRUE with respect to the data cache?

(A) Every access to S is a hit.

(B) Once P is brought to the cache it is never evicted.

Direct Cache memory

Where, cache memory size $= 2\,\text{kB}$, block size $= 64\,\text{Bytes}$, physical address space $= 64\,\text{kB}$,

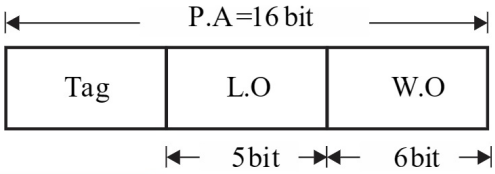
word length $= 16\,\text{bits}$.

$\therefore$ Cache line $\dfrac{2\text{kB}}{64\,\text{B}} = 32$

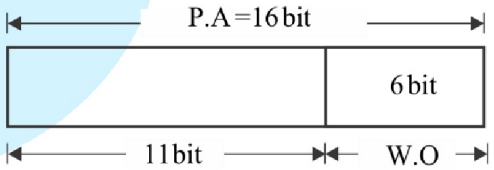
$\therefore$ Line offset $= 5\,\text{bit}$

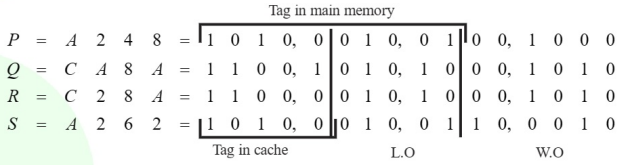
Bits in Physical address = $\log_2$ (Main memory size = $\log_2$ (64 kB) = 16 bit)

Physical address format for direct mapped cache



Physical address format for main memory





- P and S are in same block of memory physical address
- Q and S are different block of main memory but mapped to same cache line.

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

Question 55 **698808250**

Consider routing table of an organization's router shown below :

Subnet number	Subnet mask	Next hop

(C) At the end of the execution only R and S reside in the cache.

(D) Every access to R evicts Q from the cache.

Ans. **A, B, D**

Sol. **Given :**

12.20.164.0	255.255.252.0	R_1
12.20.170.0	255.255.254.0	R_2
12.20.168.0	255.255.254.0	Interface 0
12.20.166.0	255.255.254.0	Interface 1
(default)		R_3

Which of the following prefixes in CIDR notation can be collectively used to correctly aggregate all of the subnets in the routing table?

(A) 12.20.164.0/20 (B) 12.20.164.0/22

(C) 12.20.164.0/21 (D) 12.20.168.0/22

Ans. **A**

Sol. **Given :** Routing table of an organization's router shown below :

Subnet number	Subnet mask	Next hop
12.20.164.0	255.255.252.0	R_1
12.20.170.0	255.255.254.0	R_2
12.20.168.0	255.255.254.0	Interface 0
12.20.166.0	255.255.254.0	Interface 1
(default)		R_3

(A) 12.20.1010 0100.00000000, here the network address is 12.20.1010 0100.00000000 and this network covers all the required IP addresses and hence the required answer.

(B) 12.20.10100 100.00000000, here the network address is 12.20.10100 100.00000000, but this network does not have IP address 12.20.170.0, hence this cannot be the answer.

(C) 12.20.101010 00.00000000, here in this network address we do not have IP address 12.20.164.0, hence this cannot be the answer.

(D) 12.20.101001 00.00000000, here in this network we do not have IP address 12.20.170.0, hence this cannot be the answer.

So, 12.20.164.0/20 will be the network – ID of aggregated route.

Hence the correct option is (A).

Question 56 **698808251**

Consider relational database with the four schemas and their respective

Register ($\underline{sNo}$, dNo)

Student

sNo	sName	dNo
S1	James	D01
S2	Rocky	D01
S3	Jackson	D02
S4	Jane	D01
S5	Milli	D03

Department

dNo	dName
D01	CSE
D02	EEE

Course

cNo	cName	dNo
C_{11}	DS	D01
C_{12}	DS	D01
C_{21}	DE	D02
C_{22}	PT	D02
C_{23}	CV	D03

Register

sNo	cNo
S01	C_{17}
S01	C_{12}
S02	C_{11}
S03	C_{21}
S03	C_{22}
S03	C_{23}
S04	C_{11}
S04	C_{12}
S05	C_{11}
S05	C_{21}

SELECT * FROM Student AS S WHERE NOT EXIST

(SELECT cNo FROM Course WHERE dNo = "D01"

EXCEPT

SELECT cNo FROM Register WHERE

instances :

Student ($\underline{sNo}$, sName, dNo)

Department ($\underline{dNo}$, dName)

Course ($\underline{cNo}$, cName, dNo)

sNo = S.sNo)

The number of rows returned by the above SQL query is ____.

Ans. **2**

Sol. **Given :**

Relational database

Where, four schemas and their respective instances are as follows :

Student ($\underline{sNo}$, sName, dNo)

Department ($\underline{dNo}$, dName)

Course ($\underline{cNo}$, cName, dNo)

Register ($\underline{sNo}$, dNo)

So from given query,

Select * from student S where not exist

((Select cNo from course where dNo = D01 except))

(Select cNo from register where sNo = S.sno)

The above query is co-related sub query so we need to execute inner query for every row of outer table.

Hence it gives 2 rows in output

S1	J	D01
S4	M	D03

Hence the correct answer is 2.

Question 57 **698808252**

Consider a network with three routers P, Q, R shown in the figure below. All the links have cost of unity.

The routers exchange distance vector routing information and have converged on the routing tables, after which the link Q-R fails. Assume that P and Q send out routing updates at random times, each at the same average rate. The probability of a routing loop formation (rounded off to one decimal place) between P and Q, leading to count-to-infinity problem, is _____.

Ans. **0.5**

Sol. **Given :** Network with three routers *P*, *Q*, *R* as shown in the figure.

Once *Q*-*R* fails then *Q* will immediately update its distance to *R* to ∞. But *R*

Now it depends on *P* and *Q* who is sending distance vector first.

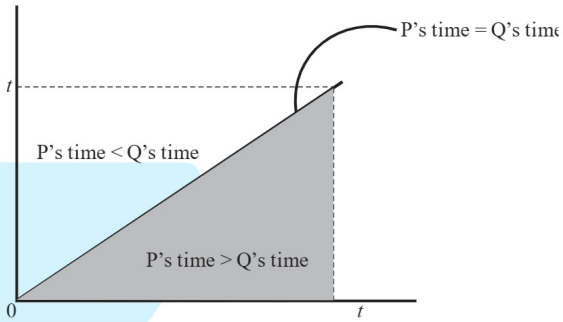
If *Q* sends then system becomes stable immediately but if *P* sends first then it will be count to infinity.

Since it is given in question that both have same average rate hence probability is also $\frac{1}{2}\rightarrow$ OR 0.5 that *P* sends first than *Q*.

Hence the correct answer is 0.5.

OR

We can also calculate the answer more mathematically considering that time is continuous variable.



Considering the probability represented by shaded area :

$$P=\frac{\text{Area of Triangle}}{\text{Area of Square}}=\frac{\frac{1}{2}t^2}{t^2}=\frac{1}{2}=0.5$$

Hence, the correct answer is 0.5.

Question 58 **698808253**

Let G (V,E) be a directed graph *V* = {1,2,3,4,5} is the set of vertices and E is the set of directed edges, as defined by the following adjacency matrix A :

$$A[i][j]=\begin{cases}1, & 1\le j\le i\le 5\\ 0, & \text{otherwise}\end{cases}$$

$A[i][j]=1$ indicates a directed edge from node i to node j. A directed spanning tree of G, rooted at $r\in V$, is defined as a subgraph T of G such that the undirected version of T is a tree, and T contains a directed path from r to every other vertex in V. The number of such directed spanning trees rooted

update its distance to A to ∞. But P will still be having same finite valve (which is 2).

at vertex 5 is _____.

Ans. **24**

Sol. **Given :**

A directed graph G with V vertices and E edges

And it is defined by adjacency matrix A :

$$A[i][j]=\begin{cases}1, & 1\le j\le i\le 5\\ 0, & \text{otherwise}\end{cases}$$

$A[i][j]=1$ indicates a directed edge from node i to node j

So, when we consider a graph of two elements, we get only 1 possible MST $(2->1)$ When we consider a graph of three elements, we get 2 possible MSTs $(3->1,3->2 \text{ or } 2->1,3->2)$. Similarly, When we consider a graph of four elements, we get only $3\times2\times1$ possible MSTs. Similarly. When we consider a graph of five elements, we get only $4\times3\times2\times1=24$ possible MSTs.

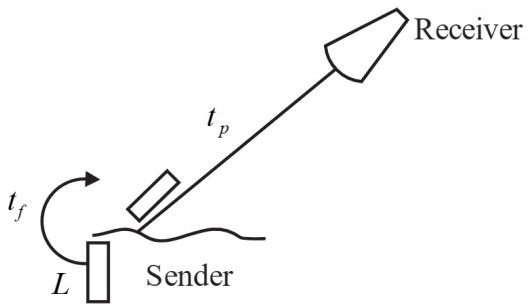
Hence the correct answer is 24.

Question 59 **698808254**

Consider a 100 Mbps link between an earth station (sender) and a satellite (receiver) at an altitude of 2100 km. The signal propagates at a speed of 3×10^8 m/s. The time taken (in milliseconds runoff to 2 decimal places) for the receiver to completely receive a packet of 1000 bytes transmitted by the sender is _____.

Ans. **7.08**

Sol. **Given :**



A sender (earth station)

& a receiver (satellite)

Where, Distance = 2100 km,

Speed = 3×10^8 m/s

Bandwidth = 10^8 m/s,

Now, $t_p=\frac{d}{s}=\frac{2100\,\text{km}}{3\times10^8\,\text{m/s}}=\frac{2100\times10^3\,\text{m}}{3\times10^8\,\text{m/s}}$

$=7\times10^{-3}\,\text{sec}=7\text{ms}$

$t_t=\frac{L}{R}=\frac{1000\,\text{bytes}}{100\text{ Mbps}}=\frac{1000\times8\text{ bits}}{100\times10^6\,\text{bits/sec}}$

$=\frac{8}{100}\times10^{-3}\,\text{sec}=0.08\,\text{ms}$

$T=t_t+t_p=0.08+7ms=7.08\text{ ms}$

Hence the correct answer is 7.08 ms.

Question 60 **698808255**

Consider the data transfer using TCP over a one Gbps link. Assuming that the maximum segment life time (MSL) is set to 60 second, the minimum number of bits required for the sequence number field of the TCP header, to prevent the sequence number space from wrapping around during the MSL is_____.

Ans. **33**

Sol. **Given :** TCP connection

Where, Maximum segment lifetime = 60 second, Bandwidth = 1 Gbps.

$4\times3\times2\times1=24$,

$n=\text{Sequence Number bits}$

$\Rightarrow 60\,\text{sec}=\frac{2^n\times8\,bits}{10^9\,bits/\,\text{sec}}$

$\Rightarrow 60\times10^9=2^{n+3}$

$\Rightarrow \log_2(60\times10^9)=\text{n}+3$

$\Rightarrow \log60+9\times\log_2 10=\text{n}+3$

$\Rightarrow 5.9+29.87=n+3$

$\Rightarrow 35.79=n+3$

$\Rightarrow n+3=36$

$\Rightarrow n=33$

Hence the correct answer is 33.

Question 61 **698808256**

A processor X_1 operating at 2 GHz has a standard 5-stage RISC instruction pipeline having a base CPI (cycles per instruction) of one without any pipeline hazards. For a given program P that has 30% branch instructions, control hazards incur 2 cycles stall for

Data size = 1000 Bytes.

control hazards incur 2 cycles stall for every branch. A new version of the

processor X_2 operating at same clock frequency has an additional branch predictor unit (BPU) that completely eliminates stalls for correctly predicted branches. There is neither any savings nor any additional stalls for wrong predictions. There are no structural hazards and data hazards for X_1 and X_2. If the BPU has a prediction accuracy of 80%, the speed up (rounded off to two decimal places) obtained by X_2 over X_1 in executing P is_____.

Ans. **1.42**

Sol. **Given :**

2 processors X_1 and X_2

Where, Cycle time = 0.5 ns and Prediction accuracy of BPU = 80%.

Speed Up x_2 over x_1 =

$$\frac{\text{Execution time using } x_1}{\text{Execution time using } x_2}$$

$$= \frac{(\text{Avg CPI})_{x_1} \times \text{Cycle time}}{(\text{Avg CPI})_{x_2} \times \text{Cycle time}}$$

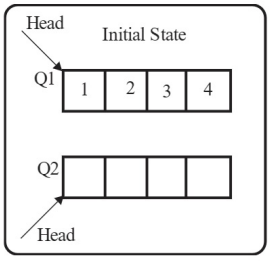
$$= \frac{(1+0.3\times 2)\times t_p}{(1+0.3\times(0.8\times 0+0.2\times 2))\times t_p}$$

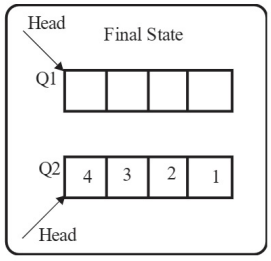
$$= \frac{1.6}{1.12} = 1.42$$

Hence the correct answer is 1.42.

Question 62 **698808257**

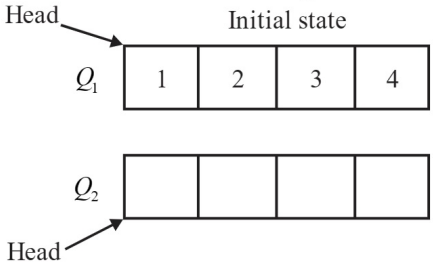
Consider the queues Q_1 containing four elements and Q_2 containing none (shown as the Initial State in the figure). The only operations allowed on these two queues are Enqueue (Q,element) and Dequeue(Q). The minimum number of Enqueue operations on Q1 required to place the elements of Q_1 in Q_2 in reverse order (shown as the Final State in the figure) without using any additional storage is _____.



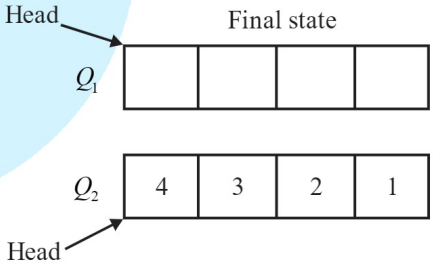


Ans. **0**

Sol. **Given :** Queues Q_1 containing four elements and Q_2 containing none as shown below in the figure.



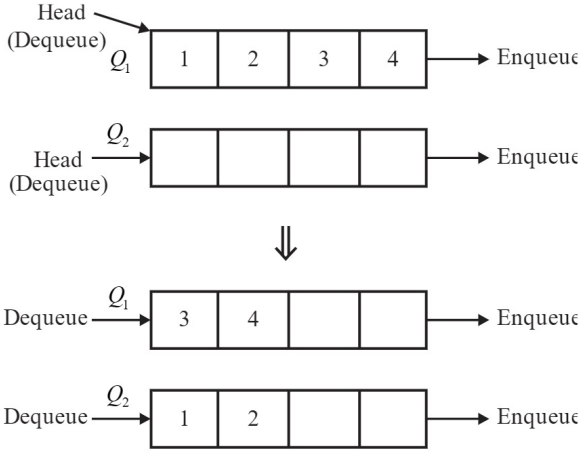
We have to obtain the following situation as shown below in the figure.



As we know that;

If queue is just having 2 elements then we can reverse a queue in place by just using simple enqueue and dequeue and if more than 2 elements we cannot reverse so, first divide 4 elements into 2-2 element each.

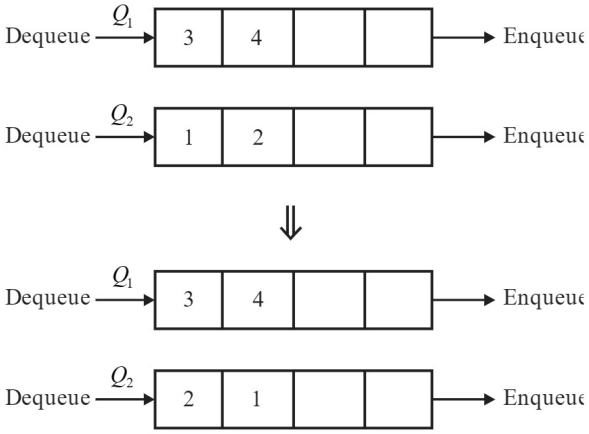
Step 1 : Enqueue 1 in Q_2, it is already sorted. Also Enqueue 2 in Q_2 i.e 1, 2.



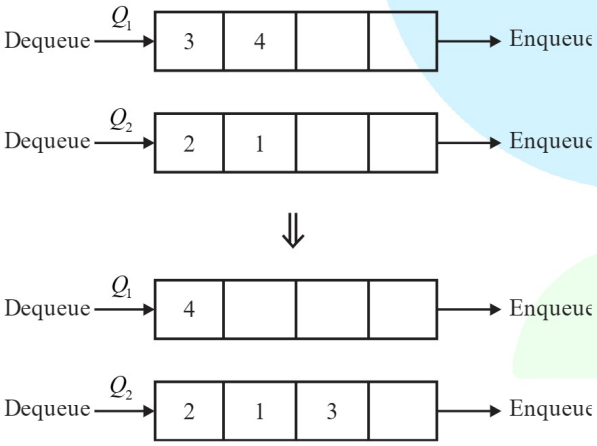
Till now, No enqueue to Q_1.

Now reverse Q_2. This doesn't cost any Enqueue to Q_1.

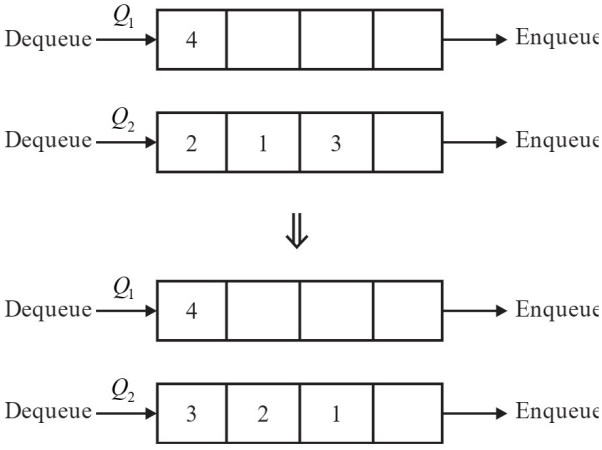
Step 2 : Perform 1 Dequeue and 1 Enqueue simultaneously for 1 time 2 in Q_2 i.e. 2, 1 (head pointing at 2 now)



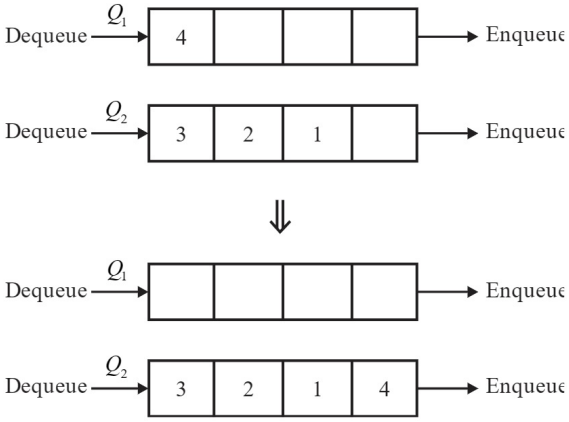
Step 3 : Enqueue 3 in Q_2 i.e 2, 1, 3



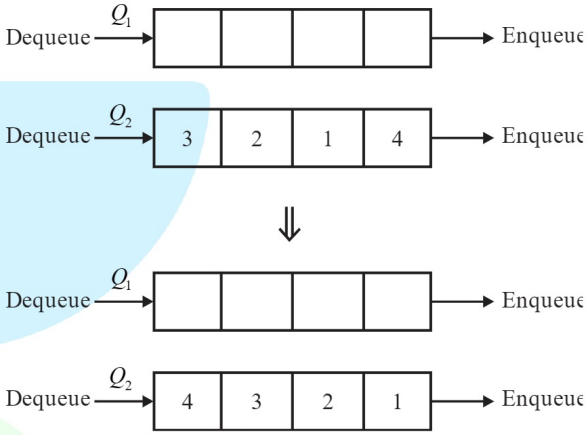
Step 4 : Perform 1 Dequeue and 1 Enqueue simultaneously for 2 times in Q_2 i.e 2, 1, 3 → 1, 3, 2 → 3, 2, 1 (head pointing at 3 now)



Step 5 : Enqueue 4 in Q_2 i.e 3, 2, 1, 4

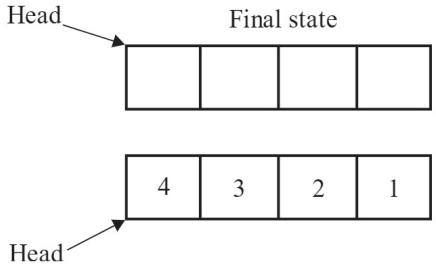


Step 6 : Perform 1 Dequeue and 1 Enqueue simultaneously for 3 times in Q_2 i.e 3, 2, 1, 4 → 2, 1, 4, 3 → 1, 4, 3, 2 → 4, 3, 2, 1



So the number of enqueue operations in Q_1 is 0.

Thus, we have obtain the final state as shown below



Hence, the correct answer is 0.

Question 63 **698808258**

Consider two file-systems A and B. that use contiguous allocation and linked allocation respectively A file of size 100 blocks is already stored in A and also in B. Now, consider inserting a new block in the middle of the file (between 50th and 51st block), whose

data is already available in the memory. Assume that there are enough free blocks at the end of the file and that the file control blocks are already in memory. Let the number of disk accesses required to insert a block in the middle of the file in A and B are n_A and n_B respectively, then the value of $n_A + n_B$ is _____.

Ans. **153**

Sol. **Given :**

Two file systems A and B,

Which uses contiguous allocation and linked allocation respectively,

Data blocks stored in A and B = 100

So, for contiguous allocation, we have to store all the blocks in a sequence, if we have to store a block in the middle, we have to first shift all the blocks after that one place right, for which we need one disk read and one disk write for each block (2 disk accesses). Now since we are storing one block in contiguous allocation at 51^{st} position, the blocks (51^{st} to 100^{th}) have to be moved one step right, for which 2*50 disk accesses are required, then one access to store the new block, thus $n_A = 100 + 1 = 101.$

In Linked allocation, we must read 50 blocks to find the middle. Then we must write the new block somewhere with the next block pointing to the block after the 50^{th} block. Then we must write the 50^{th} block to point to this new block, thus

$n_B = 50 + 1 + 1 = 52$

Hence our required answer $n_A + n_B$ is 153.

Question 64 **698808259**

Consider a demand paging system with four page frames (initially empty) and LRU page replacement policy. For the following page reference string

7, 2, 7, 3, 2, 5, 3, 4, 6, 7, 7, 1, 5, 6, 1

the page fault rate, defined as the ratio of number of page faults to the number of memory accesses. (2 decimal) is _____.

Ans. **0.6**

Sol. **Given :**

Demand paging system with four page frames

Where initial frame is empty and LRU page replacement policy used in this.

Page reference string are as follows :

7,2,7,3,2,5,3,4,6,7,7,1,5,6,1

~~7~~	4	5
~~2~~	6	
~~3~~	1	
~~5~~	7	

Total page faults $= 9$

Total Access $= 15$

Thus page fault rate $= 9/15 = 0.6$

Hence the correct answer is 0.6.

Question 65 **698808260**

Consider the following grammar along with translation rules:

$S \rightarrow S_1 \# T \quad \{S_{.val} = S_{1.val} * T_{.val}\}$

$S \rightarrow T \quad \{S_{.val} = T_{.val}\}$

$T \rightarrow T_1 \ \%R \quad (T_{.val} = T_{1.val} \div R_{.val})$

$T \rightarrow R \quad \{T_{.val} = R_{.val}\}$

$R \rightarrow id \quad \{R_{.val} = id_{.val}\}$

Here # and % are operators and id is a token that represents an integer and $id_{.val}$ represents the corresponding integer value. The set of non-terminals is $\{S, T, R, P,\}$ and a subscripted non-terminal indicates an instance of the non-terminal.

Using this translation scheme, the computed value of $S_{.val}$ for root of the parse tree for the expression 20#10%5#8%2%2 is _____.

Ans. **80**

Sol. **Given :**

Grammar with translation rules :

$S \rightarrow S_1 \# T \quad \{S_{.val} = S_{1.val} * T_{.val}\}$

$S \rightarrow T \quad \{S_{.val} = T_{.val}\}$

$T \to T_1 \ \%R \qquad (\mathrm{T_{.val}} = \mathrm{T_{1.val}} \div \mathrm{R_{.val}})$

$T \to R \qquad \{\mathrm{T_{.val}} = \mathrm{R_{.val}}\}$

$R \to id \qquad \{\mathrm{R_{.val}} = \mathrm{id_{.val}}\}$

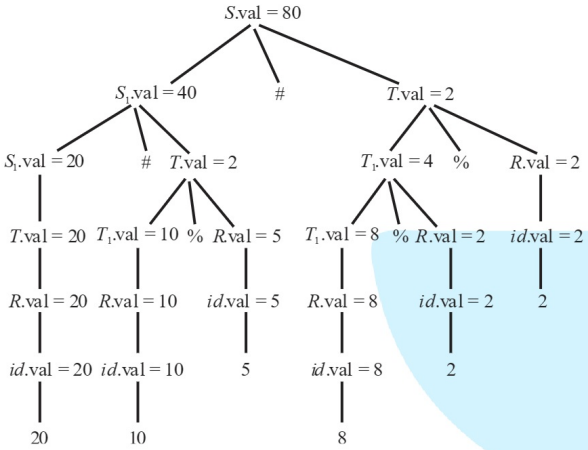
Where, # and % are operators & and *id* is a token which represents an integer

& id_{val} represents corresponding integer value.

Set of non terminals $= \{S,\ T,\ R,\ P,\}$

So, from given conditions :

Annotated parse tree :



$\therefore \quad S.\mathrm{val} = 80$

Hence the correct answer is 80.

❑❑❑

8 GATE CSE-2023

General Aptitude Part

Q.1 to Q.5 Carry One Mark Each

Question 1

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

(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

(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?

(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?

(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?

(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?

(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?

(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.

(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

dimensional figure P to Q, and then to

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?

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

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

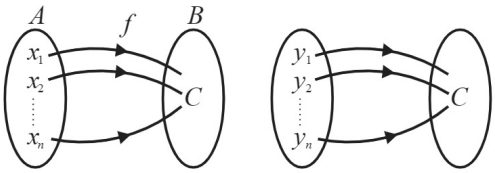
(C) $f(x)\neq$ constant and $g(y)\neq$ constant

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

Ans. **(B)**

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. $f(x)=g(y)=\text{Constant}$.

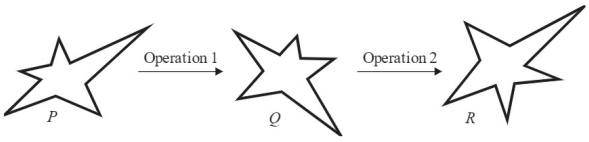


$f(x)=g(y)\forall y\in R$

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?



(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.

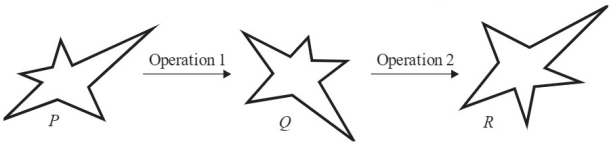
Operation 2 : A reflection along a horizontal line

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

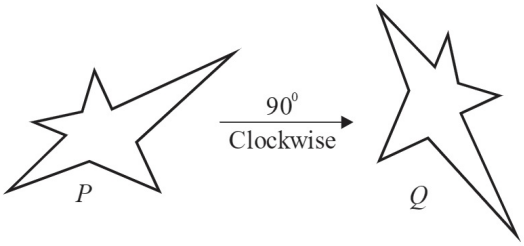
Operation 2 : A reflection along a vertical line.

Ans. **(B)**

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

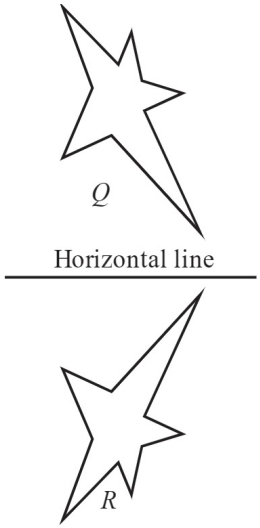


We can clearly see from P to Q, operation 1 is a clockwise rotation by 90^0 about an axis perpendicular to the plane of the figure.



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

takes intermediate code and generates target code as output. It is dependent



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

(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 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 ?

(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

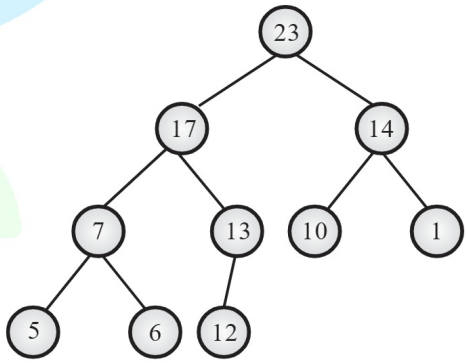
Ans. **(B)**

Sol. Here, wave 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 ?

(A) SLLdel is $O(1)$ and DLLdel is $O(n)$

(B) Both SLLdel and DLLdel are

Ans. **(C)**

Sol. The given F.A. generate strings like:

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

So, start with 1 to reach final state from

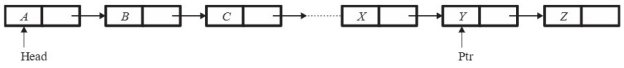
$O(\log(n))$

(C) Both SLLdel and DLLdel are $O(1)$

(D) SLLdel is $O(n)$ and DLLdel is $O(1)$

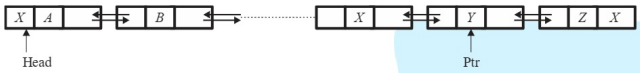
Ans. **(D)**

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:

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

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

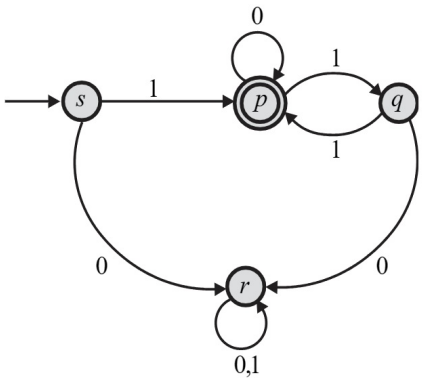
delete (ptr)

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?

(A) 1(0∗11)∗ (B) 0(0 + 1)∗

(C) 1(0 + 11)∗ (D) 1(110∗)∗

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).

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?

(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. Lunar sequence

Put $n = 1$ in option we will get

$$l_1 = \frac{1+\sqrt{5}}{2} + \frac{1-\sqrt{5}}{3} = \frac{2}{2} = 1$$

given that $l_1 = 1$

Put $n = 2$ in ophus 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).

Question 6

$$= \frac{L/Bw}{\frac{L}{Bw} + 2\left(\frac{D}{V}\right)} = \frac{L}{Bw\left(T_t + 2\frac{D}{V}\right)}$$

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

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

(A) Number of attributes of its relation schema.

(B) Number of tuples stored in the relation.

(C) Number of entries in the relation.

(D) Number of distinct domains of its relation schema.

Ans. **(A)**

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.

(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

$$(T_t) = \frac{\text{Length of Packet (L)}}{\text{Band width (B.W)}}$$

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

Link Utilisation = Efficiency $= \dfrac{T_t}{T_t + 2T_p}$

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?

(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 $\rightarrow [0 - 9]$

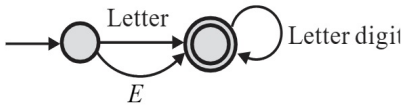
id $\rightarrow$ letter (letter/digit)*

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

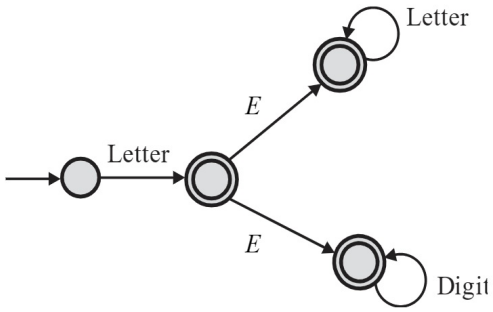
An algorithm has to store several keys generated by an adversary in a hash table. The adversary is malicious who tries to maximize the number of collisions. Let k be the number of keys, m be the number of slots in the hash table, and $k > m$. Which one of the

denotes a final state)

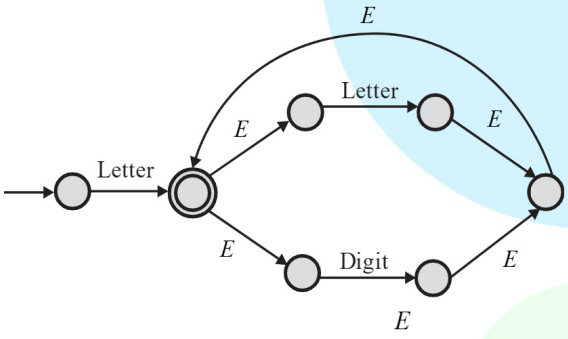
(A)



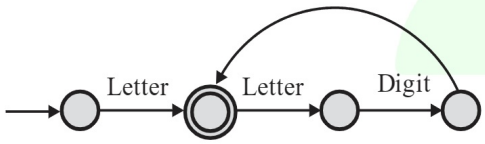
(B)



(C)



(D)



Ans. **(C)**

Sol. The regular expression is:

Letter (letter+digit)*.

The R.E. accepts strings starting with "letter" and followed by any number of "letter" "digits".

Checking all options:

(a) is false as it also accepts empty string $\in$.

(b) is false as it dosen't accept letter. Digit.letter.

(d) is false as letter digit not accepted.

Only option "c" is true.

Hence, the correct option is (C).

Question 10

following is the best hashing strategy to counteract the adversary?

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

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

(B) Universal hashing method

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

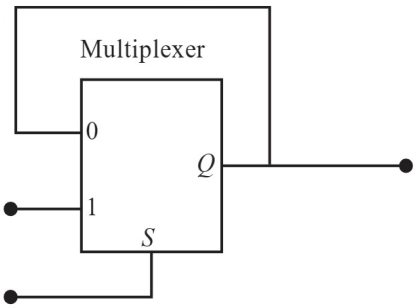
Ans. **(C)**

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.

Hence, the correct option is (C).

Question 11

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



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

(A) D Flip-flop

(B) D Latch

(C) Half-adder

(D) Demultiplexer

Ans. **(B)**

Sol. 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).

- System call guarantees that computer system will transition from user mode to kernel mode as using system calls a user requests services from 0S and transition from user mode to kernel mode.
- Page fault occures when program requests access of page not

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?

(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?

(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.

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?

(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 Enumerable 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?

(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

$p(x) = p(c) =$ 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

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

$$\forall x\left(P(x) \Rightarrow 3yQ(x,y)\right),$$

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

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

(B) $\forall_x \forall yQ(x,y)$

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

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

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

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

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

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

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) :

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

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

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

Now, since,

$\forall x \forall yQ(x,y) = \text{True.}$

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

$B = \exists yQ(x,y)$ is always, true as there exists at least one y (we assumed y = 2) such that $\forall xQ(x,2)$ 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) :

$$\frac{\exists \times[P(x) \wedge \exists y2(x,y)]}{\text{LHS}} \rightarrow \frac{E}{RHS} \text{True?}$$

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

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

Say $x = 3$ and $P(x) = \text{True}$

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?

(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

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?

(A) First-in First-Out

(B) Round Robin

(C) Priority Scheduling

(D) Shortest Job First

Ans. **(A), (C), (D) or (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'll be no starvation.

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.

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?

(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) $f \in 0(g) \Rightarrow f(n) = 0(g(n))$

$f(n) \in 0(n^2)$, is True

(B) $f(n) = \Omega(g(n))$

$f(n) = \Omega(n^2)$, is False

(C) $f \in 0(g) \Rightarrow f(n) = (g(n))$

$f(n) = 0(n^2)$ is True

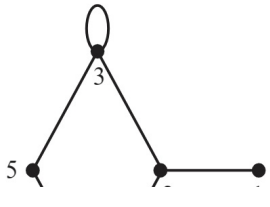
(D) $f \in 0(g) \Rightarrow f(n) = \theta(g(n))$

$f(n) = \theta(n^2)$ is 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}.



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

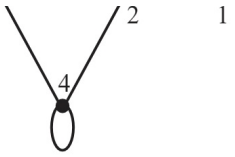
$\int_{-3}^{3} 8x^2 (0) dx = 0$

Question 22

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

Ans. **110**

Sol. **Given :** $(132)_4 = (1 \times 4^2 + 3 \times 4 + 2)_{10}$



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 = _____.

Sol.

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

Sum of Eigen values,

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

= 0 + 0 + 1 + 1 +0 = 2

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)

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

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

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

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

$= (30)_{10} = (25+5+0)_{10}$ (Power of 5)

$= (110)_s$

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.

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 $(T_p) = m_a(10,20,14) = 20\,\text{ns}$

Number of stages $(k) = 3$

So, Total execution time,

$T = [k+(n-1)]\times T_p$

$= (3+100-1)\times 20 = 2040\ \text{ns}$

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.

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(){
```

interrupt and processing a keystroke.

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

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 $100\,\mu\text{s}$

So, Total polling time

$= 100 \times 100\,\mu\text{s} = 10 \times 10^3\,\mu\text{s} = 10\,\text{ms}$

Also, it takes $200\,\mu\text{s}$ 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, $T_2 = 1\,\text{ms}$

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

Ans. **7**

Sol. When $x = \text{fun}\,cp()$ is called,

Static int $x = 1$ and $x{+}{+}$ changes Static x to 2

In main $x = 2$ is assigned.

Again $y = \text{fun}\,\text{cp}() + x = \text{fun}\,\text{cp}() + 2$

In $\text{fun}\,\text{cp}()$ the static $x = 2$ and $x{+}{+}$ makes static $x = 3$

In main, $y = 3 + 5 = 5$

As, $x = 2$ and $y = 5$

So, $x + y = 7$ which is printed out

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);
}
```

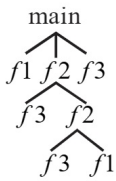
```
int f1()
{
    return(1);
}
```

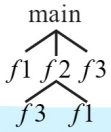
```
int f2(int X)
{
    f3();
    if (X==1)
        return f1();
    else
        return (X*f2(X-1));
}
```

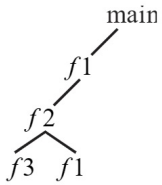
```
int f3()
{
    return(5);
}
```

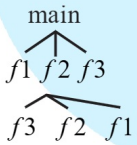
Which one of the following options represents the activation tree corresponding to the main function?

corresponding to the main function?

(A)


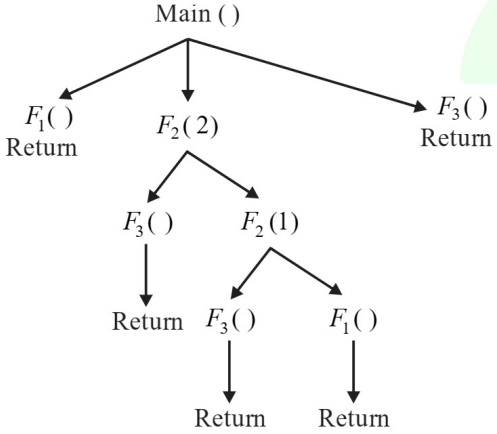
(B)


(C)


(D)


Ans. **(A)**

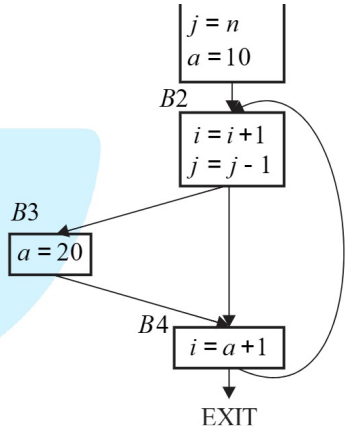
Sol. Following the execution sequence



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?

(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 $B_4 = \{a, i, J\}$.

Hence, the correct option is (D).

Question 28

Consider the two functions incr and decr shown below.

$incr()$, $decr()$, $incr()$, $decr()$, $incr()$, $decr()$ which all make X as same value 10 nd 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'

red X; //X becomes/reads and stores value 10.

Run incr ( ) 5 times

```
incr(){                 decr(){
    wait(s);                wait(s);
    X = X+1;                X = X-1;
    signal(s);              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.

$X=9$ //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

$S \to aSb|X$

$X \to aX|Xb|a|b$

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

Which one of the following statements is CORRECT?

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

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

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

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

Ans. **(B)**

Sol. 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).

Question 30

Consider the pushdown automaton (PDA) P below, which runs on the input alpha-bet $\{a,b\}$, 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

Sol. 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.

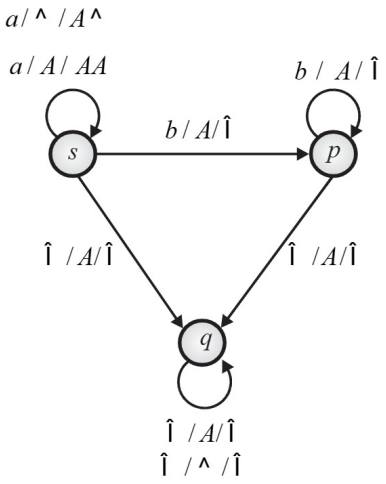
Hence, the correct option is (A).

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.

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?

(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)**

```
//C-code                    ;assembly-code (; indicates comments)
                            ;r1-r5 are 32-bit integer registers
                            ;initialize r1=0, r2=10
                            ;initialize r3, r4 with base address of a, b
int a[10], b[10], i;        L01: jeq r1, r2, end ;if(r1==r2) goto end
// int is 32-bit            L02: lw r5, 0(r4) ;r5 <- Memory[r4+0]
for (i=0; i<10;i++)         L03: shl r5, r5, U1 ;r5 <- r5 << U1
a[i] = b[i] * 8;            L04: sw r5, 0(r3) ;Memory[r3+0] <- r5
                            L05: add r3, r3, U2 ;r3 <- r3+U2
                            L06: add r4, r4, U3
                            L07: add r1, r1, 1
                            L08: jmp U4 ;goto U4
                            L09: end
```

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

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

(C) (8, 1, 1, L02) (D) (3, 1, 1, L01)

Ans. **(B)**

Sol. Here an analyzing code we can observe that. We are to shift value of r_s 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 t'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. $\angle 01$ so that for-loop can be run.

So, u_4 is $\angle 01$.

Hence, the correct option is (B)

(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 ate 4.

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

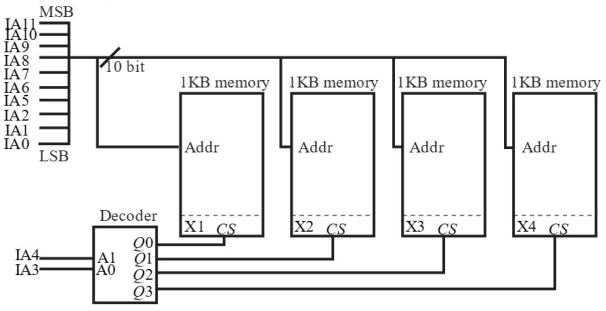
So,

I_4	I_2	**Resulting value /Starting address**
0	0 (X_0)	$0(00000)$
0	1 (X_1)	$8(01000)$
1	0 (X_2)	$16(10000)$

Hence, the correct option is (B).

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.



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?

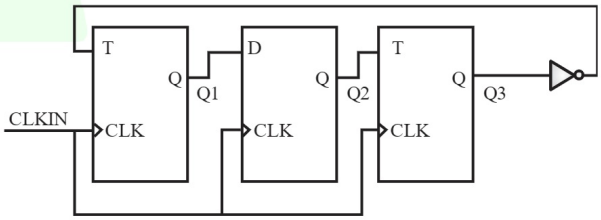
(A) (0, 1, 2, 3)

1	1 (X_3)	24(11000)

Hence, the correct option is (C).

Question 33

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



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

(A) (0, 0, 1) (B) (1, 0, 0)

(C) (1, 0, 1) (D) (1, 1, 1)

Ans. **(A)**

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

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

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

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	Q_1^+	Q_2^+	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

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

(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 :**

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

Since final output is given by 2×1 mux m_3

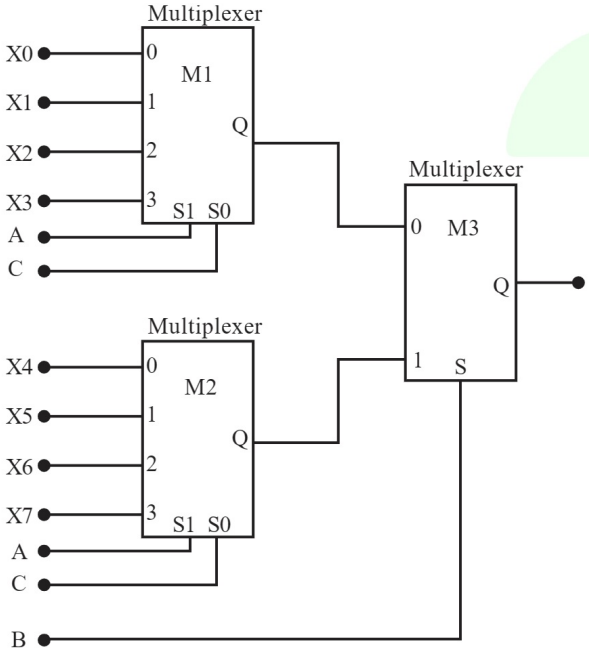
So, MSB (most significant bit) is selection line of m_3 i.e. B.

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

	B	A	C	
X_0	0	0	0	1→Due to A'
X_1	0	0	1	1→Due to A'

inputs of the multiplexers M1 and M2 and could be connected to either 0 or 1. The select lines of the multiplexers are connected to Boolean variables A, B and C as shown.



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

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

X_2	0	1	0	0
X_3	0	1	1	1→Due to $AB'C$
X_4	1	0	0	1→Due to A'
X_5	1	0	1	1→Due to A'
X_6	1	1	0	0
X_7	1	1	1	0

So, $(X_0, X_1.....X_7)=(11011100)$

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?

(A) 0x404C2EF4 (B) 0x405C2EF4

(C) 0xC15C2EF4 (D) 0xC14C2EF4

Ans. **(C)**

Sol. Here, $P=0\times1800000=1100\ \ 0001\ \ 1000\ \ 0000\ \ 0000\ \ 0000\ \ 0000\ \ 0000$

In $1EEE$ 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 $=(-1)^s\times(1.m)\times2^e$

$=(-1)^1\times1.0\times2^4=-16$

Similarity, $Q=0\times3F5C2EE4=$ 0011 1111 0101 1100 0010 1110 1111 0100

sign $=0$

Biased exponent $=126$

Actual exponent $=126-127=-1$

So,

$Q=1.10111000010111011110100\times2^{-1}$

$P*Q=-1.10111000010111011110100\times2^{-1}\times2^4$

$P*Q=-1.10111000010111011110100\times2^3$

sign $=1$

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

The number in $1EEE$ 754 format is :

(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 $O(\log(n))$.

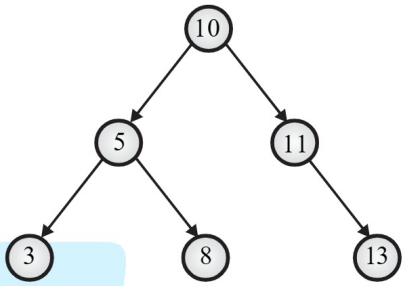
Ans. **(B)**

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

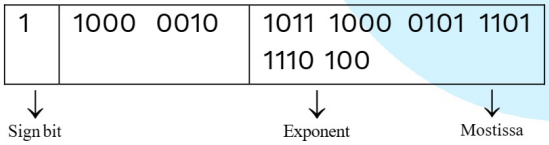
Hence, the correct option is (B).

Question 37

Consider the C function foo and the binary tree shown.




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



$0 \times C15C2EF4$

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?

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

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

```
struct node  left,  right;
} node;

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

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

(A) 3 8 5 13 11 10 (B) 3 5 8 10 11 13

(C) 3 8 16 13 24 50 (D) 3 16 8 50 24 13

Ans. **(C)**

Sol. **Given :** Retval

$= P \to val + f00(P \to \text{left}) + f00(P \to \text{right})$

Now, considering given tree with root 10.

Retval

$= 10 + f00(P \to \text{left}) + foo(P \to \text{right})$

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).

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

$A \cap B = \phi$

Permutation of $\cup$ separates of A from B

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

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 ~ 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 ~. 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?

(A) *F* is NOT well-defined.

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

following is true:

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

How many permutations of U separate A from B?

(A) $n!$

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

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

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

Ans. **(D)**

Sol. $U=\{1,2,.....n\}$

$k<n<1000$

$|A|=k$

$|B|=k$

(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

≥ 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?

(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. Colored : 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, $A\Delta BE2^X \forall A,B,E2^X$.
2. Associativity : IT's similar to XOR operation which is associative always.
3. Identity : s_{ay} $C\in 2^X$ 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
   01 each option given $A,B\in 2^X$.
   So, $(A\cup B)-(A\cap B)=\Phi$

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

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

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

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

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 $=\log_2(15\times10^8)$

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

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

S_{ay} a client Alfiya request a page from server, following steps are followed in order before Alfiya gets all data needed :

(i) There's 3-tier DNS hierarchy, 100 kup 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, n 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-prallel connections : 5 objects could be sent parallel at same time.

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

equally small objects on the same web server.

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

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

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

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

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

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

Sol. **Case I :**

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

(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.

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?

(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. A : Head on both HH

B : Head on 1st

HT

HH

C : Head on second

HH $\quad\quad$ TH

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

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

$$P(B).P(C) = \frac{1}{2}.\frac{1}{2} = \frac{1}{4}$$

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

($\therefore$ B and C are independent)

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

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

$$\frac{1}{4} \quad \frac{1}{4} \quad \frac{1}{4}$$

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

Function_1	Function_2

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

Let $f_1(n)$ and $f_2(n)$ denote the number of times the statement "$x = x + 1$" is executed in **Function_1** and **Function_2**, respectively.

Which of the following statements is/are TRUE?

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

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

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

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

So, Number of times

$n \quad n \quad n$

$P(A).P(B) = \frac{1}{4}.\frac{1}{2} = \frac{1}{8}$

$P(A \cap B) \neq P(A).P(B)$

($\therefore$ A and B are not independent)

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

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

$P(A).\mathrm{P(C)} = \frac{1}{4}.\frac{1}{2} = \frac{1}{8}$

$P(A \cap C) \neq P(A).P(C)$

($\therefore$ A and C are not independent)

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

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

Question 44

$n + \frac{n}{2} + \frac{n}{4} + \frac{n}{3} + \ldots\ldots + 1$

Inner loop runs

$A(n) = n\left(1 + \frac{1}{2} + \frac{1}{4} + \frac{1}{3} + \ldots\ldots\frac{1}{n}\right)$

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 :

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 $\Delta(G)+1$.

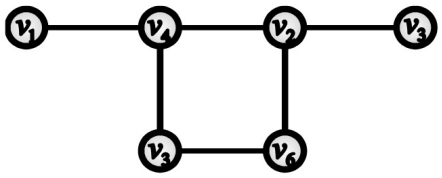
(C) The number of colors used is at most $\Delta(G)$.

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

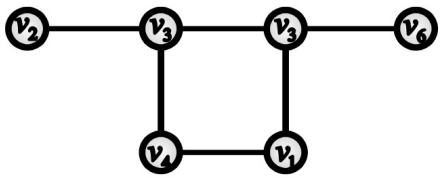
Ans (A), (B)

For Option (C) It's False as wave 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

Ans. **(A), (B)**

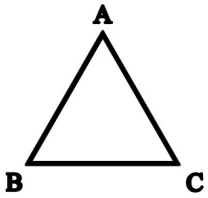
Sol. **For Option (A) :** Its, true as

"Color (vi) ← min <JEN = No neighbor of vi 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.

$B \subseteq A$. 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 $\emptyset$ denotes the empty set, then the cardinality of $B(\emptyset)$ is _____.

Ans. **5040**

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

Vertex set = Power set of U = 2^u = { Φ , <1>, <2>, <3>, <1,2>, <1,3> <1,2,3>}

So, humber of vertices = 8

Now, there's edge between A and B iff 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(Φ)=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 _____.

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

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

The value of L is _____.

Ans. **5**

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

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

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.

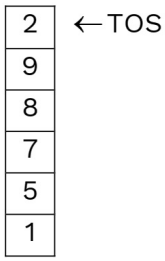
The top element of S after executing the above operations is _____.

Ans. **8**

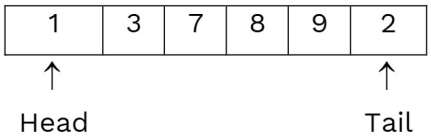
Sol. Given Elements

$(a_0, a_1, \ldots . a_4) = (i1,5,7,8,9,2)$

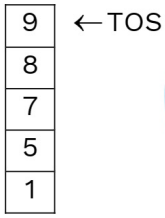
Step – 1 :



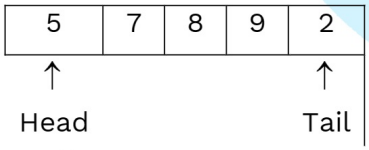
Step -2 :



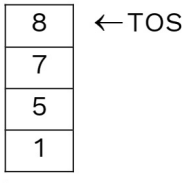
Step-3 :

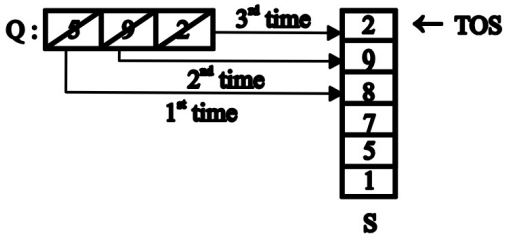


Step – 4 :

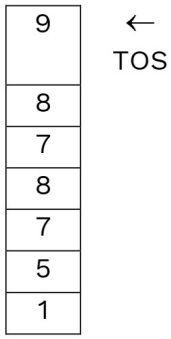


Step – 5 :

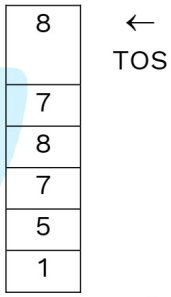




Step – 9 :



Step – 10 :



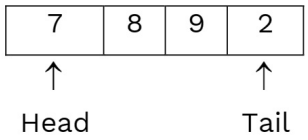
∴ '8' in Top of stack So answer is 8.

Hence, the correct option is 8.

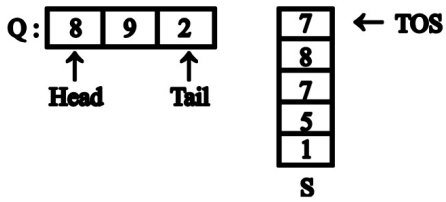
Question 50

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**

Step – 6 :



Step – 7 :



Step-8 :

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.

$$N \to I\#F$$
$$N.val \to I.val + F.val$$
$$I \to I_1 B$$
$$I.val \to (2I_1.val) + B.val$$
$$I \to B \qquad I.val = B.val$$

$$F \to BF_1$$
$$F.val = \frac{1}{2}(B.val + F_1.val)$$
$$F \to B \qquad F.val = \frac{1}{2}\mathrm{B}.val$$
$$B \to 0 \qquad B.val = \mathbf{0}.val$$
$$B \to \mathbf{1} \qquad B.val = \mathbf{1}.val$$

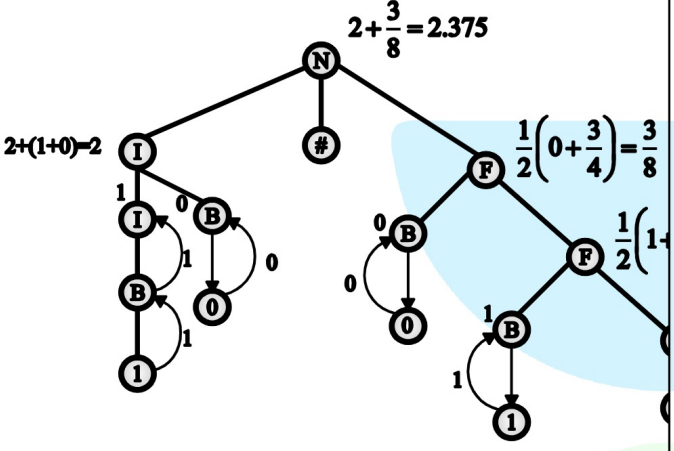
The value computed by the translation scheme for the input string

10 # 011

is _____. (Rounded off to three decimal places)

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.

The number of rows returned by the query is _____.

Ans. **2**

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

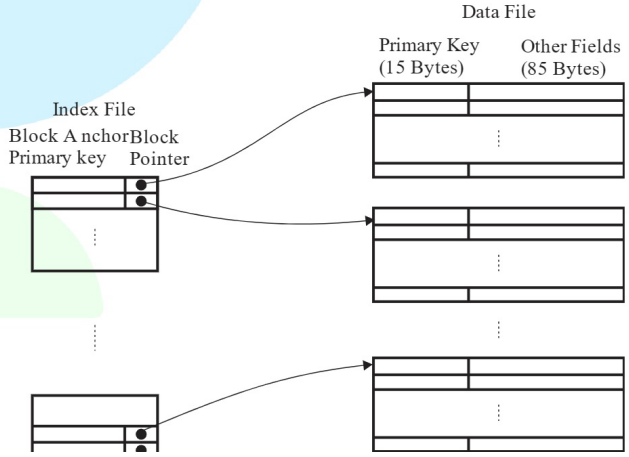
Output is :

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.

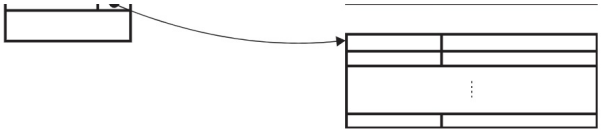


Student :

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;
```



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 _____.

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.

So, Number of records per block

$$= \left\lfloor \frac{\text{Block size}}{\text{Record size}} \right\rfloor = \left\lfloor \frac{1024\ \text{B}}{100\ \text{B}} \right\rfloor = 10$$

Number of data blocks needed

$$= \left\lceil \frac{\text{Number of records}}{\text{Number of records per block}} \right\rceil$$

$$= \frac{25000}{10} = 2500$$

No. of Index records per block

$$= \left\lfloor \frac{\text{Block size}}{\text{primany key size} + \text{Pointer size}} \right\rfloor$$

$$= \left\lfloor \frac{1024}{15+5} \right\rfloor = \left\lfloor \frac{1024}{20} \right\rfloor = 51$$

Number of index block needed

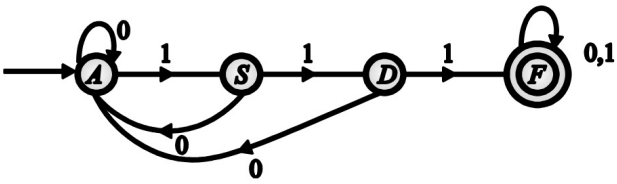
$$= \left\lceil \frac{2500}{51} \right\rceil = 50$$

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

Hence, the correct answer is 6.

Question 53

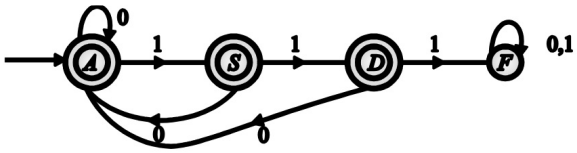
Consider the language L over the



I: set of strings not containing 3 consecutive

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

MDFA For $I \rightarrow$



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 _____.

Ans. **19**

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

System use 32 bit address (A)

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

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

$= 32 - 16 + 8 = 19$

Hence, the correct option is 19.

Question 55

The forwarding table of a router is shown below.

Subnet Number	Subnet Mask	Interface ID

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

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

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

Ans. **4**

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

The MDFA for L →

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 _____.

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 ∧ subnet = (200.150.68.118) ∧ (255.255.255.224) = (200.150.68.96)

Subnet ID didn't match.

Checking subnet 3

(200.150.68.118) ∧ (255.255.255.0).(200.150.68.0)

Subnet ID matches.

If ll be forwarded to 3.

Hence, the correct answer is 3.

❑❑❑