GATE – 2021

CS – (EVENING)

GENERAL APTITUDE

Q.1 – Q.5 Multiple Choice Question (MCQ), carry ONE mark each (for each wrong answer: – 1/3).

1. Gauri said that she can play the keyboard __________ her sister.

(a) as well as

(b) as better as

(c) as nicest as

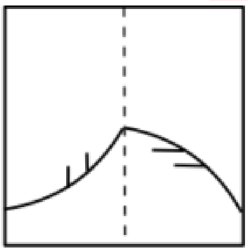
(d) as worse as

Ans. a

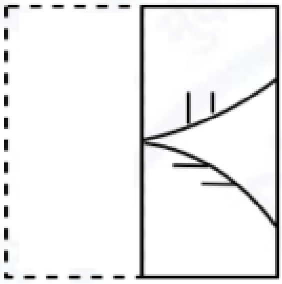
Exp:

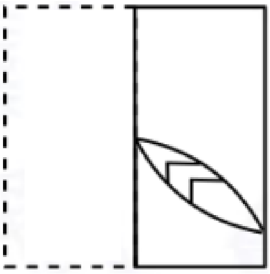
(as – as) and (so – as) are used in positive degree of comparison only. Worse, better are comparative degree and nicest is superlative degree, which are not fit between as – as and so – as.

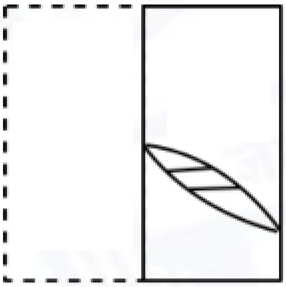
2. A transparent square sheet shown above is folded along the dotted line. The folded sheet will look like ________.

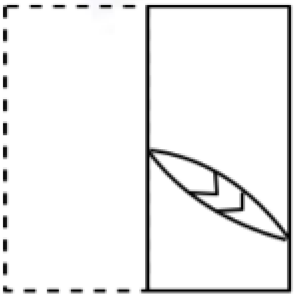


(a)



(b) 

(c) 

(d) 

Ans. b

3. If θ is the angle, in degrees, between the longest diagonal of the cube and any one of the edges of the cube, then, cos θ =

(a) $\frac{1}{2}$

(b) $\frac{1}{\sqrt{3}}$

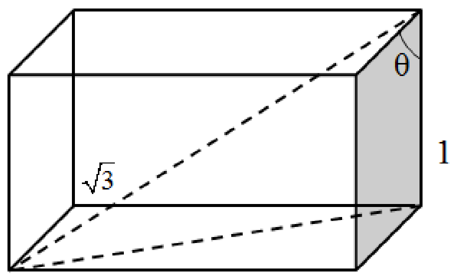
(c) $\frac{1}{\sqrt{2}}$

(d) $\frac{\sqrt{3}}{2}$

Ans. b

Exp:

Angle of longest diagonal of cube with an edge of cube.



$$\cos\theta = \frac{\text{Base}}{\text{Hypotenuse}} = \frac{1}{\sqrt{3}}$$

4. If $\left(x-\frac{1}{2}\right)^2-\left(x-\frac{3}{2}\right)^2 = x+2$, then the value of x is :

(a) 2

(b) 4

(c) 6

(d) 8

Ans. b

Exp:

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

Using $a^2 - b^2 = (a + b)(a - b)$

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

$(2x - 2) = x + 2$

$x = 4$

5. Pen : Write : : Knife : ________

Which one of the following options maintains a similar logical relation in the above?

(a) Vegetables

(b) Sharp

(c) Cut

(d) Blunt

Ans. c

Exp:

As Pen is used to write and knife is used to cut.

Q. 6 – Q. 10 Multiple Choice Question (MCQ), carry TWO marks each (for each wrong answer: – 2/3).

6. Listening to music during exercise improves exercise performance and reduces discomfort. Scientists researched whether listening to music while studying can help students learn better and the results were inconclusive. Students who needed external stimulation for studying fared worse while students who did not need any external stimulation benefited from music.

Which one of the following statements is the CORRECT inference of the above passage?

(a) Listening to music has no effect on learning and a positive effect on physical exercise.

(b) Listening to music has a clear positive effect both on physical exercise and on learning.

(c) Listening to music has a clear positive effect on physical exercise. Music has a positive effect on learning only in some students.

(d) Listening to music has a clear positive effect on learning in all students. Music has a positive effect only in some students who exercise.

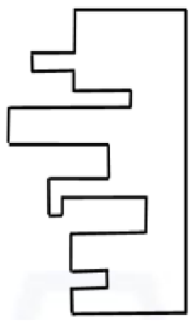
Ans. c

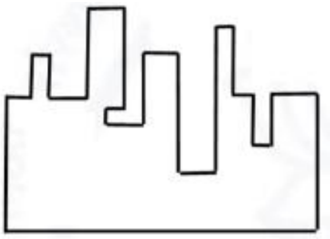
Exp:

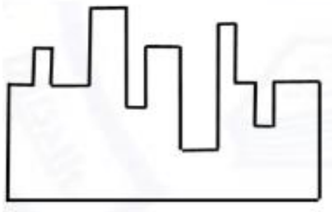
"Only in some students" is the key in option c and that matches well with the given informations in the passage.

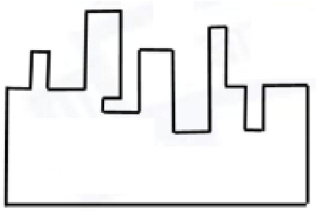
7. A jigsaw puzzle has 2 pieces. One of the pieces is shown above. Which one of the given options for the missing piece when assembled will form a rectangle?

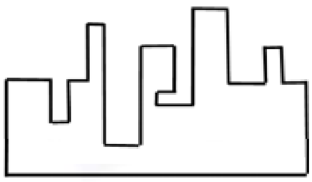
The piece can be moved, rotated or flipped to assemble with the above piece.



(a) 

(b) 

(c) 

(d) 

Ans. a

Exp:

8. The number of students in three classes is in the ratio 3:13:6. If 18 students are added to each class, the ratio changes to 15:35:21.

The total number of students in all the three classes in the beginning was:

(a) 22

(b) 66

(c) 88

(d) 110

Ans. c

Exp:

3 : 13 : 6

$$\begin{aligned} &Let \quad 3k + 13k + 6k = n \\ &Now \quad \underline{+18 + 18 + 18} \\ &\qquad\quad 15 : 35 : 21 \end{aligned}$$

15y + 35y + 21y = 22k + 54

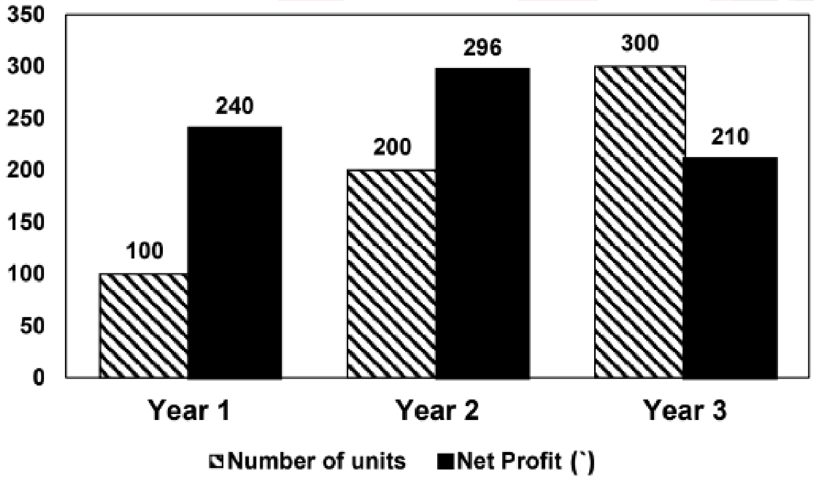
71y = 22k + 54

Put value of k and satisfy

Here for, k = 4,

n = 88

9. The number of units of a product sold in three different years and the respective net profits are presented in the figure. The cost/unit in Year 3 was ` 1, which was half the cost/unit in Year 2. The cost/unit in Year 3 was one-third of the cost/unit in Year 1. Taxes were paid on the selling price at 10%, 13% and 15% respectively for the three years. Net profit is calculated as the difference between the selling price and the sum of cost and taxes paid in that year.



The ratio of the selling price in Year 2 to the selling price in Year 3 is ________.

(a) 4:3

(b) 1:1

(c) 3:4

(d) 1:2

Ans. a

Exp:

Cost/unit in year 3 = Rs. 1

Cost/unit in year 2 = Rs. 2

Cost/unit in year 1 = Rs. 3

Net profit = S.P – (Cost + Taxes)

In year 2, 296 = S.P. – (2 × 200 + 0.13 S.P.)

S.P. = 800

Selling price in year 2 = Rs. 800

In year 3, 210 = S.P. – (300 × 1 + 0.15 S.P.)

Selling price in year 3 = Rs. 600

Hence, Required ratio = 800 : 600 = 4 : 3

10. Six students P, Q, R, S, T and U, with distinct heights, compare their heights and make the following observations.

Observation I: S is taller than R.

Observation II: Q is the shortest of all.

Observation III: U is taller than only one student.

Observation IV: T is taller than S but is not the tallest.

The number of students that are taller than R is the same as the number of students shorter than ______.

(a) T

(b) R

(c) S

(d) P

Ans. c

Exp:

S > R

Q is shortest and U is taller than only one.

T > S

Hence, possible order is : P > T > S > R > U > Q.

∵ Number of students taller than R = 3

∴ Number of students shorter than S = 3.

Computer Science and Information Technology (CS, Set-2)

Q.1 – Q.10 Multiple Choice Question (MCQ), carry ONE mark each (for each wrong answer: –1/3).

1. Let G be a connected undirected weighted graph. Consider the following two statements.

S_1 : There exists a minimum weight edge in G which is present in every minimum spanning tree of G.

S_2 : If every edge in G has distinct weight, then G has a unique minimum spanning tree.

Which one of the following options is correct?

(a) Both S_1 and S_2 are true.

(b) S_1 is true and S_2 is false

(c) S_1 is false and S_2 is true

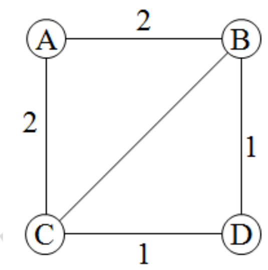
(d) Both S_1 and S_2 are false.

Ans. c

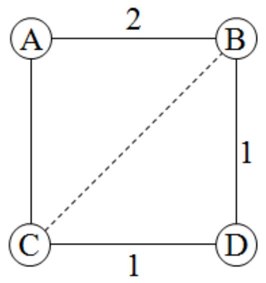
Exp:

(a)

S_1 : Consider the graph :



One of the possible MSTS can be:



But the minimum weight edge BC in G is not present. So, the S_1 is false statement.

S_2 : In any undirected graph G, distinct edge weights means Unique MST.

So, S_1 is false and S_2 is true.

2. Let H be a binary min-heap consisting of n elements implemented as an array. What is the worst case time complexity of an optimal algorithm to find the maximum element in H?

(a) Θ(1)

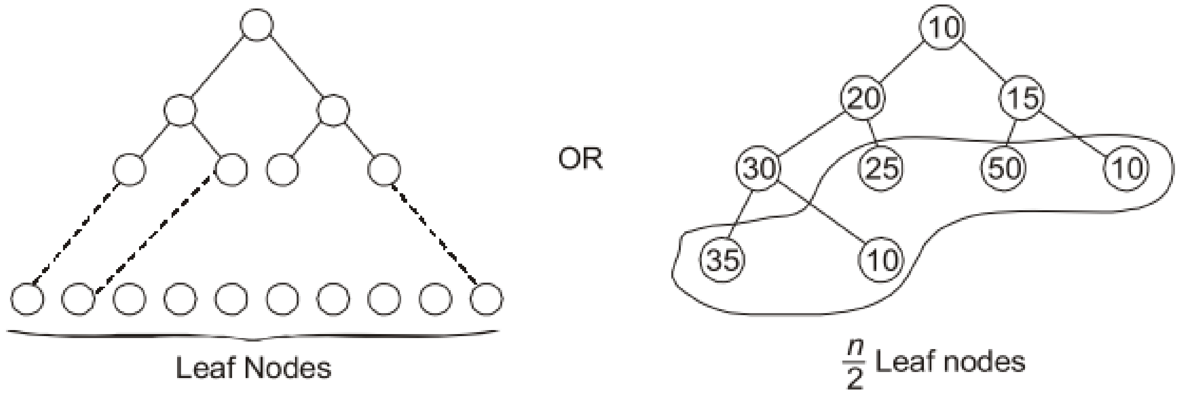
(b) Θ(log n)

(c) Θ(n)

(d) Θ(n log n)

Ans. c

Exp:



Maximum element is present somewhere in the leaf nodes.

∴ Find max in all leaf nodes from $\left(\left\lceil \frac{n}{2} \right\rceil + 1\right)........a[n]$

⇒ Number of comparisons = $\frac{n}{2} - 1 = \Theta(n)$

3. Consider the following ANSI C program:

```
int main ( ) {
        integer x ;
        return 0;
}
```

Which one of the following phases in a seven-phase C compiler will throw an error?

(a) Lexical analyzer

(b) Syntax analyzer

(c) Semantic analyzer

(d) Machine dependent optimizer

Ans. c

Exp:

```
int main ( ) {
        integer x ;
        return 0;
}
```

In this code, there is no lexical error present. But there is a syntax error at the statement.

Integer *x*;

So, syntax analyzer will throw an error.

4. The format of the single-precision floating-point representation of a real number as per the IEEE 754 standard is as follows:

sign	exponent	Mantissa

Which one of the following choices is correct with respect to the *smallest* normalized positive number represented using the standard?

(a) exponent = 00000000 and mantissa = 00000000000000000000000

(b) exponent = 00000000 and mantissa = 00000000000000000000001

(c) exponent = 00000001 and mantissa = 00000000000000000000000

(d) exponent = 00000001 and mantissa = 00000000000000000000001

Ans. c

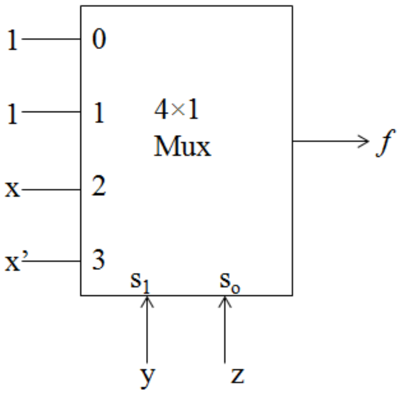
Exp:

$$\begin{Bmatrix} All\,0's\,BE \Rightarrow Used\ \ for\,"0" \\ All\,1's\,BE \Rightarrow Used\ \ for\left(+\infty\,and\,-\infty\right) \end{Bmatrix}$$

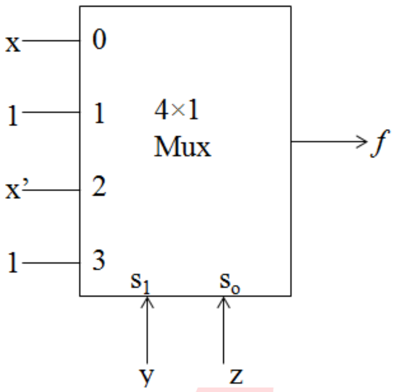
5. Which one of the following circuits implements the Boolean function given below?

$f(x, y, z) = m_o + m_1 + m_3 + m_4 + m_5 + m_6$, where m_i is the i^{th} minterm.

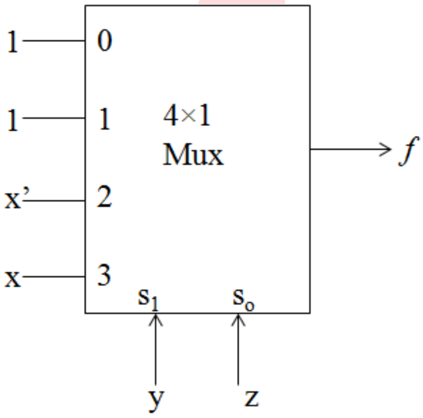
(a)



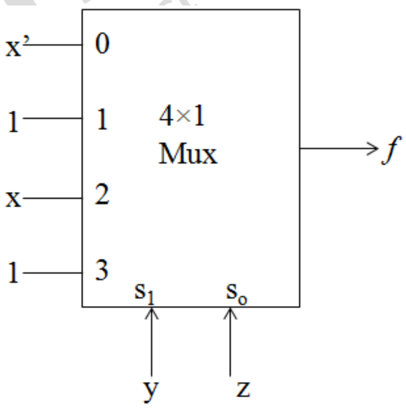
(b)



(c)



(d)



Ans. a

Exp:

$\sum(x, y, z) = m_0 + m_1 + m_3 + m_4 + m_5 + m_6 = \sum m(0, 1, 3, 4, 5, 6)$

As per the given options, variable y is connected to multiplexer select input S_1 and z is connected to select input S_0.

$S_1 \uparrow y$, $S_0 \uparrow z$

	I_0 00	I_1 01	I_2 10	I_3 11
$\bar{x}$ 0	(0)	(1)	2	(3)
x 1	(4)	(5)	(6)	7
	1	1	x	$\bar{x}$

6. Consider the following statements S_1 and S_2 about the relational data model:

S_1 : A relation scheme can have at most one foreign key.

S_2 : A foreign key in a relation scheme R cannot be used to refer to tuples of R.

Which one of the following choices is correct ?

(a) Both S_1 and S_2 are true.

(b) S_1 is true and S_2 is true.

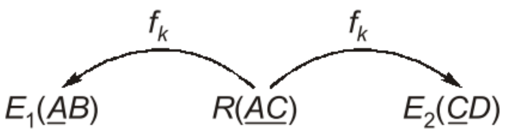
(c) S_1 is false and S_2 is true.

(d) Both S_1 and S_2 are false.

Ans. d

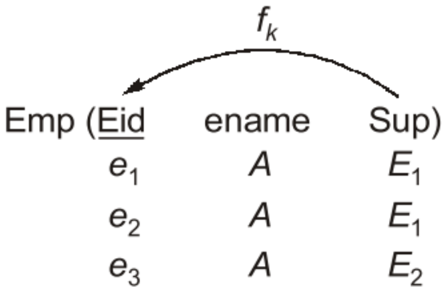
Exp:

S_1 : A relation scheme can have at most one foreign key.

e.g., 

More than 1 f_k also possible.

S_2 : A foreign key in a relation scheme R cannot be used to refer to tuples of R.



e.g. Self referential relationship.

So, both S_1 and S_2 are false.

7. Consider the three-way handshake mechanism followed during TCP connection establishment between hosts P and Q. Let X and Y be two random 32-bit starting sequence numbers chosen by P and Q respectively. Suppose P sends a TCP connection request message to Q with a TCP segment having SYN bit = 1, SEQ number = X, and ACK bit = 0. Suppose Q accepts the connection request. Which one of the following choices represents the information present in the TCP segment header that is sent by Q to P ?

(a) SYN bit = 1, SEQ number = X + 1, ACK bit = 0, ACK number = Y, FIN bit = 0

(b) SYN bit = 0, SEQ number = X + 1, ACK bit = 0, ACK number = Y, FIN bit = 1

(c) SYN bit = 1, SEQ number = Y, ACK bit = 1, ACK number = X + 1, FIN bit = 0

(d) SYN bit = 1, SEQ number = Y, ACK bit = 1, ACK number = X, FIN bit = 0

Ans. c

Exp:

Q will send the SYN bit = 1 to the connection establishment.

Q seq number will be Y different from X.

ACK bit = 1 because sending the ACK.

ACK number = X + 1 (Next seq number id)

FIN bit = 0 (Because establishing the connection)

8. What is the worst-case number of arithmetic operations performed by recursive binary search on a sorted array of size n?

(a) $\Theta(\sqrt{n})$

(b) $\Theta(\log_2(n))$

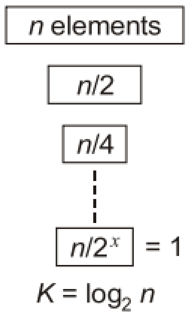
(c) $\Theta(n^2)$

(d) Θ(n)

Ans. b

Exp:

Worst case is when the element not present in the sorted array.



Worst case occurrence relation is

$$T(n) = \begin{cases} T\left(\frac{n}{2}\right) + 1, & n > 1 \\ 1, & n \le 1 \end{cases}$$

∴ $\Theta(\log_2(n))$

9. Let L ⊆ {0, 1}* be an arbitrary regular accepted by a minimal DFA with k states. Which one of the following languages must necessarily be accepted by a minimal DFA with k states?

(a) L – {01}

(b) L ∪ {01}

(c) {0, 1}* – L

(d) L · L

Ans. c

Exp:

If L is accepted by a min DFA with k states, by exchanging final and non-final states, we can make a minimal DFA with k states which accepts {0, 1}* – L = $\overline{L}$.

10. Consider the following ANSI C program.

```
#include <stdio.h>
int main ( ) {
        int arr[4][5];
        int i, j;
        for (i=0; i<4; i++){
          for (j=0; j<5; j++){
                arr[i][j] = 10*i + j;
        }
}
printf ("%d", *(arr[1] + 9));
return 0;
}
```

What is the output of the above program?

(a) 14

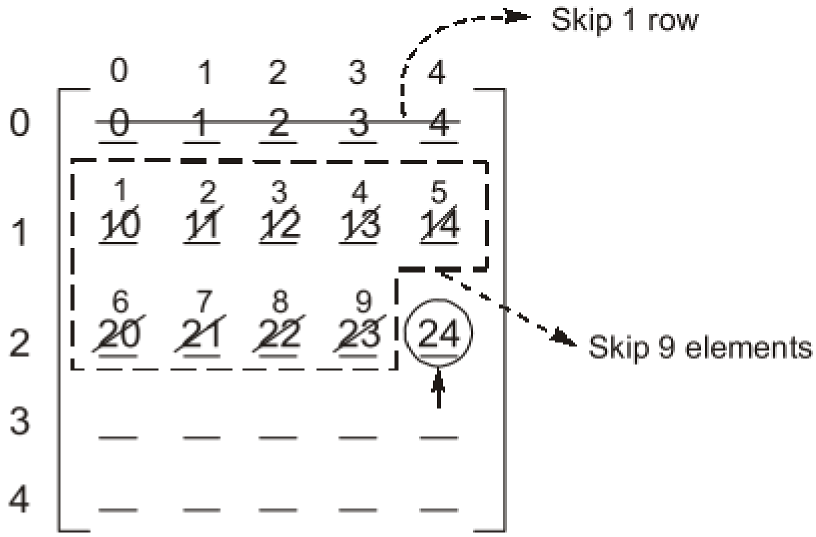
(b) 20

(c) 24

(d) 30

Ans. c

Exp:



int a[4][5]

[*(a + 1) + 9]

It means skip one row and then skip 9 elements.

So, the resultant value is 24.

Q.11 – Q.15 Multiple Select Question (MSQ), carry ONE mark each (no negative marks).

11. Consider the following sets, where $n \geq 2$.

S_1 : Set of all $n \times n$ matrices with entries from the set {a, b, c}

S_2 : Set of all functions from the set $\{0, 1, 2, ..., n^2 - 1\}$ to the set {0, 1, 2}

Which of the following choice(s) is/are correct?

(a) There does not exist a bijection from S_1 to S_2 .

(b) There exists a surjection from S_1 to S_2 .

(c) There exists a bijection from S_1 to S_2 .

(d) There does not exist an injection from S_1 to S_2 .

Ans. b, c

Exp:

$|S_1| = 3^{n^2}$

Since each of the n^2 entries in $n \times n$ matrix can be fills in 3 ways.

$|S_2| = 3^{n^2}$

Since $|\{0, 1, 2\}| = 3$ and $|\{0, 1, 2, ... n^2 - 1\}| = n^2$)

Now the theorem says A bijection $f_{A \to B}$ exists iff $|A| = |B|$.

Here, $|S_1| = |S_2|$

So, there has to be a bijection from S_1 to S_2. So, option b is correct.

If bijection exists surely surjection also exists. So, option c is correct.

12. Let L_1 be a regular language and L_2 be a context-free language. Which of the following languages is/are context-free ?

(a) $L_1 \cap \overline{L_2}$

(b) $\overline{\overline{L_1} \cup \overline{L_2}}$

(c) $L_1 \cup (L_2 \cup \overline{L_2})$

(d) $(L_1 \cap L_2) \cap (\overline{L_1} \cap L_2)$

Ans. b, c, d

Exp:

$L_1 \rightarrow$ Regular

$L_2 \rightarrow$ CFL

1. $L_1 \cup \overline{L}_2 = \text{Reg} \cap \overline{\text{CFL}} = \text{Reg} \cap \overline{\text{CSL}}$

$= \text{Reg} \cap \text{CSL} = \text{CSL}$ (need not be CFL)

2. $\overline{\overline{L_1} \cup \overline{L_2}} = L_1 \cap L_2 = \text{Reg} \cap \text{CFL} = \text{CFL}$

3. $L_1 \cup (L_2 \cup \overline{L}_2) = L_1 \cup \Sigma^* = \Sigma^* =$ Regular and hence CFL.

4. $(L_1 \cap L_2) \cup (\overline{L}_1 \cap L_2) = (L_1 \cup \overline{L}_1) \cap L_2$

$= \Sigma^* \cap L_2$

$= L_2 = \text{CFL}$

13. In the context of compilers, which of the following is/are NOT an intermediate representation of the source program?

(a) Three address code

(b) Abstract Syntax Tree (AST)

(c) Control Flow Graph (CFG)

(d) Symbol table

Ans. d

Exp:

Symbol table is a data structure which is used for storing the information about variables. So, option d is correct.

There are three major categories of intermediate code representation.

Structural, linear and hybrid.

And CFG comes under the structural intermediate code representation.

14. Which of the following statement(s)/are correct in the context of CPU scheduling?

(a) Turnaround time includes waiting time.

(b) The goal is to only maximize CPU utilization and minimize throughput.

(c) Round-robin policy can be used even when the CPU time required by each of the processes is not known apriori.

(d) Implementing preemptive scheduling needs hardware support.

Ans. a, c, d

Exp:

- Goal is to maximize CPU utilization and maximize the throughput. So, statement (a) is false.
- Statement (b) is true, because turnaround time = completion time – arrival time and waiting time is included in this.
- Statement (c) is true because using time quantum, we can run the processes even if burst time is not known initially in round-robin.
- True for example, round robin scheduling requires hardware support which is timer.

15. Choose the correct choice(s) regarding the following propositional logic assertion S:

$$S : (P \wedge Q) \rightarrow R) \rightarrow ((P \wedge Q) \rightarrow (Q \rightarrow R)$$

(a) S is neither a tautology nor a contradiction.

(b) S is a tautology

(c) S is a contradiction

(d) The antecedent of S is logically equivalent to the consequent of S.

Ans. b, d

Exp:

S : $((P \wedge Q) \rightarrow R) \rightarrow ((P \wedge Q) \rightarrow (Q \rightarrow R)$

$\equiv (pq \rightarrow r) \rightarrow (pq \rightarrow (q \rightarrow r))$

$\equiv [(pq)' + r] \rightarrow [(pq)' + (q' + r)]$

$\equiv [(pq)' + r]' + [(pq)' + (q' + r)]$

$\equiv [pq \cdot r'] + [p' + q' + q' + r]$

$\equiv pqr' + p' + q' + r$

$\equiv (p + p')(qr' + p') + q' + r$

$\equiv qr' + p' + q' + r$

$\equiv (q + q')(r' + q') + p' + r$

$\equiv r' + q' + p' + r$

$\equiv r' + r + q' + p'$

$\equiv 1 + q' + p'$

$\equiv 1$ (Tautology)

So, S is a tautology.

So, option (b) is correct.

Option (d) antecedent of S is

$pq \rightarrow r \equiv (pq)' + r$

$\equiv p' + q' + r$

The consequent of S is $pq \rightarrow (q \rightarrow r)$

$\equiv (pq)' + q' + r$

$\equiv p' + q' + q' + r$

$\equiv p' + q' + r$

So, Antecedent of S $\equiv$ Consequent of S

So, option d is also true.

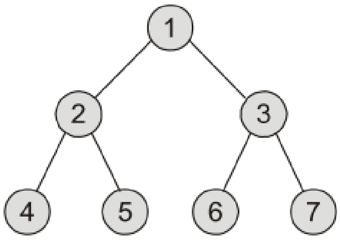
Q.16 – Q.25 Numerical Answer Type (NAT), carry ONE mark each (no negative marks).

16. Consider a complete binary tree with 7 nodes. Let A denote the set of first 3 element obtained by performing Breadth-First Search (BFS) starting from the root. Let B denote the set of first 3 elements obtained by performing Depth-First Search (DFS) starting from the root.

The value of |A – B| is ________.

Ans. 1

Exp:



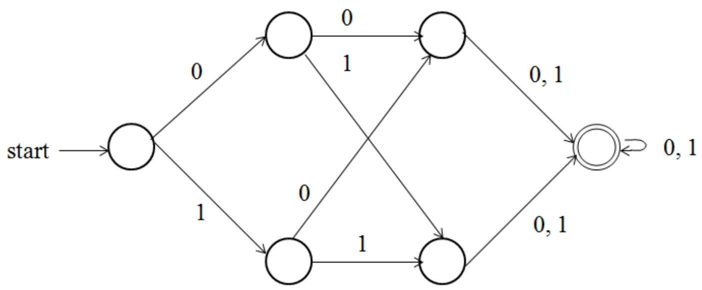
Using BFS, A = {1, 2, 3}

Using DFS, B = {1, 2, 4}

|A – B | = Number of elements which are in A but not in B is only element {3}.

So, only 1 element present.

17. Consider the following deterministic finite automaton (DFA).



The number of strings of length 8 accepted by the above automaton is ________.

Ans. 256

Exp:

The regular expression for L(M) is 0(0 + 1)(0 + 1)(0 + 1)* + 1(0 + 1)(0 + 1)(0 + 1)*

= (0 + 1)(0 + 1)(0 + 1)(0 + 1)*

So, all strings of length ≥ 3accepted.

Therefore, number of strings of length 8 is $2^8 = 256$.

18. If x and y are two decimal digits and $(0.1101)_2 = (0.8xy5)_{10}$, the decimal value of $x = y$ is ________.

Ans. 3

Exp:

$(0.1101)_2 = 1 \times 2^{-1} + 1 \times 2^{-2} + 0 \times 2^{-3} + 1 \times 2^{-4} = (0.8125)_{10}$

$(0.8125)_{10} = (0.8xy5)_{10}$

$\therefore \quad x = 1, y = 2, x + y = 1 + 2 = 3$

19. Consider a set-associative cache of size 2 KB (1 KB = 2^{10} bytes) with cache block size of 64 bytes. Assume that the cache is byte-addressable and a 32-bit address is used for accessing the cache. If the width of the tag filed is 22 bits, the associativity of the cache is ________.

Ans. 2

Exp:

Set Associative Map

CM Site = 2 KB

Block Size = 64 B

Number of lines = $\frac{2^{11}}{2^6} = 2^5 = 32$

MM Adder = 32 bit

Tag filed size = 22 bits

Set associative CM adder format

32-bit

Tag	S_o	w_o
22-bit	4-bit	$\log_2 64$ = 6 bit

Set offset (S_o) = 4 bit

$\therefore \quad$ Number of sets (S) = 2^4 (16)

Number of sets (S) = $\dfrac{N}{P-way}$

$$16=\frac{32}{P-way}$$

P–way = 2

20. Consider a computer system with DMA support. The DMA module is transferring one 8-bit character in one CPU cycle from a device to memory through *cycle stealing* at regular intervals. Consider a 2 MHz processor. If 0.5% processor cycles are used for DMA, the data transfer rate of the device is ________ bits per second.

Ans. 80000

Exp:

y = 0.5 µsec (Transfer Time)

x = Preparation time

% time CPU blocked = $\left(\dfrac{y}{x+y}\right)\times 100$

$$0.5=\left(\frac{0.5\,\mu\text{sec}}{x+0.5\,\mu\text{sec}}\right)\times 100$$

0.005x + 0.0025 = 0.5

x = 99.5µsec

(99.5 µsec + 0.5 µsec) Total time_____________ 8 bit

1 sec ______________ ?

$$=\frac{8\,bit}{100\,\mu\text{sec}}$$ = 80000 bits per second

21. A data file consisting of 1,50,000 student-records is stored on a hard disk with block size of 4096 bytes. The data file is sorted on the primary key RollNo. The size of a record pointer for this disk is 7 bytes. Each student-record has a candidate key attribute called **ANum** of size 12 bytes. Suppose an index file with records consisting of two fields, **ANum** value and the record pointer to the corresponding student record, is built and stored on the same disk. Assume that the records of data file and index file are not split across disk blocks. The number of blocks in the index file is ________.

Ans. 698

Exp:

Index entries = Number of DB file record (∵ Dense index)

Block factor for index,

$$(\text{Block factor})_{\text{index}} = \left\lfloor \frac{4096}{19} \right\rfloor \text{ entries/block} = 215$$

$$\therefore \quad \text{Number of index blocks} = \left\lceil \frac{1,50,000}{215} \right\rceil \text{ blocks} = 698 \text{ index blocks}$$

22. For a given biased coin, the probability that the outcome of a toss is a head is 0.4. This coin is tossed 1,000 times. Let X denote the random variable whose value is the number of times that head appeared in these 1,000 tosses. The standard deviation of X (rounded to 2 decimal places) is _______.

Ans. 15.00 – 16.00

Exp:

n = 1000 , p = 0.4, q = 0.6

It is binomially distributed random variable.

So, $\text{S.D.} = \sqrt{npq} = \sqrt{1000 \times 0.4 \times 0.6} = 15.49$

23. Consider the following ANSI C function:

```
int SomeFunction(int x, int y)
{
    if ((x ==1) || (y == 1)) return 1;
    if (x == y) return x;
    if (x > y) return SomeFunction(x – y, y);
    if (y > x) return SomeFunction(x, y – x);
}
```

The value returned by SomeFunction(15,255) is ________.

Ans.15

Exp:

This function will keep on subtracting till both *x* and *y* becomes equal that is 15.

24. Suppose that P is a 4 × 5 matrix such that every solution of the equation Px = 0 is a scalar multiple of $[2\ \ 5\ \ 4\ \ 3\ \ 1]^T$. The rank of P is ________.

Ans. 4

Exp:

$P_{4\times5} \Rightarrow$ Number of unknowns (n) = 5 in PX = 0

Also it is given that Nullity PX = 0 is one, i.e., N(P) = 1.

Hence, Nullity = Number of unknowns – Rank

$1 = 5 - \rho(P)$

or $\rho(P) = 5 - 1 = 4$

25. Suppose that f : ℝ → ℝ is a continuous function on the interval [–3, 3] and a differential function in the interval –3, 3) such that for every x in the interval, $f'(x) \le 2$. If $f(-3) = 7$, then $f(3)$ is at most ________.

Ans. 19

Exp:

$f'(x) \le 2,\ f(-3) = 7$

$$f'(x) = \frac{f(3)-7}{3-(-3)}$$ (Using Lagnange)

$$f'(x) = \frac{f(3)-7}{6}$$

$f(3) = 6f'(x) + 7$

Given max value of $f'(x)$ is 2.

So, $f(3) = 6 \times 2 + 7 = 19$

Q.26 – Q.39 Multiple Choice Question (MCQ), carry TWO mark each (for each wrong answer: – 2/3).

26. Consider the string **abbccddeee.** Each letter in the string must be assigned a binary code satisfying the following properties:

1. For any two letters, the code assigned to one letter must not be a prefix of the code assigned to the other letter.

2. For any two letters of the same frequency, the letter which occurs earlier in the dictionary order is assigned a code whose length is at most the length of the code assigned to the other letter.

Among the set of all binary code assignments which satisfy the above two properties, what is the minimum length of the encoded string?

(a) 21

(b) 23

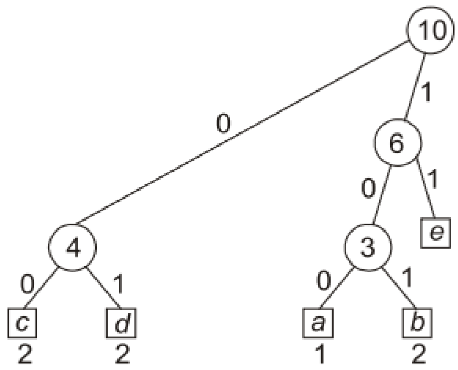
(c) 25

(d) 30

Ans. b

Exp:

Letters used in string :	a	b	c	d	E
Frequencies	1	2	2	2	3



Letters used in string:

∴ Minimum length of encoded string

= Sum frequency count using Huffman coding

= 1 * 3 + 2 * 3 + 2 * 2 + 2 * 2 + 3 * 2 = 23

Q. 27 Assume a two-level inclusive cache hierarchy, L1 and L2, where L2 is the larger of the two. Consider the following statements.

S_1 : Read misses in a write through L1 cache do not result in writebacks of dirty lines to the L2.

S_2 : Write allocate policy *must* be used in conjunction with write through caches and no-write allocate policy is used with writeback caches.

Which of the following statements is correct?

(a) S_1 is true and S_2 is false

(b) S_1 is false and S_2 is true

(c) S_1 is true and S_2 is true

(d) S_1 is false and S_2 is false

Ans. a

Exp:

28. Suppose we want to design a synchronous circuit that processes a string of 0's and 1's. Given a string, it produces another string by replacing the first 1 in any subsequence of consecutive 1's by a 0. Consider the following example.

Input sequence : 00100011000011100

Output Sequence: 00000001000001100

A *Mealy Machine* is a state machine where both the next state and the output are functions of the present state and the current input.

The above mentioned circuit can be designed as a two-state Mealy machine. The states in the Mealy machine can be represented using Boolean values 0 and 1. We denote the current state, the next state, the next incoming bit, and the output bit of the Mealy machine by the variables s, t, b and y respectively.

Assume the initial state of the Mealy machine is 0.

What are the Boolean expressions corresponding to t and y in terms of s and b?

(a) $t = s + b$

$y = sb$

(b) $t = b$

$y = sb$

(c) $t = b$

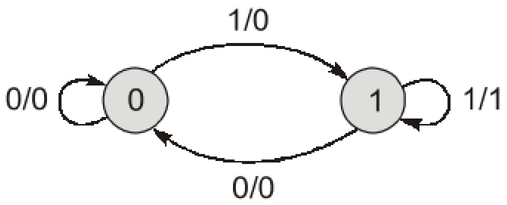
$y = s\overline{b}$

(d) $t = s + b$

$y = s\overline{b}$

Ans. b

Exp:



PS s	Next State t, b = 0	O/P y, b = 1
0 1	0, 0 0, 0	1, 0 1, 1

$t = \bar{s}b + sb = b$

$y = sb$

29. In an examination, a student can choose the order in which two questions (QuesA and QuesB) must be attempted.

- If the first question is answered wrong, the student gets zero marks.

- If the first question is answered correctly and the second question is not answered correctly, the student gets the marks only for the first question.

- If both the questions are answered correctly, the student gets the sum of the marks of the two questions.

The following table shows the probability of correctly answering a question and the marks of the question respectively.

Question	Probability of answering correctly	Marks
QuesA	0.8	10
QuesB	0.5	20

Assuming that the student always wants to maximize her expected marks in the examination, in which order should she attempt the questions and what is the expected marks for that order (assume that the questions are independent)?

(a) First QuesA and then QuesB. Expected marks 14.

(b) First QuesB and then QuesA. Expected marks 14.

(c) First QuesB and then QuesA. Expected marks 22.

(d) First QuesA and then QuesB. Expected marks 16.

Ans. d

Exp:

Case 1: Assume A is correct and attempted as the first question.

(i) P(B is correct) = 0.5

Expected marks = 0.5 × 20 = 10

(ii) P(B is wrong) = 0.5

Expected marks = 0.5 × 0 = 0

Total expected marks = (A is correct, B is wrong) or (A is correct, B is correct)

Total expected marks = $\frac{(0.8\times10+0.5\times0)+(0.8\times10+0.5\times20)}{2}=13$

Case 2: Assume B is correct and attempted as the first question.

Total expected marks = (B is correct, A is wrong) or (B is correct, A is correct)

Total expected marks = $\frac{(0.5\times20+0.8\times0)+(0.8\times10+0.5\times20)}{2}=14$

30. Consider the following ANSI C code segment:

```
z = x + 3 + y->f1 + y->f2;
for (i = 0; i < 200; i = i + 2){
  if (z > i)  {
    p = q + x + 3;
    q = q + y->f1;
} else {
    p = p + y->f2;
    q = q + x + 3;
  }
}
```

Assume that the variable y points to a struct (allocated on the heap) containing two fields f1 and f2, and the local variables x, y, z, p, q, and i are allotted registers. Common sub-expression elimination (CSE) optimization is applied on the code. The number of addition and dereference operations (of the form y->f1 or y->f2) in the optimized code, respectively, are:

(a) 403 and 102

(b) 203 and 2

(c) 303 and 102

(d) 303 and 2

Ans. d

Exp:

$t_1 = y \rightarrow f_1$ (1 dereference)

$t_2 = y \rightarrow f_2$ (1 dereference)

$t_3 = x + 3$ (1 add)

$z = t_3 + t_1 + t_2$ (2 additions)

```
For (i = 0; i < 200; i + = 2)
{
        if (z > 1)
        {
                p = p + t3
                q = q + t1 (2 add)
        }
        else
        {
                p = p + p2
                q = q + t3 (2 add)
        }
}
```

If else condition ⇒

Either it is executed (or) else is executed.

⇒ At any iteration 2 addition operations will be executed.

So, in loop the iterations are $\left(\frac{200}{2}\right) = 100$ times

∴ In loop the number of addition = 100 × 2 = 200 additions

∴ Total additions = 200 + 1 + 2 + 100 loop additions (inside for loop) = 303

and 2 dereferences.

∴ Correct answer is 303 and 2

31. The relation scheme given below is used to store information about the employees of a company, where **emId** is the key and **deptId** indicates the department to which the employee is assigned. Each employee is assigned to exactly one department.

emp(empId, name, gender, salary, deptId)

consider the following SQL query:

select deptId, count(*)

from emp

where gender = “female” and salary > (select avg(salary) from emp) group by deptId;

The above query gives, for each department in the company, the number of female employees whose salary is greater than the average salary of

(a) employees in the department

(b) employees in the company

(c) female employees in the department

(d) female employees in the company

Ans. b

Exp:

emp	empId	Name	Gender	Salary	deptid
21K > 20K	e_1	X	Female	210K	CS
	e_2	Y	Male	19K	CS
25K > 20K	e_3	XZ	Female	25K	EC
	e_4	YZ	Male	14K	EC
21K > 20 K	e_5	a	Female	21K	CS

Average salary of all employees in the company.

O/P

deptid	count(*)
CS	2
EC	1

For each department, number of female employees whose salary is greater than average salary of employees in the company.

32. Let S be the following schedule of operations of three transactions T_1 , T_2 and T_3 in a relational database system:

$R_2(Y), R_1(X), R_3(Z), R_1(Y), W_1(X), R_2(Z), W_2(Y), R_3(X), W_3(Z)$

Consider the statements P and Q below:

P: S is conflict-serializable.

Q: If T_3 commits before T_1 finishes, then S is recoverable.

Which one of the following choices is correct?

(a) Both P and Q are true.

(b) P is true and Q is false

(c) P is false and Q is true

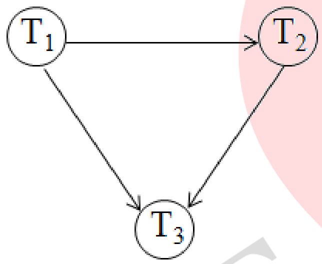
(d) Both P and Q are false.

Ans. b

Exp:

No cycle is precedence graph.

∴ Conflict serializable.



T_1	T_2	T_3
⋮	⋮	⋮
$W_1(X)$		
	$R_2(Z)$	
	$W_2(Y)$	
		$R_3(X)$
		$W_3(Z)$

T_2 is doing dirty read of updated X by T_1 .

So, recoverability only possible if T_3 commits after commit/RB of T_1 .

33. A bag has *r* red balls and *b* black balls. All balls are identical except for their colours. In a trial, a ball is randomly drawn from the bag, its colour is noted and the ball is placed back into the bag will increase by one, after the trial. A sequence of four such trials is conducted. Which one of the following choices gives the probability of drawing a red ball in the fourth trial?

(a) $\dfrac{r}{r+b}$

(b) $\dfrac{r}{r+b+3}$

(c) $\dfrac{r+3}{r+b+3}$

(d) $\left(\dfrac{r}{r+b}\right)\left(\dfrac{r+1}{r+b+1}\right)\left(\dfrac{r+2}{r+b+2}\right)\left(\dfrac{r+3}{r+b+3}\right)$

Ans. a

Exp:

There are 10 favourable ways to calculate the probability of red ball in 4th trial.

(RFR)R = R or (BRR)R = 1 way or (RRR)R = 3 ways or (BBR)R = 3 ways

$$P(RRRR) = \frac{r}{r+b}\times\frac{r+1}{r+1+b}\times\frac{r+2}{r+2+b}\times\frac{r+3}{r+3+b} \qquad (1)$$

$$P(BBBR) = \frac{b}{r+b}\times\frac{b+1}{r+b+1}\times\frac{b+2}{r+b+2}\times\frac{r}{r+b+3} \qquad (2)$$

$$P(RRBR) = \frac{3!}{2!}\times\frac{r}{r+b}\times\frac{r+1}{r+b+1}\times\frac{b}{r+b+2}\times\frac{r+2}{r+b+3} \qquad (3)$$

$$P(BBRR) = \frac{3!}{2!}\times\frac{b}{r+b}\times\frac{b+1}{r+b+1}\times\frac{r}{r+b+2}\times\frac{r+1}{r+b+3} \qquad (4)$$

Required probability = (1) + (2) + (3) + (4)

$$= \frac{r(r+1)(r+2)(r+3)+b(b+1)(b+2)r+3r(r+1)b(r+2)+3b(b+1)r(r+1)}{(r+b)(r+b+1)(r+b+2)(r+b+3)}$$

On simplify the above equation, we get

$$\text{Required probability} = \frac{r(r+1+b)}{(r+b)(r+b+1)} = \frac{r}{r+b}$$

34. Consider the cyclic redundancy check (CRC) based error detecting scheme having the generator polynomial $X^3 + X + 1$. Suppose the message $m_4m_3m_2m_1m_o$ = 11000 is to be transmitted. Check bits $c_2c_1c_o$ are appended at the end of the message by the transmitter using the above CRC scheme. The transmitted bit string is denoted by $m_4m_3m_2m_1m_oc_2c_1c_o$. The value of the checkbit sequence $c_2c_1c_o$ is

(a) 101

(b) 110

(c) 100

(d) 111

Ans. c

Exp:

$x^3 + x + 1 = 1011$


```
1011|11000000|
     1011
      1110
      1011
        1010
        1011
           100
```

35. Consider the following ANSI C program:

```
#include <stdio.h>

#include <stdlib.h>

struct Node{

        int value;

        struct Node *next;};

int main ( ) {

        struct Node *boxE, *head, *boxN; int index = 0;

        boxE = head = (struct Node *) malloc(sizeof(struct Node));

        head->value = index;

        for (index = 1; index <=3; index++){

                boxN = (struct Node *) malloc(sizeof(struct Node));

                boxE->next = boxN;

                boxN->value = index;

                boxE = boxN; }

        for (index = 0; index <=3; index++) {

                printf("Value at index %d is %d\n", index, head->value);

                head = head->next;

                printf("Value at index %d is %d\n", index+1, head->value); }  }
```

Which one of the statements below is correct about the program?

(a) Upon execution, the program creates a linked-list of five nodes.

(b) Upon execution, the program goes into an infinite loop.

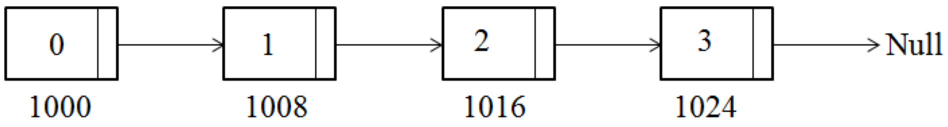
(c) It has a missing return which will be reported as an error by the compiler.

(d) It dereferences an uninitialized pointer that may result in a run-time error.

Ans. d

Exp:

As we can see in the loop, i runs from 1 to 3. So, four nodes will be created because one node is already created with value 0.



When index = 3, then head value = 3

Head = Head → Next (Now head will point to NULL)

Head → Value [which is in print. So, it will generate Run time Error].

36. Consider the following two statements about regular languages:

S_1 : Every infinite regular language contains an undecidable language as a subset.

S_2 : Every finite language is regular.

Which one of the following choices is correct?

(a) Only S_1 is true

(b) Only S_2 is true

(c) Both S_1 and S_2 are true

(d) Neither S_1 nor S_2 is true.

Ans. c

Exp:

S_1 : Every infinite regular language contains an undecidable language as a subset.

S_2 : Every finite language is regular.

Clearly, S_2 is true, since for finite language, we can design FA by brute force, with a finite number of states.

Since, any language can be subset of an infinite language (No infinite language is closed under subset operation).

So, an infinite regular language can have any type of language as a subset including undecidable (non-REC) languages.

So, S_1 is also true. So, both S_1 and S_2 are true.

37. For two n-dimensional real vectors P and Q, the operation $s(P, Q)$ is defined as follows:

$$s(P,Q)=\sum_{i=1}^{n}\left(P[i]\cdot Q[i]\right)$$

Let $\mathcal{L}$ be a set of 10-dimensional non-zero real vectors such that for every pair of distinct vectors P, Q ϵ $\mathcal{L}$, s(P, Q) = 0. What is the maximum cardinality possible for the set $\mathcal{L}$?

(a) 9

(b) 10

(c) 11

(d) 100

Ans. b

Exp:

$\mathcal{L}$ is the set of 10-dimensional orthogonal vectors. So, cardinality of $\mathcal{L} \leq 10$.

i.e., Maximum cardinality of $\mathcal{L}$ = 10.

38. For a statement S in program, in the context of liveness analysis, the following sets are defined:

USE(S)	:	the set of variables used in S
IN(S)	:	the set of variable that are live at the entry of S
OUT(S)	:	the set of variables that are live at the exit of S

Consider a basic block that consists of two statements, S_1 followed by S_2. Which one of the following statements is correct?

(a) OUT (S_1) = IN (S_2)

(b) Out (S_1) = IN (S_1) ∪ USE (S_1)

(c) OUT (S_1) = IN(S_2) ∪ OUT (S_2)

(d) OUT (S_1) = USE (S_1) ∪ IN (S_2)

Ans. a

Exp:

In live variable analysis at any node, the set of variables live at just after the block are evaluated using the formula.

OUT = ∪ IN (Successor nodes)

So, the correct option is

OUT (S_1) = IN (S_2)

39. For constants a ≥ 1 and b > 1, consider the following recurrence defined on the non-negative integers:

$$T(n) = a \cdot T\left(\frac{n}{b}\right) + f(n)$$

Which one of the following options is correct about the recurrence T(n)?

(a) If f(n) is $n\log_2(n)$, then T(n) is $\Theta(n \log_2(n))$.

(b) If f(n) is $\frac{n}{\log_2(n)}$, then T(n) is $\Theta(\log_2(n))$.

(c) If f(n) is $O\left(n^{\log_b(a)-\epsilon}\right)$ for some ϵ > 0, then T(n) is $\Theta(n^{\log_b(a)})$.

(d) If f(n) is $\Theta(n^{\log_b(a)})$, then T(n) is $\Theta(n^{\log_b(a)})$.

Ans. c

Exp:

Option c is true according to Standard Master Theorem.

Q.40 – Q.47 Multiple Select Question (MSQ), carry TWO mark each (no negative marks).

40. Suppose the following functional dependencies hold on a relation U with attributes P, Q, R, S, and T:

P → QR

RS → T

Which of the following functional dependencies can be inferred from the above functional dependencies?

(a) PS → T

(b) R → T

(c) P → R

(d) PS → Q

Ans. a, c, d

Exp:

1.	PS → T	$(PS)^+$ = {P, S, Q, R, T}
2.	R → T	$(R)^+$ = {R}
3.	P → R	$(P)^+$ = {P, Q, R}
4.	PS → Q	$(PS)^+$ = {P, S, Q, R, T}

41. For a string *w*, we define w^R to be reverse of *w*. For example, if *w* = 01101 then w^R = 10110. Which of the following languages is/are context-free?

(a) $\{wxw^Rx^R|\}$ $w, x \in \{0, 1\}^*\}$

(b) $\{ww^Rxx^R|\}w, x \in \{0, 1\}^*\}$

(c) $\{wxw^R|w, x \in \{0, 1\}^*\}$

(d) $\{wxx^Rw^R\}w, x \in \{0, 1\}^*\}$

Ans. b, c, d

Exp:

Option (a) :

By putting w as "ϵ" we will get $\{xx^R| x \in \{0, 1\}^*\}$ which still has string matching. So, this will not be regular. Similarly, by putting *x* as ϵ it will be $\{ww^R|w \in \{0, 1\}^*\}$ which still has string matching and will not become regular.

So, we need to do string matching but alternate order string matching is not possible in PDA. So, it is a CSL. Option a is a CSL but not CFL.

Option (b):

Here by putting *x* or *w* as ϵ, we cannot remove string matching. So, it is not regular. But it is CFL since in a NPDA we can push w, pop for w^R match it and then push *x* and pop for x^R and match it again and so this language is a CFL.

Option (c):

By putting w as "ϵ" we will get $\{x | x \in \{0, 1\}^*\} = (0 + 1)^*$

Since a subset of L is (0 + 1)*, L itself must be (0 + 1)* which is regular and hence CLF. Option (b) is a CFL.

Option (d):

Here, also by putting w or x as ϵ, we cannot make it regular. NPDA can do this, push both w and x and then x^R pop and w^R pop and match. By push, push, pop, pop this can be accepted by NPDA. So, option d is CFL.

42. Consider the following multi-threaded code segment (in a mix of C and pseudo-code), invoked by two processes P1 and P2, and each of the processes spawns two threads T1 and T2 :

```
int x = 0;          // global
Lock L1;            // global
main( ) {
        create a thread to execute foo ( );       //  Thread T1
        create a thread to execute foo ( );       //  Thread T2
        wait for the two threads to finish execution;
        print (x); }
foo ( )  {
        int y = 0;
        Acquire L1;
        x = x + 1;
        y = y + 1;
        Release L1;
        print (y);}
```

Which of the following statement(s) is/are correct?

(a) Both P1 and P2 will print the value of x as 2.

(b) At least one of P1 and P2 will print the value of x as 4.

(c) At least one of the threads will print the value of y as 2.

(d) Both T1 and T2, in both the processes, will print the value of y as 1.

Ans. a, d

Exp:

P_1 and P_2 can spawn two threads T_1 and T_2 .

int x = 0; //global

Lock L_1; //global

```
main( ) {
        foo( ); //Thread T1
        foo( ); //Thread T2
        print(x);
}
foo ( ) {
a.      int y = 0;
b.      Acquire L1 :
c.      x = x + 1;
d.      y = y + 1;
        release L1;
        print(y);
}
```

- Let P_1 executed T_1 and in foo( ).

X

~~0~~	1

(a) $P_1 - T_1$

(b) $P_1 - T_1$

(d) $x = x + 1(P_1 - T_1)$

..... Preempt T_1 of P_1 .

Similarly, perform thread T_2 of P_1 then $x = 2$.

Now, if we similarly perform both threads of P_2 then x will be maximum 4.

- x can be 2 also.

Note: But as we know every foo call will have its own copy of variable y so y cannot be more than 1 in any case.

43. Consider a computer system with multiple shared resource types, with one instance per resource type. Each instance can be owned by only one process at a time. Owning and freeing of resources are done by holding a global lock (L). The following scheme is used to own a resource instance :

function OWNRESOURCE(Resource R)

```
        Acquire lock L // a global lock
        if R is available then
            Acquire R
            Release lock L
        else
            if R is owned by another process P then
                Terminate P, after releasing all resources owned by P
                Acquire R
                Restart P
                Release lock L
            end if
        end if
    end function
```

Which of the following choice(s) about the above scheme is/are correct?

(a) The scheme ensures that deadlocks will not occur.

(b) The scheme may lead to live-lock

(c) The scheme may lead to starvation

(d) The scheme violates the mutual exclusion property.

Ans. a, b, c

Exp:

- Mutual exclusion is not violated.
- Also, there will be no deadlock because of forceful pre-emption of resources.
- This may lead to starvation if the process is keeps on coming and pre-empting each other like P_1 is pre-empted by P_2 and P_2 is pre-empted by P_3.
- Live-lock is also possible due to continuous pre-emption of resources.

For option (b) consider two processes P_1 and P_2 now P_1 enter the code acquires lock and resource.

Now P_2 enters the else part kills P_1 and acquire R and restart P_1 .

Now P_1 again acquire lock and kills the process P_2 this continues creating a live lock scenario but there is ambiguity in the code since "Release R" is not written anywhere so ambiguity is regarding how the process will release Resource R. According to the code, the only way to release the resource is by getting killed.

44. If the numerical value of a 2-byte unsigned integer on a little endian computer is 225 more than that on a big endian computer, which of the following choices represent(s) the unsigned integer on a little endian computer?

(a) 0x6665

(b) 0x0001

(c) 0x4243

(d) 0x0100

Ans. a, d

Exp:

Option (a): In little endian 0x6665 on converting it to decimal = 26213

In big endian it will be 6566 on converting it to decimal = 25958

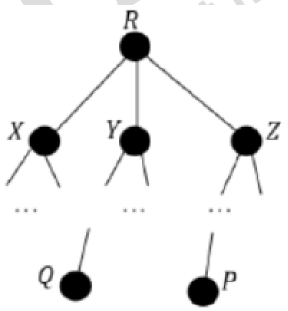
Now little endian – big endian = 26231 – 25958 = 255 which is correct.

Option (b): In little endian 0x0001 which is 1 in decimal in big endian 0x0100 which is greater than little endian in decimal. So, this is incorrect option.

Option (c): Little endian = 0x4243 and big endian = 0x4342, big endian value is greater than little endian so this is incorrect.

Option (d): Little endian = 0x0100 which is 256 in decimal and big endian = 0x0001 which is 1 in decimal and difference will be 255 hence this is also correct option.

45. Consider a computer network using the distance vector routing algorithm in its network layer. The partial topology of the network is as shown below.



The objective is to find the shortest-cost path from the router R to routers P and Q. Assume that R does not initially know the shortest routes to P and Q. Assume that R has three neighbouring routers denoted as X, Y and Z. During one iteration, R measures its distance to its neighbours X, Y, and Z as 3, 2, and 5, respectively. Router R gets routing vectors from its neighbours that indicate that the distance to router P from routers X, Y and Z are 7, 6, and 5, respectively. The routing vector also indicates that the distance to router Q from routers X, Y, and Z are 4, 6, and 8, respectively. Which of the following statement(s) is/are correct with respect to the new routing table of R, after updation during this iteration?

(a) The distance from R to P will be stored as 10.

(b) The distance from R to Q will be stored as 7.

(c) The next hop router for a packet from R to P is Y.

(d) The next hop router for a packet from R to Q is Z.

Ans. b, c

Exp:

Given R gets the distance vector (3, 2, 5)

After the one iteration distance vector from X to P, Y to P, and Z to P is (7, 6, 5) respectively.

The distance vector from R to P via XYZ is (3 + 7, 2 + 6, 5 + 5) = (10, 8, 10)

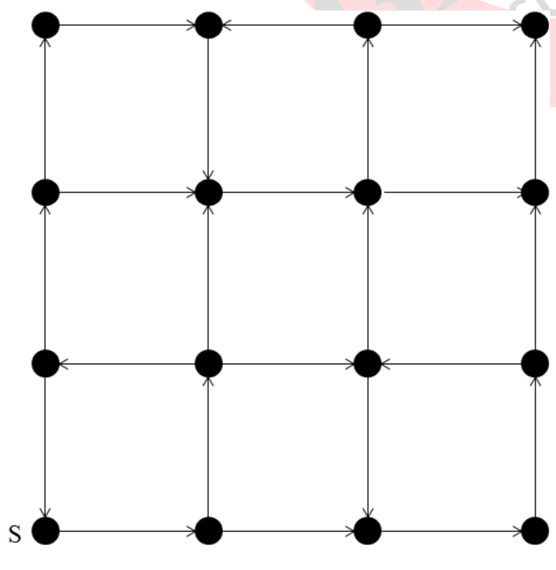
So, take minimum distance from R to P which is 8 via Y.

After the iteration distance vector from X to Q, Y to Q, Z to Q is (4, 6, 8) respectively.

The distance vector from R to Q via XYZ is (3 + 4, 2 + 6, 5 + 8) = (7, 8, 13)

So, take minimum distance from R to Q which is 7 via X.

46. Consider the following directed graph:



Which of the following is/are correct about the graph?

(a) The graph does not have a topological order.

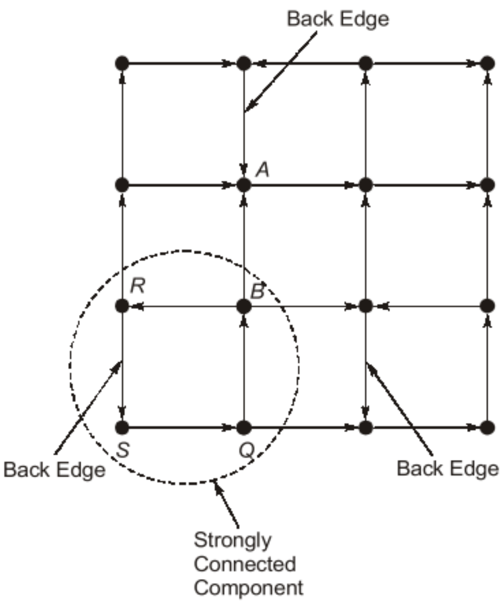
(b) A depth-first traversal starting at vertex S classifies three directed edges as back edges.

(c) The graph does not have a strongly connected component

(d) For each pair of vertices *u* and *v*, there is a directed path from *u* to *v*.

Ans. a, b

Exp:



- As we can see there is cycle in given DAG. So, topological order is not possible.
- Statement (b) is also true.
- There is no path from A to B, so statement (c) is false.
- In SQBR, it is strongly connected component. So, statement (d) is false.

47. Which of the following regular expressions represent(s) the set of all binary numbers that are divisible by three? Assume that the string ϵ is divisible by three.

(a) (0 + 1(01*0)*1)*

(b) (0 + 11 + 10(1 + 00)*01)*

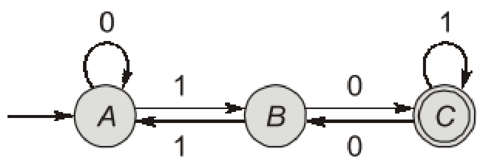
(c) (0*(1(01*0)*1)*)*

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

Ans. a, b, c

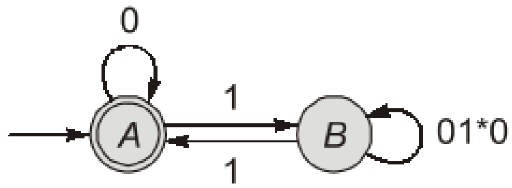
Exp:s

The DFA for accepting all binary strings divisible by 3 is given below:



Where A is residue 0 state, B is residue 1 state and C is residue 2 state.

From this we get by deleting (c).



We get option (a) is correct (0 + 1(01*0)*1)*

Now option (a) = option (c)

Because (r*s*)* = (r + s)*

So, option (c) is also correct.

Option (b) can be obtained by resolving the loop between B and C on "C" instead of on B.

Option (b) is also correct.

Also, note that whatever string option (a) can derive, option (b) also can derive.

So, option (b) is correct.

Option (d) (0 + 11 + 11(1 + 00)*00)* cannot derive "1001" which is accepted by machine.

So, option (d) is incorrect.

Q.48 – Q.55 Numerical Answer Type (NAT), carry TWO mark each (no negative marks).

48. Consider a three-level page table to translate a 39-bit virtual address to a physical address as shown below:

39-bit virtual address

Level 1 offset	Level 2 offset	Level 3 offset	Page offset
9 bits	9 bits	9 bits	12 bits

The page size is 4KB (1KB = 2^{10} bytes) and page table entry size at every level is 8 bytes. A process P is currently using 2GB (1GB = 2^{30} bytes) virtual memory which is mapped to 2GB of physical memory. The minimum amount of memory required for the page table of P across all levels is ________KB.

Ans. 4108

Exp:

For minimum consider 1 page at each level.

Now, page table size = $2^9 \times 8B = 4$ KB

If 1 page is present at each level, then total 3 pages will be there.

So, total page table size in the memory will be $4 \times 3 = 12$ KB

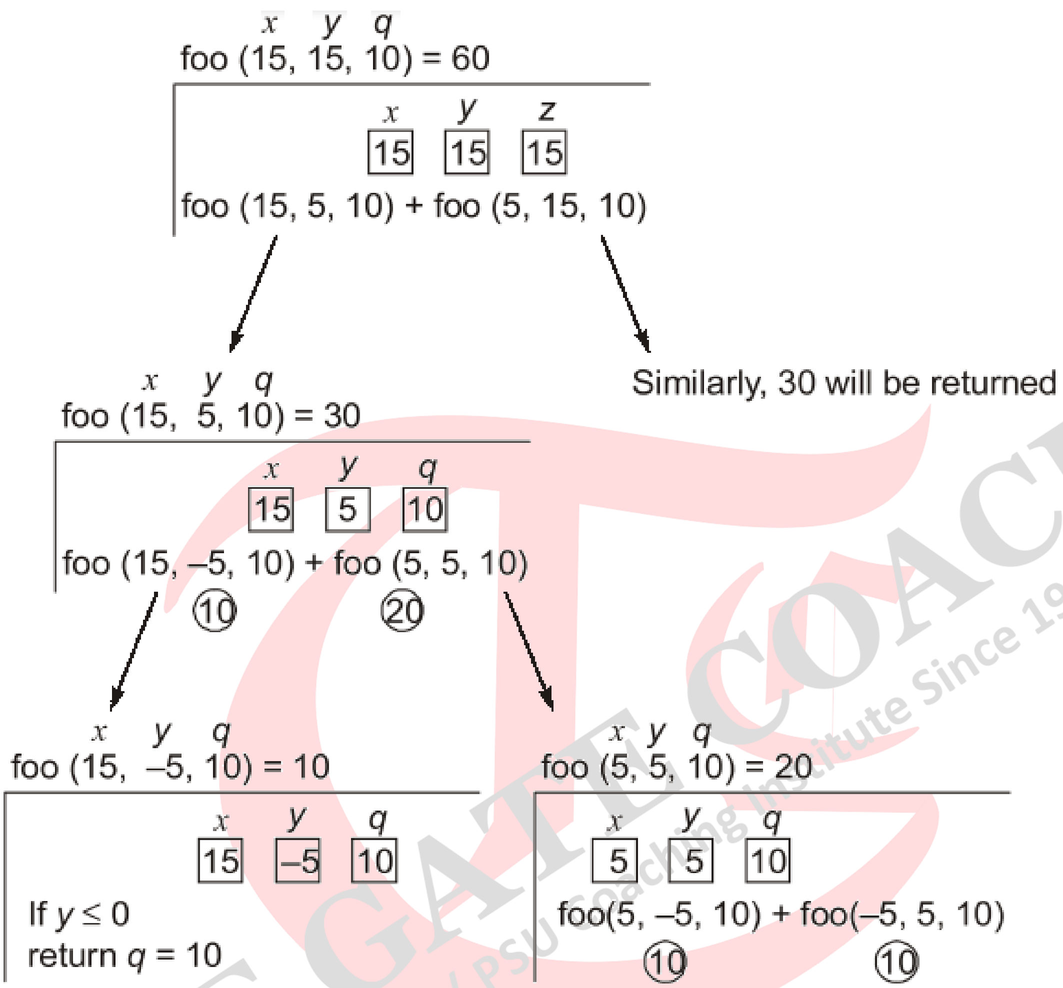
49. Consider the following ANSI C program.

```
#include <stdio.h>

int foo(int x, int y, int q)

{

        if ((x <= 0) && (y <= 0)

                return q;

        if (x <= 0)

                return foo(x, y–q, q);

        if (y <= 0)

                return foo (x–q, y, q);

        return foo (x, y–q, q) + foo(x–q, y, q);

}

int main( )

{

        int r = foo(15, 15, 10);

        printf("%d", r):

        return 0;

}
```

The output of the program upon execution is ________.

Ans. 60

Exp:

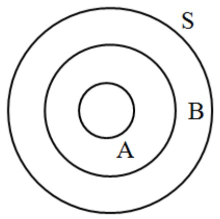


50. Let S be a set consisting of 10 elements. The number of tuples of the form (A, B) such that A and B are subsets of S, and A ⊆ B is ________.

Ans. 59049

Exp:

The Venn diagram for this is



Now every element x in S has only 3 options. It can be $x \in A$ or $x \in B - A$ or $x \in S - B$. So, the number of ways to choose A and B such that $A \subseteq B \subseteq S$ is 3^{10}.

51. Consider the following augmented grammar with {#, @, <, >, a, b, c} as the set of terminals.

$$S' \rightarrow S$$

$$S \rightarrow S \# cS$$

$$S \rightarrow S\ S$$

$$S \rightarrow S\ @$$

$$S \rightarrow < S >$$

$$S \rightarrow a$$

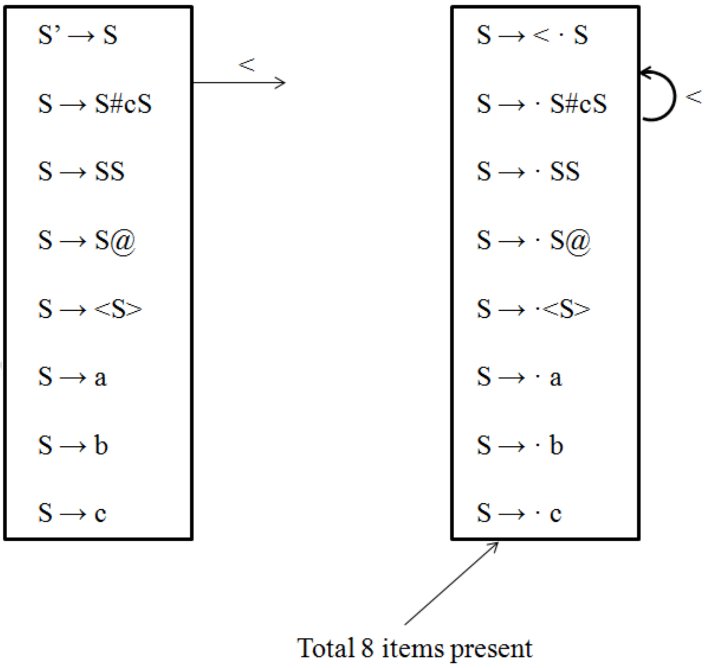
$$S \rightarrow b$$

$$S \rightarrow c$$

Let I_o = CLOSURE ({S' → •S}). The number of items in the set GOTO(GOTO(I_o, <), <) is ________.

Ans. 8

Exp:



52. Consider a Boolean function *f* (*w*, *x*, *y*, *z*) such that

$$f\,(,\ 0,\ 0,\ z) = 1$$

$$f\,(1,\ x,\ 1,\ z) = x + z$$

$$f(w, 1, y, z) = wz + y$$

The number of literals in the minimal sum-of-products expression of *f* is ________.

Ans. 6

Exp:

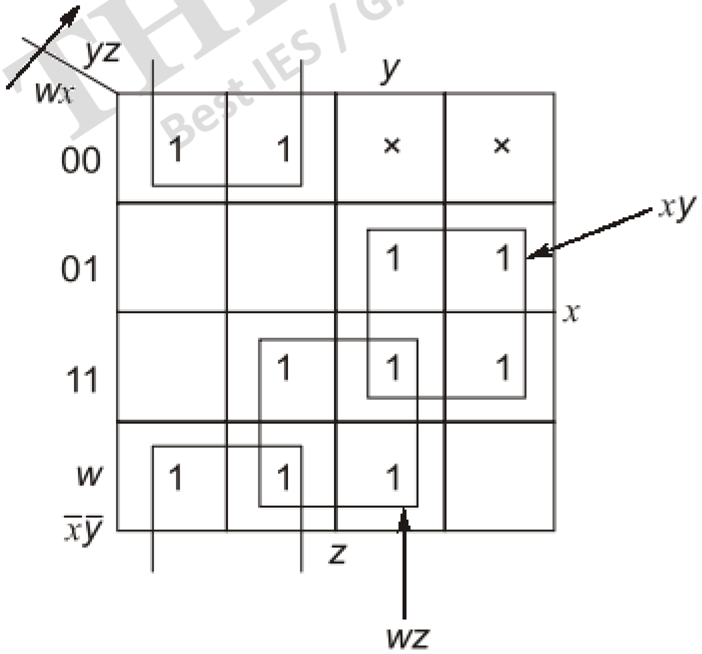
f(w, 0 0, z) = 1

f(1, *x*, 1, z) = *x* + z

f(w, 1, y, z) = wz + y

	wxyz	Eqn. 1	Eqn. 2	Eqn. 3	f
0	0000	1			1
1	0001	1			1
2	0010				×
3	0011				×
4	0100			0	0
5	0101			0	0
6	0110			1	1
7	0111			1	1
8	1000	1			1
9	1001	1			1
10	1010		0		0
11	1011		1		1
12	1100			0	0
13	1101			1	1
14	1110		1	1	1
15	1111		1	1	1

f(w, *x*, y, z) = ∑m(0, 1, 6, 7, 8, 9, 11, 13, 14, 15) + d(2, 3)



$\therefore \qquad f = \overline{x}\overline{y} + xy + wz$

The number of literals in the minimal SOP expression is 6.

53. Consider a pipelined processor with 5 stages, **I**nstruction Fetch (**IF**), Instruction Decode (**ID**), Execute (**EX**), Memory Access (**MEM**), and Write Back (**WB**). Each stage of the pipeline, except the **EX** stage, takes one cycle. Assume that the **ID** stage merely decodes the instruction and the register read is performed in the **EX** stage. The **EX** stage takes one cycle for **ADD** instruction and two cycles for **MUL** instruction. Ignore pipeline register latencies.

Consider the following sequence of 8 instructions:

ADD, MUL, ADD, MUL, ADD, MUL, ADD, MUL

Assume that every **MUL** instruction is data-dependent on the **ADD** instruction just before it and every **ADD** instruction (except the first **ADD**) is data-dependent on the **MUL** instruction just before it. The Speedup is defined as follows:

$$Speedup = \frac{\text{Execution time without operand forwarding}}{\text{Execution time with operand forwarding}}$$

The *Speedup* achieved in executing the given instruction sequence on the pipelined processor (rounded to 2 decimal places) is ________.

Ans. 1.87 – 1.88

Exp:

With operand forwarding:

8 Instructions + 4 MUL instruction × 1 Extra Cycle in Ex-stage

n = 12 (finite)

K = 5

ET_{Pipe} = (K + n – 1) Cycles

= (5 + 12 – 1) = 16 Cycles

Without operand forwarding :

- 8 Instructions + 4 MUL Instruction × 2 Stalls at ID stage for ADD O/P + 3 ADD Instruction × 3 Stalls at ID stage for MUL O/P + 1 MUL Instruction × 1 Extra Cycle in Ex-Stage (Last Instruction)

n = 26

K = n

ET_{Pipe} = (K + n – 1) Cycles

= (5 + 26 – 1) Cycles

= 30 Cycles

∴ $S = \frac{30}{16} = 1.875$

54. Consider a network using the pure ALOHA medium access control protocol, where each frame is of length 1,000 bits. The channel transmission rate is 1 Mbps (= 10^6 bits per second). The aggregate number of transmissions across all the nodes (including new frame transmissions and retransmitted frames due to collisions) is modelled as a Poisson process with a rate of 1,000 frames per second. Throughput is defined as the average number of frames successfully transmitted per second. The throughput of the network (rounded to the nearest integer) is ________.

Ans. 130 – 140

Exp:

1 frame takes = Tt = $\frac{L}{B.W.}$

⇒ $\frac{1000}{10^6} = 1 \text{milli sec}$

1000 frame Tt = 1000 × 1 millisec = 1 sec

In 1 sec, 1000 frames sends, which is 1 millisec per frame.

So, G = 1

Efficiency of pure Aloha (η) = G × e^{-2G}

Where, G = Number of requests per time slot willing to transmit

e = Mathematical constant approximately equal to 2.718.

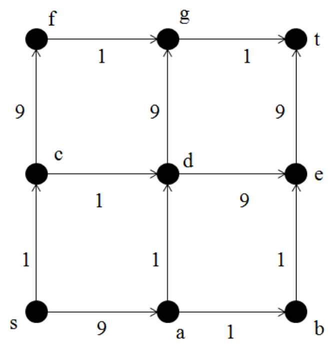
So, $\eta = 1\ 2.718^{(-2 \times 1)} = 0.1353$

Therefore, in 1sec 1000 frames = 0.1353 × 1000 = 135.3 (closest integer)

⇒ 135

⇒ Throughput ⇒ 135

55. In a directed acyclic graph with a source vertex s, the *quality-score* of a directed path is defined to be the product of the weights of the edges on the path. Further, for a vertex *v* other than s, the quality-score of *v* is defined to be the maximum among the quality-scores of all the paths from s to *v*. The quality-score of s is assumed to be 1.



The sum of the quality-scores of all the vertices in the graph shown above is ________.

Ans. 929

Exp:

Modify Dijkstra's Algo to get longest path in terms of quality scores (Use Max heap)

Algo:

1. Choose vertex u which is maximum quality score value.

V is set of adjacent of u.

for (each vertex (v))

{ if (q[v] < q[u]*cos (u, v)]

{

q[v] = q[u]* cost(u, v)

prev[v] = 4

2. Repeat (1) for each vertex exactly once.

Quality score (q):

1	0	0	0	0	0	0	0	0
1	9	9	1	9	81	9	81	729

Initially, let q[v] = 0 or –∞ (take smallest possible value)

Prev. :

–1	s	a	s	a	d	c	d	e

S ⇒ {a, c} q(a) = 9, q(c) = 1

a ⇒ {d, b} q(d) = |ad|*q(a) = 1*9 = 9, q(b) = |ab|*q(a) = 1*9 = 9 b ⇒ {e} q(e) =|be|*q(b) = 1*9 = 9

d ⇒ {e, g} q(e) = |de|*q(d) = 9*9 = 81, q(g) = |dg|*q(d) = 9*9 = 81

e ⇒ {t} q(t) = |et|*q(e) = 9*81 = 729

g ⇒ {t} t already relaxed.

c ⇒ {f, d} q(f) = |cf|*q(c) = 9*1 = 9

f ⇒ {g} g already relaxed.