Solved Paper 2016

GATE Computer Science and IT

Time : 3 hrs **MM :** 100

Read the following instructions carefully

1. There are 65 questions carrying 100 marks of 3 hrs duration in this paper.
2. Questions 1 to 25 carry 1 mark each and questions 26 to 55 carry 2 marks each.
3. Questions 56 to 65 belong to General Aptitude (GA) Type. Questions 56 to 60 carry 1 mark each and questions 61 to 65 carry 2 marks each.
4. Unattempted questions will carry zero marks.
5. For questions 1 to 25 and 56 to 60, 1/3 mark will be deducted for each wrong answer. For questions 26 to 55 and 61 to 65, 2/3 mark will be deducted for each wrong answer.
6. There is no negative marking for numerical answer type questions.
7. Physical calculator, charts, graph sheets and mathematical tables are not allowed in the examination hall.

(1 *Mark Questions*)

1. Let p, q, r, s represent the following propositions.

$p : x \in \{8, 9, 10, 11, 12\}$
$q : x$ is a composite number
$r : x$ is a perfect square
$s : x$ is a prime number

The integer $x \geq 2$ which satisfies $\neg((p \Rightarrow q) \wedge (\neg r \vee \neg s))$ is ________.

Sol. (11) $(p \Rightarrow q)$ will give {8, 9, 10, 12}

$\neg$r will give {8, 10, 11, 12}

$\neg$s will give {8, 9, 10, 12}

($\neg$r $\vee$ $\neg$s) will give {8, 9, 10, 11, 12}

$(p \Rightarrow q) \wedge$ ($\neg$r $\vee$ $\neg$s) will give {8, 9, 10, 12}

$\neg((p \Rightarrow q) \wedge$ ($\neg$r $\vee$ $\neg$s)) will give 11.

Thus, answer is 11.

2. Let a_n be the number of n-bit strings that do not contain two consecutive 1's. Which one of the following is the recurrence relation for a_n?

(a) $a_n = a_{n-1} + 2a_{n-2}$
(b) $a_n = a_{n-1} + a_{n-2}$
(c) $a_n = 2a_{n-1} + a_{n-2}$
(d) $a_n = 2a_{n-1} + 2a_{n-2}$

Sol. (b) The least value of n for the recursion would be 3.

For n = 1, number of strings = 2 (0, 1)

For n = 2, number of strings = 3 (00, 01, 10)

For n = 3, number of strings = 5 (000, 001, 010, 100, 101)

For n = 4, number of strings = 8 (0000, 0001, 0010, 0100, 1000, 0101, 1010, 1001)

...

This seems to follow Fibonacci series and the recurrence relation for it is

$$a_n = a_{n-1} + a_{n-2}.$$

3. $\lim_{x \to 4} \frac{\sin(x-4)}{x-4} =$ ________.

Sol. (1) Put $y = x - 4$.

So, the problem becomes

$$\lim_{y \to 0} (\sin y)/y = 1.$$

(Property of limits on sin)

Thus, 1 is the answer.

4. A probability density function on the interval $[a, 1]$ is given by $1/x^2$ and outside this interval the value of the function is zero. The value of a is ________.

Sol. (0.5) Given, $f(x) = \frac{1}{x^2} \quad a \le x \le 1$

$= 0 \quad$ elsewhere

So $\int_a^1 f(x) = 1$

$\Rightarrow \int_a^1 \frac{1}{x^2} = 1$

$\Rightarrow \left[\frac{-1}{x}\right]_a^1 = 1$

$\Rightarrow -\left[\frac{1}{1} - \frac{1}{a}\right] = 1$

$\Rightarrow \frac{1}{a} = 2$

$\Rightarrow a = \frac{1}{2} = 0.5$

5. Two eigenvalues of a 3×3 real matrix P are $(2 + \sqrt{-1})$ and 3. The determinant of P is ________.

Sol. (15) The determinant of a real matrix can never be imaginary. So, if one eigen value is complex, the other eigen value has to be its conjugate.

So, the eigen values of the matrix will be $2 + i$, $2 - i$ and 3.

Also, determinant is the product of all eigen values $= (2 + i)(2 - i)3 = 15$

6. Consider the Boolean operator # with the following properties.

$x \# 0 = x$, $x \# 1 = \bar{x}$, $x \# x = 0$ and $x \# \bar{x} = 1$. Then, $x \# y$ is equivalent to

(a) $x\bar{y} + \bar{x}y$ (b) $x\bar{y} + \bar{x}\,\bar{y}$
(c) $\bar{x}y + xy$ (d) $xy + \bar{x}\,\bar{y}$

Sol. (a) $x \# 0 = x \quad \ldots \quad 1$

$x \# 1 = \bar{x} \quad \ldots \quad 2$

$x \# x = 0 \quad \ldots \quad 3$

$x \# \bar{x} = 1 \quad \ldots \quad 4$

$x \# y = x\bar{y} + \bar{x}y$

x	y	$x \# y$
0	0	0
0	1	1
1	0	1
1	1	0

7. The 16-bit 2's complement representation of an integer is 1111 1111 1111 0101; its decimal representation is ________.

Sol. (d) (– 11)

$\boxed{1}$ 111 1111 1111 0101 ← Given number in 2's complement form

No. is –ve

0000 0000 0000 1011 ← 2's of the number

∴ Decimal equivalent is – 11.

8. We want to design a synchronous counter that counts the sequence 0-1-0-2-0-3 and then repeats. The minimum number of J-K flip-flops required to implement this counter is ________.

Sol. (4) We need four J-K flip-flops

$0 \to 1 \to 0 \to 2 \to 0 \to 3$

$0000 \to 0001 \to 0100 \to 0010 \to 1000 \to 0011$

There are 6 states and 3 of them correspond to same state to differentiate between 0, 1, 2, 3 we need 2 bits. To differentiate between 3, 0's we need 2 bits.

So, total 4 bits = 4 FF.

9. A processor can support a maximum memory of 4 GB, where the memory is word-addressable (a word consists of two bytes). The size of the address bus of the processor is at least ________ bits.

Sol. (31) Maximum memory = 4 GB = 2^{32} bytes

Size of a word = 2 bytes

Therefore, number of words = $2^{32} / 2 = 2^{31}$

So, we require 31 bits for the address bus of the processor.

10. A queue is implemented using an array such that ENQUEUE and DEQUEUE operations are performed efficiently. Which one of the following statements is correct (n refers to the number of items in the queue)?

(a) Both operations can be performed in $O(1)$ time
(b) At most one operation can be performed in $O(1)$ time but the worst case time for the other operation will be $\Omega(n)$
(c) The worst case time complexity for both operations will be $\Omega(n)$
(d) Worst case time complexity for both operations will be $\Omega(\log n)$

Sol. (a) Implementing queue using array:

ENQUEUE Operation

Check array full or not

if array is full

stop

else enter the element in the end of array;

which will take O(1) time.

DEQUEUE Operation

Check array empty or not

if array is empty

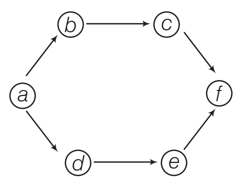
stop

else delete the element from front of array and increment the head value (pointer to the starting element of array).

which will take O(1) time.

So for array implementation of queue, ENQUEUE and DEQUEUE operation takes O(1) time.

11. Consider the following directed graph



The number of different topological orderings of the vertices of the graph is ________.

Sol. (6) Following are different 6 topological sortings

a b c d e f

a d e b c f

a b d c e f

a d b c e f

a b d e c f

a d b e c f

12. Consider the following C program.

```
void f(int, short);
void main()
{
    int i = 100;
    short s = 12;
    short *p = &s;
    .......... ; //call to f()
}
```

Which one of the following expressions, when placed in the blank above, will not result in a type checking error?

(a) $f(s, *s)$

(b) $i = f(i, s)$

(c) $f(i, *s)$

(d) $f(i, *p)$

Sol. (d) $f(s, *s)$, since there is no pointer variable define with $*s$. So, this function will give type checking error.

$i = f(i, s)$ since function prototype is void in void f(int, short) *i.e.*, f is accepting argument int type and short type and its return type should be integer because we store the output of function in variable i which is integer type. So there must be type casting into integer type but type casting is not present.

So, this function will give type checking error.

$f(i, *s)$ since there is no pointer variable define with *s. So, this function will give type checking error.

$f(i, *p)$ in this function to argument are pass one is int type and another is short type defined in the main function. So this function will not give type checking error.

13. The worst case running times of Insertion sort, Merge sort and Quick sort, respectively, are

(a) $\Theta(n \log n)$, $\Theta(n \log n)$ and $\Theta(n^2)$

(b) $\Theta(n^2)$, $\Theta(n^2)$ and $\Theta(n \log n)$

(c) $\Theta(n^2)$, $\Theta(n \log n)$ and $\Theta(n \log n)$

(d) $\Theta(n^2)$, $\Theta(n \log n)$ and $\Theta(n^2)$

Sol. (d) The worst case time complexity of also given are:

Insertion sort $= \Theta(n^2)$

Merge sort $= \Theta(n \log n)$

Quick sort $= \Theta(n^2)$

14. Let, G be a weighted connected undirected graph with distinct positive edge weights. If every edge weight is increased by the same value, then which of the following statements is/are true?

P : Minimum spanning tree of G does not change

Q : Shortest path between any pair of vertices does not change

(a) Only P (b) Only Q

(c) Neither P nor Q (d) Both P and Q

Sol. (a) The shortest path may change. The reason is, there may be different number of edges in different paths from s to t. For example, let shortest path be of weight 15 and has 5 edges. Let there be another path with 2 edges and total weight 25. The weight of the shortest path is increased by $5 * 10$ and becomes $15 + 20$. Weight of the other path is increased by $2 * 10$ and becomes $25 + 20$. So, the shortest path changes to the other path with weight as 45.

The minimum spanning tree does not change. Remember the Kruskal's algorithm where we sort the edges first. If we increase all weights, then order of edges won't change.

15. Consider the following C program.

```
#include<stdio.h>
void mystery(int *ptra, int *ptrb)
{
    int *temp;
    temp = ptrb;
    ptrb = ptra;
    ptra = temp;
}
```

```
int main()
{
      int a=2016, b=0, c=4, d = 42;
      mystery(&a, &b);
      if(a < c)
        mystery(&c, &a);
      mystery(&a, &d);
      printf("%d\n", a);
}
```

The output of the program is ________.

Sol. (2016)

a	b	c	d
2016	0	4	42
100	200	300	400

1. Mystery (&a, &b); address of 'a' and 'b' is passed.

   *ptr a = &a ; *ptr b= &b ;

ptr a	ptr b	temp
100	~~200~~ 100	200
1000	2000	3000

$$\left.\begin{aligned}&\text{temp} = \text{ptr b}; \Rightarrow \text{temp} = 200\\&\text{ptr b} = \text{ptr a}; \Rightarrow \text{ptr b} = 100\\&\text{ptr a} = \text{temp}; \Rightarrow \text{ptr a} = 200\end{aligned}\right\}\text{No effect on variables 'a' and 'b'}$$

2. if(2016 < 4) false

   So, mystery(&a, &b);

   *ptr a =&a   *ptr b =&d;

ptr *a*	ptr *b*	temp
100	~~200~~ 100	400
1000	2000	3000

$$\left.\begin{aligned}&\text{temp} = \text{ptr b}; \Rightarrow \text{temp} = 400\\&\text{ptr b} = \text{ptr a}; \Rightarrow \text{ptr b} = 100\\&\text{ptr a} = \text{temp}; \Rightarrow \text{ptr a} = 400\end{aligned}\right\}\text{No effect on variables 'a' and 'd'}$$

Printf("a"); ⇒ 2016

Output 2016

16. Which of the following languages is generated by the given grammar?

$$S \to aS \mid bS \mid \varepsilon$$

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

(b) $\{w \in \{a, b\}^* \mid w$ has equal number of a's and b's$\}$

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

(d) $\{a, b\}^*$

Sol. (d) We can generate, a, ab, abb, b, aaa, ...

17. Which of the following decision problems are undecidable?

I. Given NFAs N_1 and N_2, is $L(N_1) \cap L(N_2) = \phi$?

II. Given a CFG $G = (N, \Sigma, P, S)$ and a string $x \in \Sigma^*$, does $x \in L(G)$?

III. Given CFGs G_1 and G_2, is $L(G_1) = L(G_2)$?

IV. Given, a TM M, is $L(M) = \phi$?

(a) I and IV

(b) II and III

(c) III and IV

(d) II and IV

Sol. (c) A problem is undecidable if there is no algorithm to find the solution for it. Problem give in III and IV have no solutions, so these are undecidable.

18. Which one of the following regular expressions represents the language : the set of all binary strings having two consecutive 0s and two consecutive 1s?

(a) $(0+1)^* 0011(0+1)^* + (0+1)^* 1100(0+1)^*$

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

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

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

Sol. (b) Option A represents those strings which either have 0011 or 1100 as substring.

Option C represents those strings which either have 00 or 11 as substring.

Option D represents those strings which start with 11 and end with 00 or start with 00 and end with 11.

19. Consider the following code segment.

$x = u - t;$
$y = x * v;$
$x = y + w;$
$y = t - z;$
$y = x * y;$

The minimum number of total variables required to convert the above code segment of static single assignment form is ________.

Sol. (7)

20. Consider an arbitrary set of CPU-bound processes, with unequal CPU burst lengths submitted at the same time to a computer system. Which one of the following process scheduling algorithms would minimise the average waiting time in the ready queue?

(a) Shortest remaining time first

(b) Round-robit with time quantum less than the shortest CPU burst

(c) Uniform random

(d) Highest priority first with priority proportional to CPU burst length

Sol. (a) To minimise the average waiting time, we need to select the shortest remaining time process first, because all are arriving at the same time, and they have unequal CPU burst times.

All other options will not minimise the waiting time. So, the answer is SRTF algorithm.

21. Which of the following is not a superkey in a relational schema with attributes *V, W, X, Y, Z* and primary key *V Y* ?

(a) *VXYZ* (b) *VWXZ*
(c) *VWXY* (d) *VWXYZ*

Sol. (b) Super key = Candidate Key + other attributes. But option B does not include Y which is a part of primary key or candidate key.

22. Which one of the following is not a part of the ACID properties of database transactions?

(a) Atomicity (b) Consistency
(c) Isolation (d) Deadlock-freedom

Sol. (d) D refers to Durability.

23. A database of research articles in a journal uses the following schema.

(VOLUME, NUMBER, STARTPAGE, ENDPAGE, TITLE, YEAR, PRICE)

The primary key is (VOLUME, NUMBER, STARTPAGE, ENDPAGE) and the following functional dependencies exist in the schema.

(VOLUME, NUMBER, STARTPAGE, ENDPAGE) → TITLE

(VOLUME, NUMBER) → YEAR

(VOLUME, NUMBER, STARTPAGE, ENDPAGE) → PRICE

The database is redesigned to use the following schemas.

(VOLUME, NUMBER, STARTPAGE, ENDPAGE, TITLE, PRICE)

(VOLUME, NUMBER, YEAR)

Which is the weakest normal form that the new database satisfies, but the old one does not?

(a) 1NF (b) 2NF
(c) 3NF (d) BCNF

Sol. (b) Volume, Number → Year is partial dependency. So, it does not follow 2NF. But decomposed relation follows.

24. Which one of the following protocols is not used to resolve one form of address to another one?

(a) DNS
(b) ARP
(c) DHCP
(d) RARP

Sol. (a) DNS is used for mapping host name to IP Address.

25. Which of the following is/are example(s) of stateful application layer protocols?

I. HTTP
II. FTP
III. TCP
IV. POP3

(a) I and II (b) II and III
(c) II and IV (d) Only IV

Sol. (c) In computing, a stateless protocol is a communications protocol that treats each request as an independent transaction that is unrelated to any previous request, so that the communication consists of independent pairs of request and response.

Examples of stateless protocols (IP) and (HTTP)

TCP is stateful as it maintains connection information across multiple transfers, but TCP is not an application layer protocol.

(2 *Marks Questions*)

26. The coefficient of x^{12} in $(x^3+x^4+x^5+x^6+\ldots)^3$ is ________.

Sol. (10) The expression can be rewritten as

$$(x^3(1+x+x^2+x^3+\ldots))3 = x^9(1+x+x^2+x^3+\ldots))^3$$

Expanding $(1+x+x^2+x^3)^3$ using binomial expansion

$$(1+(x+x^2+x^3))^3 = 1+3(x+x^2+x^3)$$
$$+3\times2/2\ ((x+x^2+x^3)2+3\times2\times1/6(x+x^2+x^3)^3\ldots$$

The coefficient of x^3 will be 10, it is multiplied by x^9 outside, so coefficient of x^{12} is 10.

27. Consider the recurrence relation $a_1=8$, $a_n=6n^2+2n+a_{n-1}$. Let, $a_{99}=K\times10^4$. The value of K is ________.

Sol. (198) $a_1=8$

$$a_n = 6n^2+2n+a_{n-1}$$
$$a_n = 6[n^2+(n-1)^2]+2[n+(n-1)]+a_{n-2}$$

Continuing the same way till $n=2$, we get

$$a_n = 6[n^2+(n-1)^2+(n-2)^2+\ldots+(2)^2+2[n+(n-1)]$$
$$+(n-2)+\ldots+(2)]+a_1$$
$$a_n = 6[n^2+(n-1)^2+(n-2)^2+\ldots+(2)^2]$$
$$+2[n+(n-1)]+(n-2)+\ldots+2)]+8$$
$$a_n = 6[n^2+(n-1)^2+(n-2)^2+\ldots+(2)^2]$$
$$+2[n+(n-1)]+(n-2)+\ldots+2)]+6+2$$
$$a_n = 6[n^2+(n-1)^2+(n-2)^2+\ldots+(2)^2+1]$$
$$+2[n+(n-1)]+(n-2)+\ldots+(2)+1]$$
$$a_n = (n)\times(n+1)\times(2n+1)+(n)+(n+1)$$
$$= (n)\times(n+1)\times(2n+2)$$
$$a_n = 2\times(n)\times(n+1)\times(n+1)$$
$$= 2\times(n)\times(n+1)^2$$

Now,

put $n=99$.

$$a_{99} = 2\times99\times(100)^2 = 1980000 = K\times10^4$$

Therefore, $K=198$.

28. A function $f : \mathbb{N}^+ \rightarrow \mathbb{N}^+$, defined on the set of positive integers $\mathbb{N}^+$, satisfies the following properties :

$$f(n) = f(n/2), \text{ if } n \text{ is even}$$

$$f(n) = f(n+5), \text{ if } n \text{ is odd}$$

Let, $R = \{i \mid \exists j : f(j) = i\}$ be the set of distinct values that f takes. The maximum possible size of R is ________.

Sol. (2) Let us assume: $f(1) = x$.

Then, $f(2) = f(2/2) = f(1) = x$

$f(3) = f(3+5) = f(8) = f(8/2)$

$= f(4/2) = f(2/1) = f(1) = x$

Similarly, $f(4) = x$

$f(5) = f(5+5) = f(10/2) = f(5) = y$

So, it will have two values. All multiples of 5 will have value y and others will have value x. It will have 2 different values.

29. Consider the following experiment.

Step I. Flip a fair coin twice.

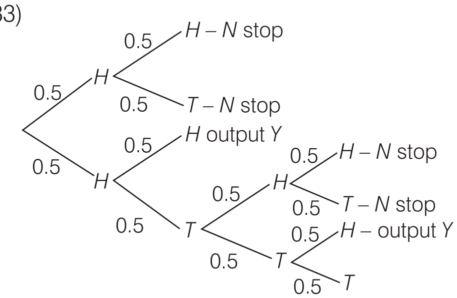
Step II. If the outcomes are (TAILS, HEADS), then output Y and stop.

Step III. If the outcomes are either (HEADS, HEADS) or (HEADS, TAILS), then output N and stop.

Step IV. If the outcomes are (TAILS, TAILS), then go to Step I.

The probability that the output of the experiment is Y is ________ (up to two decimal places)

Sol. (0.33)



The tree diagram for the processes is given above.

The desired output is Y.

Now by rule of total probability

$$p\text{ (output} = y) = 0.5 \times 0.5 + 0.5 \times 0.5 \times 0.5 \times 0.5 + \ldots$$

Infinite geometric series with

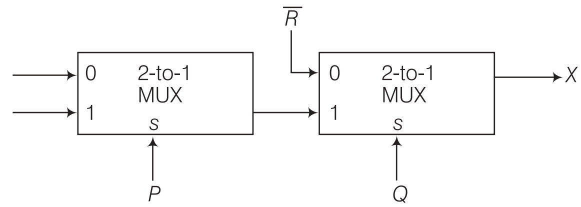
$$a = 0.5 \times 0.5$$

and $$r = 0.5 \times 0.5$$

$$\text{so } p\text{ (output} = y) = \frac{0.5 \times 0.5}{1 - 0.5 \times 0.5} = \frac{0.25}{0.75}$$

$$= \frac{1}{3} = 0.33 \text{ (upto 2 diagonal places)}$$

30. Consider the two cascaded 2-to-1 multiplexers as shown in the figure.



The minimal sum of products form of the output X is

(a) $\overline{P}\,\overline{Q} + PQR$ (b) $\overline{P}Q + QR$ (c) $PQ + \overline{P}\,\overline{Q}R$ (d) $\overline{Q}\overline{R} + PQR$

Sol. (d) MUX-1 output $\Rightarrow \overline{P}\,(0) + P\,(R) = PR$

MUX-2 output $\Rightarrow X = \overline{Q}\,(\overline{R}) + Q\,(PR) = \overline{Q}\,\overline{R} + PQR$

31. The size of the data count register of a DMA controller is 16 bits. The processor needs to transfer a file of 29,154 kilobytes from disk to main memory. The memory is byte addressable. The minimum number of times the DMA controller needs to get the control of the system bus from the processor to transfer the file from the disk to main memory is ________.

Sol. (456) Data count register gives the number of words the DMA can transfer in a single cycle.

Here, it is 16 bits. So, max 2^{16} words can be transferred in one cycle. Since memory is byte addressable

1 word = 1 byte

So, 2^{16} bytes in 1 cycle

Now, for the given file

File size = 29154KB * 2^{10} B in 1 cylce

DMA transfers 2^{16} B i.e. 1 B transferred by DMA

= $1/2^{16}$ cycles

Now, for full file of size 29154 KB, minimum number of cycles = (29154 * 2^{10} B) / 2^{16} = 455.53

but number of cycles is asked so 455.53 is 456.

32. The stage delays in a 4-stage pipeline are 800, 500, 400 and 300 picoseconds. The first stage (with delay 800 picoseconds) is replaced with a functionally equivalent design involving two stages with respective delays 600 and 350 picoseconds. The throughput increase of the pipeline is________ percent.

Sol. (33.33% increase)

Initial throughput is 1 instruction for 3200 picoseconds

Reason : 4* 800 (here 800 is maximum stage delay of any stage in an instruction so its selected as synchronous clock cycle time).

In the next design, throughput will be 1 instruction for 2400 picoseconds

reason : 4* 600 (here 600 is maximum stage delay of any stage in an instruction, so its selected as synchronous clock cycle time).

Now, increase in throughput is calculated by

$$((1/2400) - (1/3200))/(1/3200) * 100$$

Now, there is an assumption that the pipeline used is synchronous because if asynchronous is used the through put is droped but not increased.

33. Consider a carry lookahead adder for adding two n-bit integers, built using gates of fan-in at most two. The time to perform addition using this adder is

(a) Θ (1) (b) Θ (log (n)) (c) $\Theta(\sqrt{n})$ (d) Θ (n)

Sol. (b) The gates to be used in CLA adder with the fan-in at the most '2'. Time to perform addition using this adder is Θ(log (n)),

34. The following function computes the maximum value contained in an integer array p[] of size n(n >= 1).

```
int max(int *p, int n)
{
  int a=0, b=n-1;
  while(..........)
  {
    if(p[a] <= p[b])
    {
      a = a+1;
    }
    else
    {
      b = b-1;
    }
  }
return p[a];
}
```

The missing loop condition is

(a) a != n (b) b != 0

(c) b > (a + 1) (d) b != a

Sol. (d)

```
#include<iostream>
int max(int *p, int n)
{
  int a=0, b=n-1;
  while(a!=b)
  {
    if(p[a]<=p[b])
    {
      a=a+1;
    }
  else
  {
      b=b-1;
    }
  }
  return p[a];
}
int main()
{
  int arr[]={10,5,1,40,30};
  int n=size of(arr)/size of(arr[0]);
  std::count<<max(arr,5);
}
```

35. What will be the output of the following C program?

```
void count(int n)
{
   static int d=1;
   printf("%d", n);
   printf("%d", d);
   d++;
   if(n>1)
     count(n–1);
   printf("%d", d);
}
void main()
{
   count(3);
}
```

(a) 3 1 2 2 1 3 4 4 4 (b) 3 1 2 1 1 1 2 2 2

(c) 3 1 2 2 1 3 4 (d) 3 1 2 1 1 1 2

Sol. (a) Here d is static, so the value of d will persists between the function calls.

1. count(3) will print the value of n and d and increments d and call count(2) => prints 3 1.
2. count(2) will print the value of n and d and increments d and call count(1) => prints 2 2.
3. count(1) will print the value of n and d and increments d => prints 1 3.

Now, it will return and prints the final incremented value of d which is 4, 3 times. So, output will be printed in solution i.e., 3 1 2 2 1 3 4 4 4

36. What will be the output of the following pseudo-code when parameters are passed by reference and dynamic scoping is assumed?

```
a=3;
void n(x)
{
   x = x * a;
   print(x);
}
void m(y)
{
   a = 1; a = y-a;
   n(a);
   print(a);
}
void main()
{
   m(a);
}
```

(a) 6, 2 (b) 6, 6 (c) 4, 2 (d) 4, 4

Sol. (c) a=1

a= 3 – 1=2

n(2)

{x=2*2=4 print 4} // since dynamic scoping is used

print 2.

37. An operator delete (i) for a binary heap data structure is to be designed to delete the item in the i-th node. Assume that the heap is implemented in an array and i refers to the i-th index of the array. If the heap tree has depth d (number of edges on the path from the root to the farthest leaf), then what is the time complexity to re-fix the heap efficiently after the removal of the element?

(a) $O(1)$

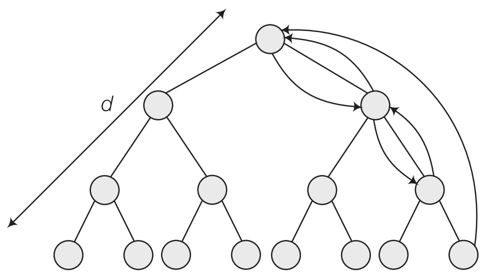
(b) $O(d)$ but not $O(1)$

(c) $O(2^d)$ but not $O(d)$

(d) $O(d2^d)$ but not $O(2^d)$

Sol. (b) Heap is implemented using array. If 'i' is parent element then '$2i$' is left child and '$2i+1$' is right child.

So, if an element is delete from last level of the heap then it will take $O(1)$ time. Since element can be deleted from any level of heap tree is worst case root element is deleted then at every level one element is exchange.



Minimum $O(d)$ time will take if a element is deleted in heap tree but not $O(1)$.

38. Consider the weighted undirected graph with 4 vertices, where the weight of edge $\{i, j\}$ is given by the entry W_{ij} in the matrix W.

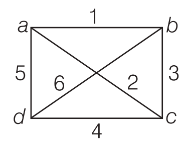
$$W = \begin{bmatrix} 0 & 2 & 8 & 5 \\ 2 & 0 & 5 & 8 \\ 8 & 5 & 0 & x \\ 5 & 8 & x & 0 \end{bmatrix}$$

The largest possible integer value of x, for which at least one shortest path between some pair of vertices will contain the edge with weight x is ________.

Sol. (x =12) Here, when we read the last sentence of the question, i.e. the largest possible integer value of x. when x=11 , shortest path is edge with weight x only. But when x=12, there are 2 shortest paths, and we can say that the edge with weight x is also a shortest path. Atleast 1 shortest path contain edge x. So answer will be 12.

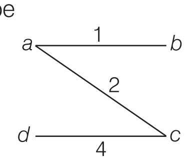
39. Let G be a complete undirected graph on 4 vertices, having 6 edges with weights being 1, 2, 3, 4, 5 and 6. The maximum possible weight that a minimum weight spanning tree of G can have is ________.

Sol. (7) Since graph will be complete graph contain 4 vertex and 6 edges with weigth 1, 2, 3, 4, 5, 6.



If we consider edge weights in such order, that form the cycle, then we have to choose two minimum we choose minimum value i.e., 4.

So MST will be



So, max weight wil be $1+2+4=7$.

40. $G=(V, E)$ is an undirected simple graph in which each edge has a distinct weight, and e is a particular edge of G. Which of the following statements about the minimum spanning trees (MSTs) of G is/are true?

I. If e is the lightest edge of some cycle in G, then every MST of G includes e

II. If e is the heaviest edge of some cycle in G, then every MST of G excludes e

(a) Only I

(b) Only II

(c) Both I and II

(d) Neither I nor II

Sol. (b) **I is NOT true.**

Suppose in a rectangular with sides (1, 2, 4, 5) and 3 is the weight of the diagonal connecting vertex between (4, 5) and (1, 2), here $e = 3$ is the lightest edge of some cycle in G but in MST it is not including. I i am wrong can anyone please explain me why ?

II is true

Let the heavies edge be e. Suppose the minimum spanning tree which contains e. If we add one more edge to the spanning tree we will create a cycle. Suppose we add edge e' to the spanning tree which generated cycle C.

We can reduce the cost of the minimum spanning tree if we choose an edge other than e from C for removal which implies that e must not be in minimum spanning tree and we get a contradiction.

41. Let Q denote a queue containing sixteen numbers and S be an empty stack. Head (Q) returns the element at the head of the queue Q without removing it from Q.

Similarly Top (S) returns the element at the top of S without removing it from S. Consider the algorithm given below.

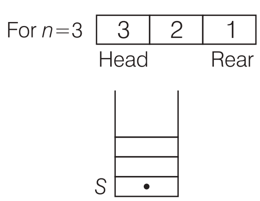
```
while Q is not Empty do
if S is Empty or TOP(S)≤ Head(Q) then,
  x : = Dequeue(Q);
  Push(S, x);
  else
    x : = Pop(s);
    Enqueue(Q, x);
  end
end
```

The maximum possible number of iterations of the while loop in the algorithm is ________.

Sol. (256) The minimum number of iterations of the while loop of algorithm when use take queue contain element in ascending order i.e., 1, 2, 3, 4, …, 16 is 16. The maximum number of iterations of while loop in algorithm when we take queue containing elements in descending order i.e., 16, 15, 14, …, 1.

First 16 will push into stack and then enqueue it in the end of the queue. This process do till we get 1 as head element. When head point to 1 then simple push the 1 in stack. In this manner we have to push all element in stack in ascending order, until queue is empty it will take 256 of iterations.

Example



Sequence of operation with while loop execution.

1. dequeue (3) push (3)
2. pop (3) enqueue (3)
3. dequeue (2) push (2)
4. pop (2) enqueue (2)
5. dequeue (1) push (1)
6. dequeue (3) push (3)
7. pop (3) enqueue (3)
8. dequeue (2) push (2)
9. dequeue (3) push (3)

So, for $n = 3$ it takes $3 \times 3 = 9$ iterations of while loop in algorithm. So, for $n = 16$ it will take $16 \times 16 = 256$ iterations of while loop.

42. Consider the following context free grammars

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

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

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

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

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

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

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

Sol. (d) G_1 : $S \to aS \mid B$

$B \to b \mid bB$

G_2 : $S \to aA \mid bB$

$A \to aA \mid B \mid_{\varepsilon}$

$B \to bB \mid_{\varepsilon}$

G : $B \to b \mid bB \Rightarrow B \to b^{+}$

Now substitute in $S \to aS \mid B$

We get $S \to aS \mid b^{+} \Rightarrow S \to a^{*}\, b^{+}$

So, $L(G_1) = \{a^m b^n \mid m \geq 0 \text{ and } n > 0\}$

$(G_2) = B \to bB\mid_{\varepsilon} \Rightarrow B \to b^{*}$

Substitute in $A \to aA \mid B \mid_{\varepsilon} \Rightarrow A \to aA \mid b^{*} \mid \varepsilon$

$\Rightarrow A \to aA \mid b^{*} \;\Rightarrow\; A \to a^{*} b^{*}$

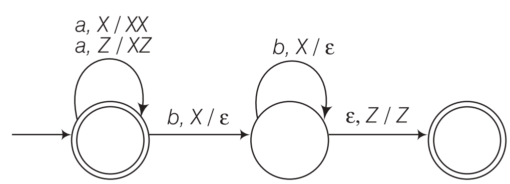
Now substitute A and B in $S \to aA \mid bB$

$\Rightarrow S \to aa^{*} b^{*} \mid bb^{*}$

$S \to aa^{*} b^{*} + bb^{*}$

So, $L(h_2) = \{a^m b^n \mid m > 0 \text{ or } n > 0\}$

43. Consider the transition diagram of a PDA given below with input alphabet $\Sigma = \{a, b\}$ and stack alphabet $r = \{X, Z\}$. Z is the initial stack symbol. Let L denote the language accepted by the PDA.



Which one of the following is true?

(a) $L = \{a^n b^n \mid n \geq 0\}$ and is not accepted by any finite automata

(b) $L = \{a^n \mid n \geq 0\} \cup \{a^n b^n \mid n \geq 0\}$ and is not accepted by any deterministic PDA

(c) L is not accepted by any Turing machine that halts on every input

(d) $L = \{a^n \mid n \geq 0\} \cup \{a^n b^n \mid n \geq 0\}$ and is deterministic context-free

Sol. (a) The first state accepts only null string. Only a's will not be accepted since on first state ε, X will be dead reject.

The third state accept is $\{a^n b^n \mid n \geq 1\}$

So $\quad L = \{\varepsilon\} \cup \{a^n b^n \geq 1\}$

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

Clearly this is a non-regular CFL and hence not accepted by any FA.

44. 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 Y reduces to W, and Z reduces to 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.

Sol. (c) X is recursive language and Y is recursive enumerable language. Y bar reduces to W means - W is not recursive enumerable. Z reduces to X bar means - $\bar{X}$ is recursive hence Z is also recursive as (A is reducible to B) , *i.e.*, solving A cannot be "harder" than solving B.

1. if A is reducible to B, and B is decidable, then A is decidable.
   (i) if A is reducible to B, and B is recursive, then A is recursive.
2. if A is undecidable, and reducible to B, then B is undecidable.
   (i) if A is recursive enumerable, and reducible to B, then B is recursive enumerable.
   (ii) if A is not recursive enumerable, and reducible to B, then B is not recursive enumerable.

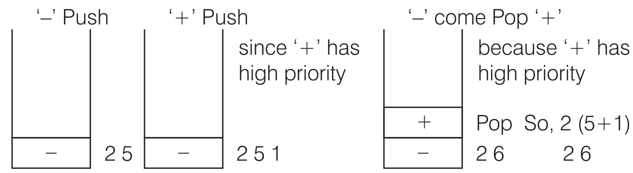
Hence, answer is c Z is not recursive enumerable and Z is recursive.

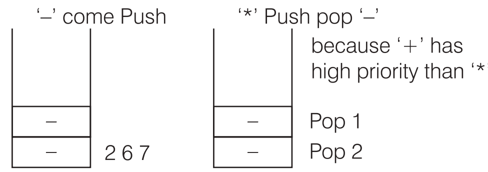
45. The attributes of three arithmetic operators in some programming language are given below.

Operator	Precedence	Associativity	Arity
+	High	Left	Binary
–	Medium	Right	Binary
*	Low	Left	Binary

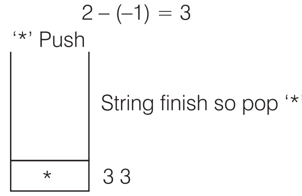
The value of the expression $2 - 5 + 1 - 7 * 3$ in this language is ________.

Sol. (9) Since given expression in infix expression. So we use operator stack $2 - 5 + 1 - 7 * 3$





So, 2 – (6 – 7) ∴ '–' right associative.
2 – (–1) = 3



So, 3 * 3 = 9.
So, 2 – 5 + 1 – 7 * 3 evaluates to 9.

46. Consider the following Syntax Directed Translation Scheme (SDTS), with non-terminals {S, A} and terminals {a, b}.

$S \to aA$ { print 1 }
$S \to a$ { print 2 }
$A \to Sb$ { print 3 }

Using the above SDTS, the output printed by a bottom-up parser, for the input aab is

(a) 1 3 2 (b) 2 2 3 (c) 2 3 1 (d) syntax error

Sol. (c) aab could be derived as follows by the bottom up parser :

$S \to aA$ prints 1
$A \to aSb$ prints 3
$A \to aab$ prints 2

Now, since bottom up parser will work in reverse of right most derivation, so it will print in bottom up fashion i.e., 231 which is option C.

Note that this could also be visualized easily by drawing the derivation tree.

47. Consider a computer system with 40-bit virtual addressing and page size of sixteen kilobytes. If the computer system has a one-level page table per process and each page table entry requires 48 bits, then the size of the per-process page table is ________ megabytes.

Sol. (384 MB) $(2^{20} * 2^6 * 6 \text{ bytes})$

Page table entry size = $4^{8/8}$ = 6 byte

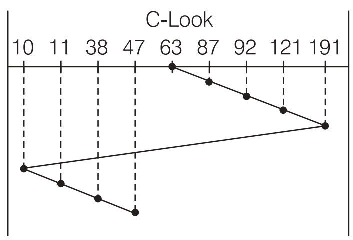
Number of pages = 2^40/2^14 = 2^26

Page size =16 kB = 2^14

Hence, size of per process page table = number of pages×page table entry size = 2^26×6 = 384 MB

48. Consider a disk queue with requests for I/O to blocks on cylinders 47, 38, 121, 191, 87, 11, 92, 10. The C-LOOK scheduling algorithm is used. The head is initially at cylinder number 63, moving towards larger cylinder numbers on its servicing pass. The cylinders are numbered from 0 to 199. The total head movement (in number of cylinders) incurred while servicing these requests is ________.

Sol. (346)



$$\begin{aligned}&(87-63)+(92-87)+(121-92)+(191-121)\\ &\quad+(191-10)+(11-10)+(38-11)+(47-38)\\ &=24+5+29+70+181+1+27+9\\ &=346\end{aligned}$$

49. Consider a computer system with ten physical page frames. The system is provided with an access sequence $\{a_1, a_2, \ldots, a_{20}, a_1, a_2, \ldots, a_{20}\}$, where each a_i is a distinct virtual page number. The difference in the number of page faults between the last-in-first-out page replacement policy and the optimal page replacement policy is ________.

Sol. (1) **LIFO stands for Last In, First Out** a1 to a10 will result in page faults. So, 10 page faults from a1 to a10. Then, a11 will replace a10(last in is a10), a12 will replace a11 and so on till a20, so 10 page faults from a11 to a20 and a20 will be top of stack and a9…a1 are remained as such. Then, a1 to a9 are already there. So, 0 page faults from a1 to a9.

a10 will replace a20, a11 will replace a10 and so on. So, 11 page faults from a10 to a20. So total faults will be 10+10+11 = 31.

Optimal a1 to a10 will result in page faults, So 10 page faults from a1 to a10. Then, a11 will replace a10 because among a1 to a10, a10 will be used later, a12 will replace a11 and so on. So, 10 page faults from a11 to a20 and a20 will be top of stack and a9…a1 are remained as such. Then, a1 to a9 are already there. So, 0 page faults from a1 to a9.

a10 will replace a1 because it will not be used afterwards and so on, a10 to a19 will have 10 page faults.

a20 is already there, so no page fault for a20.

Total faults 10+10+10 = 30.

Difference = 1

50. Consider the following proposed solution for the critical section problem. There are n processes $P_0 \ldots P_{n-1}$. In the code, function *pmax* returns an integer not smaller than any of its arguments. For all i, t[i] is initialised to zero.

```
Code for Pi:
do
{
    c[i]=1;
    t[i]=pmax(t[0],..., t[n-1])+ 1;
    for every j ≠ i in {0, ..., n – 1}
    {
        while(c [j]);
        while(t[j] != 0 && t[j] < t[i]);
    }
    Critical Section;
    t [i] = 0;
Remainder Section;
} while(true) ;
```

Which one of the following is true about the above solution?

(a) At most one process can be in the critical section at any time
(b) The bounded wait condition is satisfied
(c) The progress condition is satisfied
(d) It cannot cause a deadlock

Sol. (a) Consider the critical section point. When a process reaches here, it has c[i] = 1 and all other c values must be 0. This means no other process can be in critical section.

Deadlock is possible, if two processes set c value 1 and this also causes no progress. Starvation is also possible as there is nothing to ensure that a request is granted in a timed manner.

51. Consider the following two phase locking protocol. Suppose a transaction T accesses (for read or write operations), a certain set of objects $\{O_1, \ldots, O_k\}$. This is done in the following manner:

Step I. T acquires exclusive locks to $O_1, \ldots, O_k$ in increasing order of their addresses.

Step II. The required operations are performed.

Step III. All locks are released.

This protocol will

(a) guarantee serializability and deadlock-freedom
(b) guarantee neither serializability nor deadlock- freedom
(c) guarantee serializability but not deadlock-freedom
(d) guarantee deadlock-freedom but not serializability

Sol. (a) 2 PL over objects $O_1 \ldots O_k$

Step I : T acquires exclusive lock to $O_1, \ldots, O_k$ in increasing order of their address.

Step II : The required operations are performed.

Step III : All locks are released.

Because of 2PL it guarantee serializability and objects locks in increasing order of address and all objects locks before read/write which avoids deadlock.

52. Consider that B wants to send a message m that is digitally signed to A. Let the pair of private and public keys for A and B be denoted by K_x^- and K_x^+ for $x = A, B$, respectively. Let $K_x(m)$ represent the operation of encrypting m with a key K_x and $H(m)$ represent the message digest. Which one of the following indicates the correct way of sending the message m along with the digital signature to A?

(a) $\{m, K_B^+(H(m))\}$
(b) $\{m, K_B^-(H(m))\}$
(c) $\{m, K_A^-(H(m))\}$
(d) $\{m, K_A^+(m)\}$

Sol. (b) Digital signature uses private key of the sender to sign digest. So, option B is correct as it is encrypting digest of message $H(m)$ using its private key K-B.

53. An IP datagram of size 1000 bytes arrives at a router. The router has to forward this packet on a link whose MTU (Maximum Transmission Unit) is 100 bytes. Assume that the size of the IP header is 20 bytes.

The number of fragments that the IP datagram will be divided into for transmission is ________.

Sol. (13) IP datagram size = 1000B

MTU = 100B

IP header size = 20B

So, each packet will have 20B header + 80B payload.

Therefore, $80 * 12 = 960$

Now remaining 40B data could be sent in next fragment. So, total 12 +1 = 13 fragments.

54. For a host machine uses the token bucket algorithm for congestion control, the token bucket has a capacity of 1 megabyte and the maximum output rate is 20 megabytes per second. Tokens arrive at a rate to sustain output at a rate of 10 megabytes per second. The token bucket is currently full and the machine needs to send 12 megabytes of data. The minimum time required to transmit the data is ________ seconds.

Sol. (1.1 sec) Initially, token bucket is full. The rate at which it is emptying is $(20-10)$ Mbps. Time take to empty token bucket of 1 mb is 1/10 i.e 0.1 sec data send in this time is $0.1 * 20 = 2$ mb. Data left to send is $12 - 2 = 10$ mb . Now, bucket is empty and rate of token arriving is less than that of going out so effective data speed will be 10Mbps. Time to send remaining 10 mb will be 1 sec. So total time is 1+0.1=1.1 sec

55. A sender uses the Stop-and-Wait ARQ protocol for reliable transmission of frames. Frames are of size 1000 bytes and the transmission rate at the sender is 80 Kbps (1 Kbps = 1000 bits/second).

Size of an acknowledgement is 100 bytes and the transmission rate at the receiver is 8 Kbps. The one-way propagation delay is 100 milliseconds.

Assuming no frame is lost, the sender throughput is ________ bytes/second.

Sol. (2500 bytes per second) Throughput is number of bytes we are able to send per second.

Calculate the transmission time of sender Tt_Send, calculate one way propogation delay Tp, Calculate the transmission time of receiver Tt_Recv. We get Tt_Send here as 1/10 seconds , Tp as 1/10 seconds(given in question as 100 ms) , Tt_Recv as 1/10 seconds. So , total time taken to send a frame from sender to destination = Tt_Send + 2 * Tp + Tt_Recv = 4/10 seconds

So, we can send 1000 bytes (frame size) in 4/10 seconds. So in 1 second, we can send 2500 bytes. So throughput is 2500 bytes per second.

Number of bytes is $\frac{4}{10}s = 1000$ bytes

1000 bytes in 1/10 second then in 1 second

$$= 1000 \times \frac{10}{4} \text{ bytes}$$

$$= 2500 \text{ bps.}$$

General Aptitude (GA) Questions

(1 *Mark Questions*)

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

(a) I will not leave the place until the minister does not meet me

(b) I will not leave the place until the minister doesn't meet me

(c) I will not leave the place until the minister meet me

(d) I will not leave the place until the minister meets me

Sol. (d) Not is already embedded in until. So, A and B are incorrect.

Also, the minister is a single person, and with a singular subject, singular verb follow s(ending in 's').

Thus, C is incorrect and D is the right answer.

57. A rewording of something written or spoken is a ________.

(a) paraphrase (b) paradox
(c) paradigm (d) paraffin

Sol. (a) Paraphrase – To express something in different words, so that it becomes easy for the listener to understand.

Paradox – A statement which sounds logical, but proves to be illogical when investigated.

Paradigm – A way of looking or thinking (perception) about something.

Paraffin – A flammable substance used in candles, polishes, etc.

58. Archimedes said, "Give me a lever long enough and a fulcrum on which to place it, and I will move the world."

The sentence above is an example of a ________ statement.

(a) figurative (b) collateral
(c) literal (d) figurine

Sol. (a)

59. If 'relftaga' means carefree, 'otaga' means careful and 'fertaga' means careless, which of the following could mean 'aftercare'?

(a) zentaga (b) tagafer
(c) tagazen (d) relffer

Sol. (c) 'taga' and 'care' are a matching pair in every combination.

So, 'taga' surely represents 'care'.

Also, note here that the second half of the word in encoded value refers to the first half of the word in the decoded value.

So, 'fer' represents 'less', 'relf' represents 'free' and 'o' represents 'full'.

Going by the same logic, the answer would be tagazen, i.e., C.

60. A cube is built using 64 cubic blocks of side one unit. After it is built, one cubic block is removed from every corner of the cube. The resulting surface area of the body (in square units) after the removal is ________ .

(a) 56 (b) 64
(c) 72 (d) 96

Sol. (d) Original surface area = $6(4)^2 = 96$

If corner cubes are removed, three exposed surfaces are removed which will create 3 new surfaces in original large cube. So surface area will remain unchanged, i.e. 96

(2 Marks Questions)

61. A shaving set company sells 4 different types of razors, Elegance, Smooth, Soft and Executive. Elegance sells at ₹ Smooth at ₹ 63, Soft at ₹ 78 and Executive at ₹ 173 per piece. The table below shows the numbers of each razor sold in each quarter of a year.

Quarter / Product	Elegance	Smooth	Soft	Executive
Q1	27300	20009	17602	9999
Q2	25222	19392	18445	8942
Q3	28976	22429	19544	10234
Q4	21012	18229	16595	10109

Which product contributes the greatest fraction to the revenue of the company in that year?

(a) Elegance (b) Executive
(c) Smooth (d) Soft

Sol. (b) Revenue from Elegance

$= (27300+25222+28976+21012) \times ₹\ 48$

$= ₹\ 4920480$

Revenue from Smooth

$= (20009+19392+22429+18229) \times ₹\ 63$

$= ₹\ 5043717$

Revenue from Soft

$= (17602+18445+19544+16595) \times ₹\ 78$

$= ₹\ 5630508$

Revenue from Executive

$= (9999+8942+10234+10109) \times ₹\ 173$

$= ₹\ 6796132$

Total Revenue = ₹ 22390837

Fraction of Revenue for Elegance = 0.219

Fraction of Revenue for Smooth = 0.225

Fraction of Revenue for Soft = 0.251

Fraction of Revenue for Executive = 0.303

Which is highest for B (executive).

62. Indian currency notes show the denomination indicated in at least seventeen languages. If this is not an indication of the nation's diversity, nothing else is.

Which of the following can be logically inferred from the above sentences?

(a) India is a country of exactly seventeen languages
(b) Linguistic pluralism is the only indicator of a nation's diversity
(c) Indian currency notes have sufficient space for all the Indian languages
(d) Linguistic pluralism is strong evidence of India's diversity

Sol. (d) A is incorrect as it cannot be inferred that exactly 17 languages are there, because the statement says that there are atleast 17 languages on the currency note.

B is incorrect because of the word 'only' in the option, which is too strong to be inferred.

C is incorrect as it says 'space for all Indian languages', but the number of languages in India is not mentioned in the question.

D is correct as it can be easily inferred from the statement.

63. Consider the following statements relating to the level of poker play of four players P, Q, R and S.

I. P always beats Q

II. R always beats S

III. S loses to P only sometimes

IV. R always loses to Q

Which of the following can be logically inferred from the above statements?

(i) P is likely to beat all the three other players

(ii) S is the absolute worst player in the set

(a) Only I

(b) Only II

(c) I and II

(d) Neither I nor II

Sol. (a) P is likely to beat all the three other players as P always beats Q, which always beats R, which always beats S. So, (i) can be inferred from the given statements.

All three can beat S, but S loses to P only sometimes. So, (ii) can not be inferred from the given statements.

Thus, *a* is correct answer.

64. If $f(x) = 2x^7 + 3x - 5$, which of the following is a factor of $f(x)$?

(a) $(x^3 + 8)$ (b) $(x - 1)$

(c) $(2x - 5)$ (d) $(x + 1)$

Sol. (b) $f(x) = 2x^7 + 3x - 5$

Use option (b), if $(x-1)$ will be a factor then on putting $x - 1 = 0$, i.e. $(x = 1)$ in $f(x)$.

$$f(1) = 2(1)^7 + 3 - 5$$
$$= 5 - 5 = 0$$

65. In a process, the number of cycles to failure decreases exponentially with an increase in load. At a load of 80 units, it takes 100 cycles for failure. When the load is halved, it takes 10000 cycles for failure. The load for which the failure will happen in 5000 cycles is ________.

(a) 40.00 (b) 46.02

(c) 60.01 (d) 92.02

Sol. (b)