Detailed Analysis of GATE 2016 Papers

GATE CSIT Solved Paper 2016 (Set 1) Detailed Analysis

Subject	Topic	1 Mark Questions	2 Marks Questions	Total Questions	Total Marks
General Aptitude	Numerical Ability	2	4	6	10
	Verbal Ability	3	2	5	5
Total Marks					**15**
Engineering Maths	Discrete Maths	2	3	5	8
	Calculus	1	-	1	1
	Probability	1	1	2	3
	Linear Algebra	1	-	1	1
Total Marks					**13**
Digital	Number System				
	Boolean Algebra	1		1	1
	Combinational Circuit		1	1	2
	Sequential Circuits	1		1	1
Total Marks					**4**
Computer Organization	Machine instructions, Addressing modes and number representation	1		1	1
	ALU and Data Path, CPU Control Design				
	Memory Interface, I/O Interface		1	1	2
	Instruction Pipelining		1	1	2
	Cache and Main Memory, Secondary Storage	1		1	1
Total Marks					**6**
Programming & Data Structures	C Programming		1	1	2
	Functions	1	2	3	5
	Pointers & Structures	1		1	1
	Stacks, Queues & Linked lists		2	2	4
	Trees and Heaps				
	Graphs				
Total Marks					**12**
Algorithms	Asymptotic analysis	1	2	3	5

	Divide & Conquer strategy				
	Greedy design Technique				
	Dynamic programming				
	Sorting and Searching	2		2	2
	Graph search, Spanning trees and Shortest paths	1	3	4	7
Total Marks					**14**
Theory of Computation	Finite Automata & Regular languages	2		2	2
	Context-free languages & Push down Automata		2	2	4
	Recursive enumerable sets, Turing machines and decidability	1	1	2	3
Total Marks					**9**
Compiler design	Lexical analysis & parsing				
	Syntax directed translation		1	1	2
	Intermediate code generation				
	Code optimization	1		1	1
Total Marks					**3**
Operating Systems	Processes, Threads and CPU scheduling	1		1	1
	Process Synchronization		1	1	2
	Deadlocks				
	Memory management and Virtual memory		2	2	4
	File systems		1	1	2
Total Marks					**9**
Databases	ER model, Relational model				
	Normalization	1		1	1
	Relational algebra				
	SQL	1		1	1
	Transactions & Concurrency management	1	1	2	3
	File Organization				
Total Marks					**5**
Computer Networks	OSI Layers and LAN Technologies	1	1	2	3
	Routing Algorithms and application layer protocols	1		1	1

	TCP/UDP		1	1	2
	IP(V4), IPV6 and wireless networks		1	1	2
	Network Security		1	1	2
Total Marks					**10**

GATE CSIT Solved Paper 2016 (Set 2) Detailed Analysis

Subject	Topic	1 Mark Questions	2 Marks Questions	Total Questions	Total Marks
General Aptitude	Numerical Ability	3	3	6	9
	Verbal Ability	2	2	4	6
Total Marks					**15**
Engineering Maths	Discrete Maths	3	3	6	9
	Probability	1	-	1	1
	Linear Algebra	2	1	3	4
Total Marks					**14**
Digital	Number System				
	Boolean Algebra	1		1	1
	Combinational Circuit	1		1	1
	Sequential Circuits				
Total Marks					**2**
Computer Organization	Machine instructions, Addressing modes and number representation	2	1	3	4
	ALU and Data Path, CPU Control Design		1	1	2
	Memory Interface, I/O Interface				
	Instruction Pipelining		1	1	2
	Cache and Main Memory, Secondary Storage		2	2	4
Total Marks					**12**
Programming & Data Structures	C Programming		1	1	2
	Functions	1	1	2	3
	Pointers & Structures				
	Stacks, Queues & Linked lists		3	3	6
	Trees and Heaps				
	Graphs				
Total Marks					**11**

Algorithms	Asymptotic analysis	1	2	3	5
	Divide & Conquer strategy				
	Greedy design Technique				
	Dynamic programming	1	1	2	3
	Sorting and Searching	1		1	1
	Graph search, Spanning trees and Shortest paths	1		1	1
Total Marks					**10**
Theory of Computation	Finite Automata & Regular languages	2	1	3	4
	Context-free languages & Push down Automata		1	1	2
	Recursive enumerable sets, Turing machines and decidability	1	1	2	3
Total Marks					**9**
Compiler design	Lexical analysis & parsing	1	2	3	5
	Syntax directed translation				
	Intermediate code generation				
	Code optimization				
Total Marks					**5**
Operating Systems	Processes, Threads and CPU scheduling		1	1	2
	Process Synchronization		2	2	4
	Deadlocks				
	Memory management and Virtual memory	1		1	1
	File systems				
Total Marks					**7**
Databases	ER model, Relational model		1	1	2
	Normalization				
	Relational algebra	1	1	2	3
	SQL				
	Transactions & Concurrency management	1		1	1
	File Organization				
Total Marks					**6**

Computer Networks	OSI Layers and LAN Technologies	1	2	3	5
	Routing Algorithms and application layer protocols	1		1	1
	TCP/UDP				
	IP(V4), IPV6 and wireless networks		1	1	2
	Network Security	1		1	1
Total Marks					**9**

GATE 2016 Solved Paper
CSIT: Computer Science and Information Technology
Set – I

Number of Questions: 65 **Total Marks:100.0**

Wrong answer for MCQ will result in negative marks, (–1/3) for 1 Mark Questions and (–2/3) for 2 Marks Question.

General Aptitude

Number of Questions: 10 **Section Marks: 15.0**

Question 1 to Question 5 carry 1 mark each and Question 6 to Question 10 carry 2 marks each.

Question Number: 1 **Question Type: MCQ**

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

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

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

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

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

Solution: The use of does not and doesn't after until is redundant therefore options (A) and (B) are incorrect. Option (C) is also incorrect because the verb 'meet' does not agree with the singular noun minister.

Hence the correct option is (D).

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

A rewording of something written or spoken is a _____.

(A) paraphrase (B) paradox

(C) paradigm (D) paraffin

Solution: Hence the correct option is (A)

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

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

The above sentence is an example of a ____ statement.

(A) figurative (B) collateral

(C) literal (D) figurine

Solution: To create a particular mental picture the words lever and fulcrum are used in a way that is different from the usual meaning in order.

Hence the correct option is (A).

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

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

(A) zentaga (B) tagafer

(C) tagazen (D) relffer

Solution: Hence the correct option is (C).

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

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

(A) 56 (B) 64 (C) 72 (D) 96

Solution: The total surface area of the body after the 8 unit cubes are removed, is

$$= 6 \times 16 = 96.$$

Hence the correct option is (D).

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

A shaving set company sells 4 different types of razors, elegance, smooth, soft and executive. Elegance sells at Rs. 48, smooth at Rs. 63, soft at Rs.78 and executive at Rs. 173 per price. The table below shows the numbers of each razor sold in each quarter of a year.

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

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

(A) Elegance (B) Executive

(C) Smooth (D) Soft

Solution: If the numbers of razors are divided by 1000 the date is shown below

Quarter	El	Sm	Sf	Ex
Q1	27	20	18	10
Q2	25	19	18	9
Q3	29	22	20	10
Q4	21	18	17	10
Total	102	79	73	39
Rate	48	63	78	173
Revenue	4896	4977	5694	6747

Executive is the product that contributes the greatest amount from the table given above.

Hence the correct option is (B).

Question Number: 7 Question Type: MCQ

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

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

(A) India is a country of exactly seventeen languages.

(B) Linguistic pluralism is the only indicator of a nation's diversity.

(C) Indian currency notes have sufficient space for all the Indian languages.

(D) Linguistic pluralism is a strong evidence of India's diversity.

Solution: According to the statement nothing else, apart from the currency note, can represent the diversity better. Hence, (D) can be inferred.

Hence, the correct option is (D).

Question Number: 8 Question Type: MCQ

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

I. P always beats Q

II. R always beats S

III. S loses to P only sometimes

IV. R always loses to Q

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

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

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

(A) (i) only

(B) (ii) only

(C) (i) and (ii)

(D) neither (i) nor (ii)

Solution: Consider the statements (i) and (ii)

(ii) definitely cannot be inferred

(i) As S loses to P only sometimes, it is not likely that P beats S. Therefore,

(i) too cannot be inferred.

Hence, the correct option is (D).

Question Number: 9 Question Type: MCQ

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

(A) $(x^3 + 8)$ (B) $(x - 1)$

(C) $(2x - 5)$ (D) $(x + 1)$

Solution: The given function is

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

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

$\Rightarrow$ $x - 1$ is a factor of $f(x)$

The other expressions are not factors.

Hence, the correct option is (B).

Question Number: 10 Question Type: MCQ

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

(A) 40.00 (B) 46.02

(C) 60.01 (D) 92.02

Solution: Let the load be x and the number of cycles to failure be y. As y decreases exponentially with x

$$y = \frac{k}{a^x} \quad (1)$$

$\Rightarrow$ $ya^x = k$

$\Rightarrow$ $\log y + x \log a = \log k$

For $x = 40$, $y = 10^4$ and for $x = 80$, $y = 10^2$

$\therefore$ $\log 10^4 + 40 \log a = \log 10^2 + 80 \log a$

$\Rightarrow$ $\frac{4-2}{40} = \log a \Rightarrow a = 10^{\frac{1}{20}}$

From (1), $y = \dfrac{k}{10^{\frac{x}{20}}}$ As $y = 10^4$ for $x = 40$, it follows that $k = 10^6$

Therefore from (1),

$$y = \frac{10^6}{10^{\frac{x}{20}}}$$

If $y = 5000$, $10^{\frac{x}{20}} = \dfrac{10^6}{5000} = 200$

$\Rightarrow \quad \dfrac{x}{20} = \log 200 = 2.3010$

$\Rightarrow \quad x = 46.02.$

Hence, the correct option is (B).

Computer Science and Information Technology

Number of Questions: 55 **Section Marks: 85.0**

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

Question Number: 11 **Question Type: NAT**

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

$p : x \in \{8,9,10,11,12\}$

$q : x$ is a composite number

$r : x$ is a perfect square

$s : x$ is a prime number

The integer $x \geq 2$ which satisfies

$$\neg ((p \Rightarrow q) \wedge (\neg r \vee \neg s)) \text{ is } \_\_\_\_.$$

Solution:

$$\therefore \quad \neg[(p \Rightarrow q) \wedge (\neg r \vee \neg s)]$$
$$\equiv \neg[(\neg p \vee q) \wedge (\neg r \vee \neg s)]$$
$$\equiv \neg(\neg p \vee q) \vee \neg(\neg r \vee \neg s)$$
$$\equiv (p \wedge \neg q) \vee (r \wedge s)$$

$\therefore$ The value of x that satisfies the above proposition is 11 only.

Hence, the correct Answer is (11).

Question Number: 12 **Question Type: MCQ**

Let a_n be the number of n-bit strings that do not contain two consecutive 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) $a_n = 2a_{n-1} + 2a_{n-2}$

Solution: $a_1 = 0, 1$ (2 strings)

$a_2 = 00, 01, 10$ (3 strings)

$a_3 = 000, 001, 010, 100, 101$ (5 strings)

$a_3 = a_2 + a_1 = 2 + 3 = 5$ strings

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

Hence, the correct option is (B).

Question Number: 13 **Question Type: NAT**

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

Solution: $\lim\limits_{x \to 4} \dfrac{\sin(x-4)}{x-4} = \lim\limits_{(x-4) \to 0} \dfrac{\sin(x-4)}{x-4} = 1$

$$\left(\because \lim_{\theta \to 0} \frac{\sin\theta}{\theta} = 1\right)$$

Hence, the correct Answer is (1).

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

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

Solution: $f(x) = \begin{cases} \dfrac{1}{x^2}; x \in [a,1] \\ 0 \quad ; \text{otherwise} \end{cases}$

As $f(x)$ is a probability density function,

We have

$$\int_{-\infty}^{\infty} f(x)\,dx = 1$$

$\Rightarrow \quad \displaystyle\int_a^1 \frac{1}{x^2}\,dx = 1$

$\Rightarrow \quad \left.\dfrac{-1}{x}\right]_a^1 = 1$

$\Rightarrow \quad -1 + \dfrac{1}{a} = 1$

$\Rightarrow \quad a = \dfrac{1}{2} = 0.5.$

Hence, the correct Answer is (0.5).

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

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

Solution: As $2+\sqrt{-1}$ is an Eigen value of P, $2-\sqrt{-1}$ is also an Eigen value of P.

The determinant of $P \equiv |P|$

= Product of the Eigen vales of P

$$= \left(2+\sqrt{-1}\right)\left(2-\sqrt{-1}\right) \times 3 = 15.$$

Hence, the correct Answer is (15).

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

Consider the Boolean operator # with the following properties:

$$x \# 0 = x, x \# 1 = \bar{x}, x \# x = 0$$

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) $x\,y + \bar{x}\,\bar{y}$

Solution: $x \# 0 = x$

$$x \# 1 = x'$$

$x \# x = 0$, $x \# x' = 1$, by observing, # operation is XOR

so $$x \# y = x'y + xy'$$

Hence, the correct option is (A).

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

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

Solution: We know that 2's complement representation is 1111 1111 1111 0101.

By looking at MSB, we can understand it is negative number (MSB = 1), so by taking the 2's complement we will get positive number.

2's complement of given number is 0000 0000 0000 1011.

Its decimal equivalent is 11.

So given number is –11.

Hence, the correct Answer is (–11).

Question Number: 18 **Question Type: MCQ**

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

Solution: For 6 states we require 3-flipflops. Therefore, the minimum number of J-K flip-flops required to implement this counter is 3.

Hence, the correct Answer is (3).

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

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

Solution: 1 word = 2 Bytes = 2×8 bits

= 16 - bits

Number of words in memory

$$= \frac{4 \times 2^{30} \times 2^3}{16}$$

$$= 2 \times 2^{30} = 2^{31}$$

The size of the address bus of the processor is at least 31 - bit length.

Hence, the correct Answer is (31).

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

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

(A) Both operations can be performed in O(1) time.

(B) At most one operation can be performed in O(1) time but the worst case time for the other operation will be $\Omega(n)$.

(C) The worst case time complexity for both operations will be $\Omega(n)$.

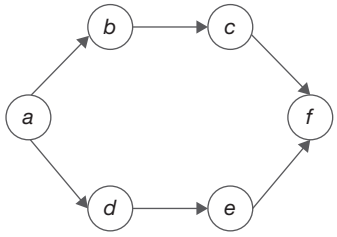
(D) Worst case time complexity for both operations will be $\Omega(\log n)$.

Solution: We know that Enqueue and Dequeue operations always take one unit of time. Thus Both operations can be performed in O(1) time.

Hence, the correct option is (A).

Question Number: 21 **Question Type: NAT**

Consider the following directed graph:



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

Solution: '*a*' and '*f*' are fixed in first and last positions respectively.

Possible topological orderings are given below:

(1) *a* *b* *c* *d* *e* *f*
(2) *a* *d* *e* *b* *c* *f*
(3) *a* *b* *d* *c* *e* *f*
(4) *a* *b* *d* *e* *c* *f*
(5) *a* *d* *b* *c* *e* *f*
(6) *a* *d* *b* *e* *c* *f*

Hence, the correct Answer is (6).

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

Consider the following C program.

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

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

(A) f (s,*s) (B) i = f (i,s)
(C) f (i,*s) (D) f (i,*p)

Solution: As per the program given in question the function prototype is void and its arguments are int, short with return type as void.

Hence f(i, *p) matches with the arguments.

Hence, the correct option is (D).

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

The worst case running times of *Insertion sort, Merge sort* and *Quick sort,* respectively are:

(A) $\Theta(n \log n)$, $\Theta(n \log n)$, and $\Theta(n^2)$
(B) $\Theta(n^2)$, $\Theta(n^2)$ and $\Theta(n \log n)$
(C) $\Theta(n^2)$, $\Theta(n \log n)$ and $\Theta(n \log n)$
(D) $\Theta(n^2)$, $\Theta(n \log n)$ and $\Theta(n^2)$

Solution: We know that the worst case running time of insertion sort is $\theta(n^2)$ and of merge sort is $\theta(n \log n)$ and of quick sort is $\theta(n^2)$.

Hence, the correct option is (D).

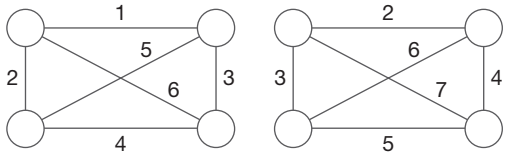
Question Number: 24 **Question Type: MCQ**

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

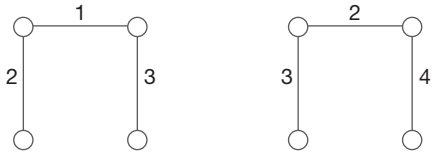
P: Minimum spanning tree of *G* does not change.
Q: Shortest path between any pair of vertices does not change.

(A) P only (B) Q only
(C) Neither P nor Q (D) Both P and Q

Solution: Let us consider a graph *G*

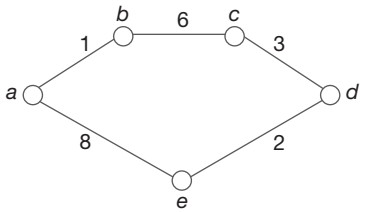


Spanning tree **Spanning tree**



∴ P is TRUE

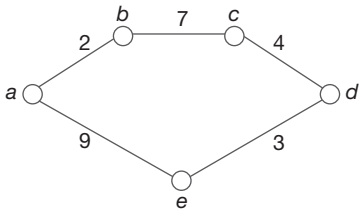
Q



Shortest path:

$$a - b - c - d$$

$$1 + 6 + 3 = 10$$



Shortest path:

$$a - e - d$$

$$9 + 3 = 12$$

Q is false.

Hence, the correct option is (A).

Question Number: 25 Question Type: NAT

Consider the following C program.

```
# include<stdio.h>
void mystery (int *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 _____.

Solution: The value of "*a*" will be 2016 because the routine mystery ( ) is manipulating with the addresses of variables and the values of variables *a*, *b*, *c*, *d* are not changing.

Hence, the correct Answer is (2016).

Question Number: 26 Question Type: MCQ

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

Solution: Consider some string derivations from given grammar:

$$S \to \in$$
$$S \to aS$$
$$S \to a$$
$$S \to bS$$
$$\to b$$
$$S \to aS$$
$$\to abS$$
$$\to ab$$
$$S \to bS$$
$$\to baS$$
$$\to ba$$
$$S \to aS$$
$$\to abS$$
$$\to abaS$$
$$\to aba.$$

The strings generated by given grammar are

$$\{\in, a, b, ab, ba, aba\ldots\}$$

As per the above strings we can conclude that the language is $\{a, b\}^*$

Hence, the correct option is (D).

Question Number: 27 Question Type: MCQ

Which of the following decision problems are not decidable?

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 CFG's G_1 and G_2, is

$$L(G_1) = L(G_2)?$$

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

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

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

Solution:

I. This decision problem is empty is decidable.

II. This decision problem is decidable.

III. This decision problem is not decidable.

IV. This decision problem is not decidable.

Therefore, decision problems III and IV are not decidable.

Hence, the correct option is (C).

Question Number: 28 Question Type: MCQ

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

(A) $(0+1)^*\,0011\,(0+1)^* + (0+1)^*\,1100\,(0+1)^*$

(B) $(0+1)^*\,(00(0+1)^*11 + 11\,(0+1)^*00)\,(0+1)^*$

(C) $(0+1)^*\,00\,(0+1)^* + (0+1)^*\,11\,(0+1)^*$

(D) $00\,(0+1)^*\,11 + 11\,(0+1)^*\,00$

Solution:

(A) $(0+1)^*0011(0+1)^* + (0+1)^*1100(0+1)^*$
The above regular expression accepts the strings which has 0011 or 1100 as substrings. This does not accept strings of the form 001010111.

(B) $(0+1)^*(00(0+1)^*11 + 11(0+1)^*00)(0+1)^*$
The above regular expression accepts all the strings having two consecutive 0's and two consecutive 1's.

(C) $(0+1)^*00(0+1)^* + (0+1)^*11(0+1)^*$
The above regular expression accepts the strings which have either 00 or 11 as sub strings.

(D) $00(0+1)^*11 + 11(0+1)^*00$
The above regular expression accepts the strings which starts with 00 or 11 and ends with 11 or 00 respectively.

Hence, the correct option is (B).

Question Number: 29 Question Type: NAT

Consider the following code segment.

$x = u - t;$

$y = x * v;$

$x = y + w;$

$y = t - z;$

$y = x * y;$

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

Solution: An intermediate representation that facilitates certain code optimizations is known as Static single assignment form (SSA). All the assignment in SSA is variables with distinct names.

	SSA
$x = u - t;$	$x_1 = u - t;$
$y = x * v;$	$y_1 = x_1 * v;$
$x = y + w;$	$x_2 = y_1 + w;$
$y = t - y;$	$t_2 = t - y_1;$
$y = x * y;$	$y_3 = x_2 * t_2;$

From the above equations we conclude that total 10 variables $x_1, y_1, x_2, t_2, y_3, u, t, v, w$, and y are used.

Hence, the correct Answer is (10).

Question Number: 30 Question Type: MCQ

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

(A) Shortest remaining time first.

(B) Round - robin with time quantum less than the shortest CPU burst.

(C) Uniform random.

(D) Highest priority first with priority proportional to CPU burst length.

Solution: Shortest remaining time first would minimize the average waiting time in the ready queue because in CPU scheduling, the scheduling policy-shortest job first will give a minimal average turn around time, minimal waiting time and high throughput.

Hence, the correct option is (A).

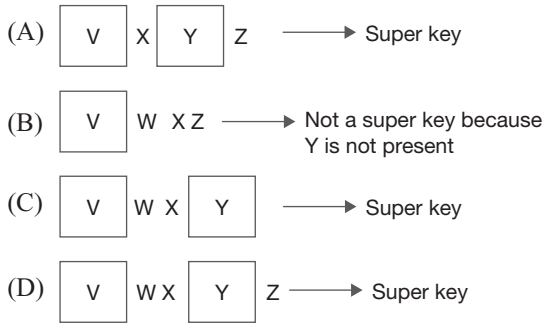
Question Number: 31 Question Type: MCQ

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

(A) V XYZ (B) V WXZ

(C) V WXY (D) V WXYZ

Solution: Primary key = VY therefore for a superkey both V and Y should be present in relation schema. Considering all the options we get



Hence, the correct option is (B).

Question Number: 32 Question Type: MCQ

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

(A) Atomicity

(B) Consistency

(C) Isolation

(D) Deadlock-freedom

Solution: Deadlock-freedom is not a part of the ACID properties of database transactions because the acid properties are atomicity, consistency, isolation and durability.

Hence, the correct option is (D).

Question Number: 33 Question Type: MCQ

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

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

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

(VOLUME, NUMBER, STARTPAGE, ENDPAGE) → TITLE

(VOLUME, NUMBER) → YEAR

(VOLUME, NUMBER,

STARTPAGE, ENDPAGE) → PRICE

The database is redesigned to use the following schemas.

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

(VOLUME, NUMBER, YEAR)

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

(A) 1NF (B) 2NF

(C) 3NF (D) BCNF

Solution:

Old database:

Primary key = (Volume, Number, Start page, End page)

Volume, Number, Startpage, Endpage → Title

(Fully dependency)

Volume, Number → Year (Partial dependency)

Volume, Number, Start page, End page → Price

(Full dependency)

Old database does not satisfy 2NF because it has partial dependency.

New database:

(Volume, Number, Start page, End page, Title, Price)

(Volume, Number, Year)

All three given functional dependencies satisfy second normal form.

Hence, the correct option is (B).

Question Number: 34 Question Type: MCQ

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

(A) DNS (B) ARP

(C) DHCP (D) RARP

Solution: DHCP is a client/server protocol that automatically provides an IP host with its IP address and other related configuration information. Therefore, this is the protocol which is not used to resolve one form of address to another one.

Hence, the correct option is (C).

Question Number: 35 Question Type: MCQ

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

(i) HTTP (ii) FTP

(iii) TCP (iv) POP3

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

(C) (ii) and (iv) only (D) (iv) only

Solution: .

TCP is transport layer protocol.

HTTP is stateless protocol.

FTP is stateful protocol

POP3 is stateful protocol.

Hence, (ii) and (iv) are stateful application layer protocols.

Hence, the correct option is (C).

Question Number: 36 **Question Type: NAT**

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

Solution:

$$(x^3 + x^4 + x^5 + \ldots)^3 = [x^3(1 + x + x^2 + \ldots)]^3$$
$$= x^9 (1 + x + x^2 + \ldots..)^3$$
$$= x^9 . \frac{1}{(1-x)^3}$$
$$= x^9 . \sum_{r=0}^{\infty} C(3-1+r, r) x^r$$
$$= x^9 \sum_{r=0}^{\infty} C(r+2, r) x^r$$
$$= x^9 [C(2, 0) x^0 + C(3, 1) x^1 + C(4, 2)x^2 + C(5, 3) x^3 + \ldots]$$
$$= x^9 + 3x^{10} + 6x^{11} + 10x^{12} + \ldots$$

From the above expression the coefficient of x^{12} in $(x^3 + x^4 + x^5 + \ldots)^3$ is 10.

Hence, the correct Answer is (10).

Question Number: 37 **Question Type: NAT**

Consider the recurrence relation $a_1 = 8$, $a_n = 6n^2 + 2n + a_{n-1}$. Let $a_{99} = K \times 10^4$. The value of K is _____.

Solution: The given relation is

$$a_n = 6n^2 + 2n + a_{n-1} \quad (1)$$

Where $a_1 = 8$

Using (1), we get

$$a_2 = 6 \times 2^2 + 2 \times 2 + a_1$$
$$a_3 = 6 \times 3^2 + 2 \times 3 + a_2$$
$$= 6 \times 3^2 + 2 \times 3 + 6 \times 2^2 + 2 \times 2 + a_1$$
$$= 6 \times (2^2 + 3^2) + 2 \times (2 + 3) + a_1$$
$$a_4 = 6 \times 4^2 + 2 \times 4 + a_3$$
$$= 6 \times 4^2 + 2 \times 4 + 6 \times (2^2 + 3^2) + 2 \times (2 + 3) + a_1$$
$$= 6 \times (2^2 + 3^2 + 4^2) + 2 \times (2 + 3 + 4) + a_1$$

And

$$a_n = 6 \times (2^2 + 3^2 + 4^2 + \ldots + n^2) + 2 \times (2 + 3 + 4 + \ldots + n) + a_1$$
$$= 6 \times [(1^2 + 2^2 + 3^2 + \ldots + n^2) - 1^2] + 2 \times [(1 + 2 + 3 + \ldots + n) - 1] + a_1$$
$$= 6 \Sigma n^2 - 6 \times 1^2 + 2 \Sigma n - 2 \times 1 + a_1$$
$$= 6\left(\frac{n(n+1)(2n+1)}{6}\right) - 6 + 2\left(\frac{n(n+1)}{2}\right) - 2 + a_1$$
$$= (2n^3 + 3n^2 + n) + (n^2 + n) - 8 + 8$$
$$= 2n^3 + 4n^2 + 2n$$
$$\therefore a_n = 2n (n + 1)^2 \quad (2)$$

We know that

$$a_{99} = k \times 10^4$$

i.e. $2 \times 99 \times (99 + 1)^2 = k \times 10^4$ (from (2))

$\Rightarrow$ $198 \times 100^2 = k \times 10^4$

$\Rightarrow$ $198 \times 10^4 = k \times 10^4$

$\Rightarrow$ $k = 198$

Hence, the correct Answer is (197.9 : 198.1).

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

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

$f(n) = f(n/2)$ if n is even

$f(n) = f(n+5)$ if n is odd

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

Solution: From the definition of $f(n)$ it can be observed that,

$$f(1) = f(2) = f(3) = f(4) = f(6) = f(7) = f(8) = f(9)$$
$$= f(11) = f(12) = f(13) = f(14) = f(16) = \ldots$$

and $f(5) = f(10) = f(15) = f(20)$

The maximum possible size of $R = \{i / \exists j$: $f(j) = i\}$ is 2.

Hence, the correct Answer is (2).

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

Consider the following experiment.

Step 1. Flip a fair coin twice.

Step 2. If the outcomes are (TAILS, HEADS) then output Y and stop.

Step 3. If the outcomes are either (HEADS, HEADS) or (HEADS, TAILS), then output N and stop.

Step 4. If the outcomes are (TAILS, TAILS), then go to Step 1.

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

Solution: If A = Getting the output Y then

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

If B = Getting the output other than Y and N then

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

The possible events that are favourable for getting the output Y are

$$A, B \cap A, B \cap B \cap A, \ldots\ldots.$$

The probability of getting the output Y

$$= P[A \cup (B \cap A) \cup (B \cap B \cap A) \cup (B \cap B \cap B \cap A) \cup \ldots\ldots]$$

$$= P(A) + P(B \cap A) + P(B \cap B \cap A) + \ldots$$

$$= \frac{1}{4} + \frac{1}{4} \times \frac{1}{4} + \frac{1}{4} \times \frac{1}{4} \times \frac{1}{4} + \ldots$$

$$= \frac{1}{4} + \left(\frac{1}{4}\right)^2 + \left(\frac{1}{4}\right)^3 + \ldots$$

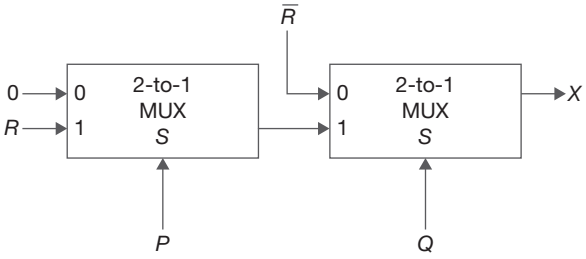
$$= \frac{\frac{1}{4}}{\left(1 - \frac{1}{4}\right)}$$

$$= \frac{1}{3} = 0.33$$

Hence, the correct Answer is (0.33 to 0.34).

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

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) $\overline{Q}\ \overline{R} + PQR$

Solution:

Output of first multiplexer = $I_0\overline{S} + I_1 S$

$= 0 \cdot \overline{P} + R \cdot P$

$= PR$

Output of second multiplexer = $I_0\overline{S} + I_1 S$

$= \overline{R} \cdot \overline{Q} + PR \cdot Q$

$= \overline{Q}\overline{R} + PQR$

Hence, the correct option is (D).

Question Number: 41 **Question Type: NAT**

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

Solution: The DMA will transfer data once when the data count register reached its maximum value.

With 16-bits, maximum number possible is $2^{16} = 65536$.

i.e., one interrupt will be generated for every 65536 bytes.

$\therefore$ Total numbers of interrupts

$$= \frac{29154 \times 2^{10}}{65536}$$

$$= 455.5$$

$$\simeq 456$$

Hence, the correct Answer is (456).

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

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

Solution: Throughput = $\frac{1}{\text{cycle time}} = \frac{1}{800}$

Delays for new 5-stage pipeline are 600, 350, 500, 400, 300 ps.

Cycle time = 600 ps.

$$\text{Throughput} = \frac{1}{600}$$

Percent of increase in throughput

$$= \frac{\frac{1}{600} - \frac{1}{800}}{\frac{1}{800}} \times 100$$

$$= \frac{4-3}{2400} \times 800 \times 100$$

$$= \frac{800}{2400} \times 100$$

$$= 33.33\%$$

Hence, the correct Answer is (33.0 : 34.0).

Question Number: 43 **Question Type: MCQ**

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

(A) $\Theta(1)$ (B) $\Theta(\log(n))$

(C) $\Theta\left(\sqrt{n}\right)$ (D) $\Theta(n)$

Solution: But here maximum fan in (number of inputs of gate) is 2. So to implement higher order bits more number of stages are required.

Number of Inputs	Number of Stages of 2 Input Gates
1 – 2	1
3 – 4	2
5 – 8	3
9 – 16	4

So far 'n' bit adder, it requires $\log_2 n$ stages. So delay is also in the order of $\log_2 n$.

Hence, the correct option is (B).

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

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

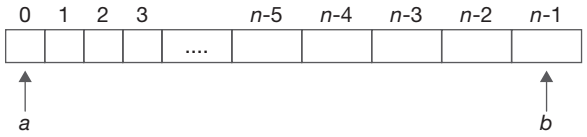
```
int max (int *p, int n) {
   int a = 0, b = n - 1;
   while (_____) {

     if (p [a] < = p [b]) {a = a+1;}
     else    { b = b - 1;}
   }
   return p[a];
}
```

The missing loop condition is

(A) $a != n$ (B) $b != 0$

(C) $b > (a + 1)$ (D) $b != a$

Solution: The routine max( ) computes the maximum value contained in an array p[ ] of size n.



The maximum value is computed by comparing the values from both ends of an array. The routine should stop, when 'a' and 'b' get intersect each other. The condition for it will be $b != a$

Hence, the correct option is (D).

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

What will be the output of the following C program?

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

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

(C) 3 1 2 2 1 3 4 (D) 3 1 2 1 1 1 2

Solution: The initial values of n, d are

n 3 d 1

here 'd' is a static variable. Initialization is done only once.

count( ) performs five operations.

(1) print n

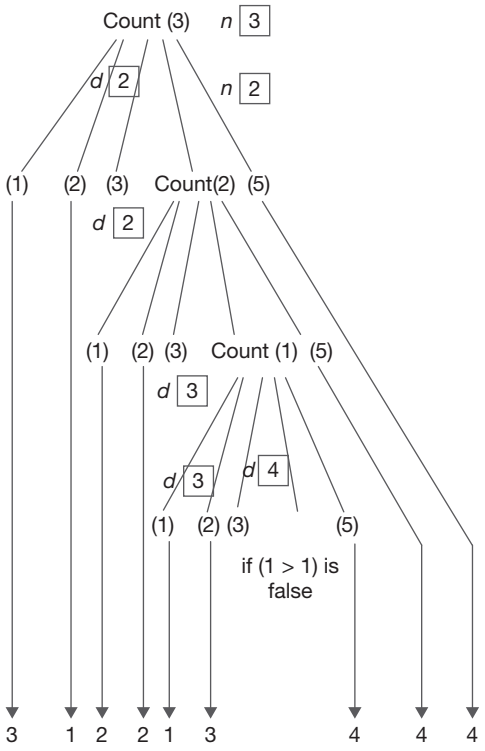
(2) print d

(3) increment d

(4) call recursively count (n – 1) if n > 1

(5) print d

The 'd' value is printed from the present updated values rather activation record value.



The output is 3 1 2 2 1 3 4 4 4
Hence, the correct option is (A).

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

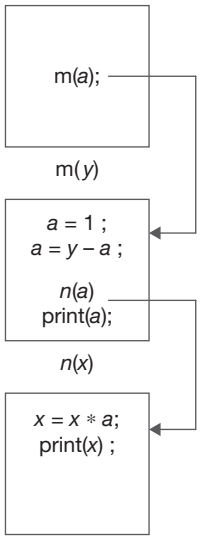
What will be the output of the following pseudo-code when parameters are passed by reference and dynamic scoping is assumed?

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

(A) 6,2
(B) 6,6
(C) 4,2
(D) 4,4

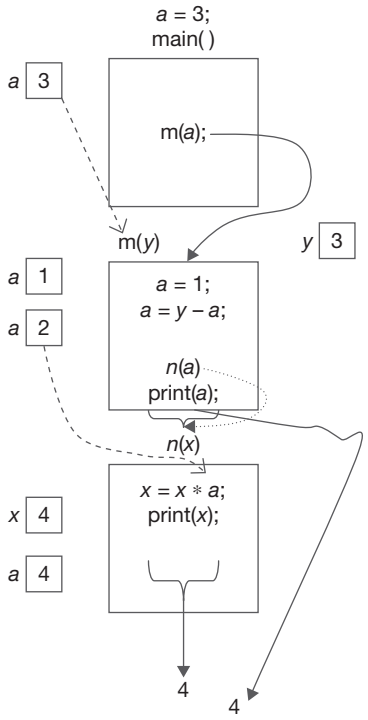
Solution:

```
a = 3
main( )
```



a 3 1 2 4

$y = 3$
$x = 2$
$x = 2 * 2$
$= 4$



It prints 4 4.
Hence, the correct option is (D).

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

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

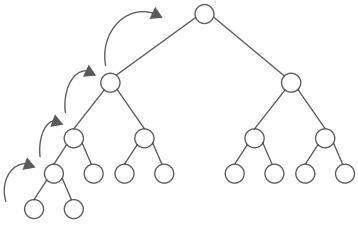
(A) O(1)

(B) O(d) but not O(1)

(C) O(2^d) but not O(d)

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

Solution: Assume a binary heap with 4-levels (depth = 4)



To refix the heap, we performed 4 swap operations that is equal to the depth of the tree (d).

$\therefore$ O(d) but not O(1).

Hence, the correct option is (B).

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

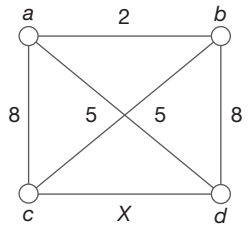
Consider the weighted undirected graph with 4 vertices, where the weight of edge $\{i, j\}$ is given by the entry W_{ij} in the matrix W.

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

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

Solution:

$$W = \begin{array}{c} \\ a \\ b \\ c \\ d \end{array} \begin{array}{c} \begin{array}{cccc} A & B & C & D \end{array} \\ \begin{pmatrix} 0 & 2 & 8 & 5 \\ 2 & 0 & 5 & 8 \\ 8 & 5 & 0 & \boldsymbol{X} \\ 5 & 8 & X & 0 \end{pmatrix} \end{array}$$



Distance from a to $c = 7$

Distance from b to $c = 5$

Distance from d to $c = 13$ $(d - a - c)$

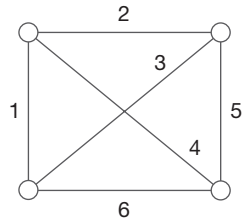
If we take $X = 12$, we would have taken shortest path from d to c as $d - c$. the largest possible value for X is 12.

Hence, the correct Answer is (12).

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

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

Solution:



Maximum possible minimum spanning tree weight = 1 + 2 + 4 = 7.

Hence, the correct Answer is (7).

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

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

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

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

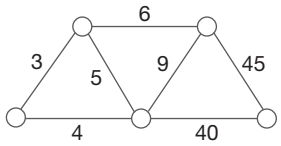
(A) I only

(B) II only

(C) Both I and II

(D) Neither I nor II

Solution:



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

Hence, the correct option is (B).

Question Number: 51 Question Type: NAT

Let Q denote a queue containing sixteen numbers and S be an empty stack.

Head (Q) returns the element at the head of the queue Q without removing it from Q. Similarly, Top(S) returns the element at the top of S without removing it from S.

Consider the algorithm given below.

```
while Q is not Empty do
   if S is Empty OR Top(S) ≤ Head(Q)
   then
      x : = Dequeue (Q)
      Push (S, x);
   else
      x : = Pop (S);
      enqueue (Q, x);
   end
end
```

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

Solution: If the number of elements are 1.

The maximum numbers of iterations are 1.

N	Maximum Iterations
1	1
2	4
3	9
.	.
.	.
.	.
16	256

[if the elements present in the Queue ascending order].

Hence, the correct Answer is (256).

Question Number: 52 Question Type: MCQ

Consider the following context-free grammars:

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

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

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

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

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

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

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

Solution: G1: $S \rightarrow aS|B, B \rightarrow b|bB$

Let's consider the strings derived by this grammar.

$S \rightarrow B$ $\quad$ $S \rightarrow aS$

$\rightarrow b$ $\quad$ $\rightarrow aB$

$\rightarrow ab$

$G1$ can generate strings without a's also. But there need to be atleast one b for getting terminal string.

$G1$ generates the language.

$$\left\{ a^m b^n \middle| \ m \geq 0 \ \ and \ \ n > 0 \right\}$$

$$G2 : S \rightarrow aA \middle| bB$$

$$A \rightarrow aA \middle| B \middle| \in$$

$$B \rightarrow bB \middle| \in$$

Consider the strings which are generated by G2:

$S \rightarrow aA$ $\quad$ $S \rightarrow bB$

$\rightarrow a$ $\quad$ $\rightarrow b$

$G2$ may contain one or more a's (or) one or more b's.

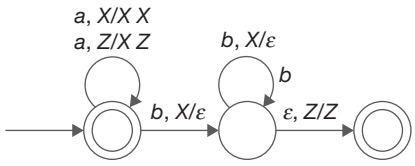
The language generated by $G2$ is

$$\left\{ a^m b^n \middle| m > 0 \ or \ n > 0 \right\}$$

Hence, the correct option is (D).

Question Number: 53 Question Type: MCQ

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



Which one of the following is true?

(A) $L = \{a^n b^n | n \geq 0\}$ 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.

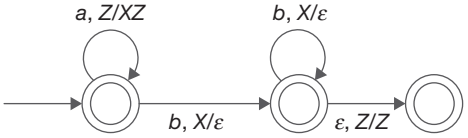
(D) $L = \{a^n | n \geq 0\} \cup \{a^n b^n | n \geq 0\}$ and is deterministic context-free.

Solution: Given, input alphabet $\sum = \{a, b\}$

Stack alphabet $\Gamma = \{X, Z\}$

Z is initial stack symbol.

L is the language accepted by below PDA:



This PDA accepts the strings with n number of a's $(n \geq 0)$ or strings with equal number of a's and b's in the form $a^n b^n$ such that $n \geq 0$.

$$L = \{a^n | n \geq 0\} \cup \{a^n b^n | n \geq 0\}$$

And is accepted by a deterministic CFL.

Hence, the correct option is (D).

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

Let X be a recursive language and Y be a recursively enumerable but not recursive language. Let W and Z be two languages such that $\overline{Y}$ reduces to W, and Z reduces to $\overline{X}$ (reduction means the standard many-one reduction). Which one of the following statements is true?

(A) W can be recursively enumerable and Z is recursive.

(B) W can be recursive and Z is recursively enumerable.

(C) W is not recursively enumerable and Z is recursive.

(D) W is not recursively enumerable and Z is not recursive.

Solution: As X is recursive, $\overline{X}$ is also recursive.

As Y is recursively enumerable but not recursive so $\overline{Y}$ is not recursively enumerable.

Z reduces to $\overline{X}$ and $\overline{X}$ is recursive so Z is recursive. $\overline{Y}$ reduces to W and $\overline{Y}$ is not recursively enumerable. So, W is not recursively enumerable.

Hence, the correct option is (C).

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

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

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

The value of the expression **2 – 5 + 1 – 7 * 3** in this language is _____.

Solution: 2 – 5 + 1 – 7 * 3

'+' has high precedence, so it evaluates

5 + 1 = 6

2 – 6 – 7 * 3

'–' has medium precedence, and associates from right. So it evaluates to

6 – 7 = –1 and 2 – (–1) = 3

3 * 3

* has low precedence.

3 * 3 = 9

Hence, the correct Answer is (9).

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

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

$S \rightarrow \boldsymbol{aA}$ { print 1 }

$S \rightarrow \boldsymbol{a}$ { print 2 }

$A \rightarrow \boldsymbol{Sb}$ { print 3 }

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

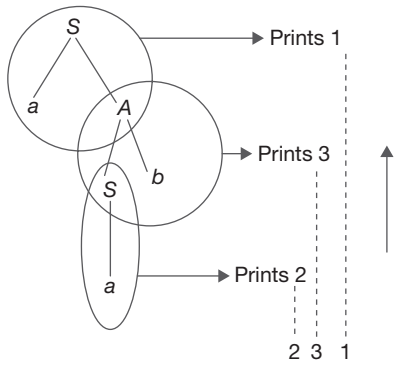
(A) 1 3 2

(B) 2 2 3

(C) 2 3 1

(D) syntax error

Solution: Input string = *a a b*



It prints as 2 3 1.

Hence, the correct option is (C).

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

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

Solution: Number of pages = $\frac{2^{40}}{2^{14}} = 2^{26}$

Page table size = $2^{26} \times 48$ bits

= 3072 Mbits

= 384 MB

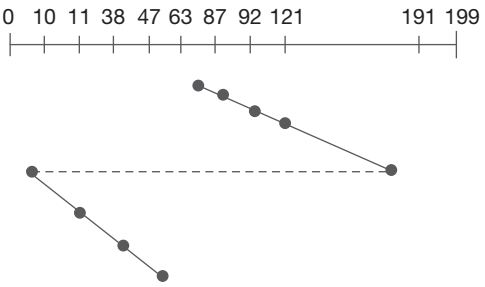
Hence, the correct Answer is (384).

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

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

Solution:

C – LOOK:



Total head movement = 87 – 63 + 92 – 87 + 121 – 92 + 191 – 121 + 191 – 10 + 11 – 10 + 38 – 11 + 47 – 38 = 346

Hence, the correct Answer is (346).

Question Number: 59 **Question Type: NAT**

Consider a computer system with ten physical page frames. The system is provided with an access sequence ($a_1, a_2, \ldots, a_{20}, a_1, a_2, \ldots a_{20}$), 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 _____.

Solution:

LIFO

It just simulates the operation of stack.

$a_1, a_2, a_3 \ldots a_{10}$

$a_{11}, a_{12}, a_{13} \ldots a_{20}$

$a_1, a_2, a_3 \ldots a_{10}$

$a_{11}, a_{12}, a_{13} \ldots a_{20}$

Using LIFO the system will have 31 pages faults.

Using optimal page replacement policy the system will be having 30 page faults.

The difference in page faults = 31 – 30.

Hence, the correct Answer is (1).

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

Consider the following proposed solution for the critical section problem. There are *n* 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 initialized to zero.

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

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

(A) At most one process can be in the critical section at any time.

(B) The bounded wait condition is satisfied.

(C) The progress condition is satisfied.

(D) It cannot cause a deadlock.

Solution: The synchronization solutions for the above n processes guarantee mutual exclusion.

Hence, the correct option is (A).

Question Number: 61 Question Type: MCQ

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

Step 1. T acquires exclusive locks to $O_1, \ldots, O_k$ in increasing order of their addresses.

Step 2. The required operations are performed.

Step 3. All locks are released.

This protocol will

(A) guarantee serializability and deadlock-freedom.

(B) guarantee neither serializability nor deadlock-freedom.

(C) guarantee serializability but not deadlock-freedom.

(D) guarantee deadlock-freedom but not serializabilty.

Solution: If every transaction in a schedule follows 2-phase locking protocol, that schedule is definitely serialiazable.

→ It guarantees serializability.

→ There is deadlock freedom.

Hence, the correct option is (A).

Question Number: 62 Question Type: MCQ

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

(A) $\{m, K_B^+(H(m))\}$ (B) $\{m, K_B^-(H(m))\}$

(C) $\{m, K_A^-(H(m))\}$ (D) $\{m, K_A^+(m)\}$

Solution: $K_x(m)$ represents encryption of m with key K_x.

$H(m)$ represents message digest.

To send a digitally signed message from B to A, the message need to be encrypted by private key of B. i.e.,

$$\left\{m, K_B^-\left(H(M)\right)\right\}$$

Hence, the correct option is (B).

Question Number: 63 Question Type: NAT

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

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

Solution: IP datagram has a size of 1000 Bytes.

Maximum transmission unit capacity is 100 bytes.

In these 100 bytes, 20 bytes is for header.

So 80 bytes is for data.

To transfer 1000 bytes, with 80 byte data in the packet,

$\frac{1000}{80} = 12.5 \simeq 13$ packets required.

Hence, the correct Answer is (13).

Question Number: 64 Question Type: NAT

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

Solution: Time taken for 1 MB of data (s) $\frac{c}{m-\rho}$

$$= \frac{1}{20-10} = 0.1 \text{ sec.}$$

Data transmitted in 0.1 sec

$$= 0.1 \times \text{output rate}$$

$$= 0.1 \times 20 \text{ MBPS}$$

$$= 2 \text{ MB.}$$

Remaining data = 12 MB – 2 MB.

= 10 MB.

To transmit 10 MB, time taken

$= 0.1 \times 10 = 1$ sec.

Total time required to transmit 12 MB

$= 1 + 0.1 = 1.1$ sec

Hence, the correct Answer is (1.1).

Question Number: 65 **Question Type: NAT**

A sender uses the Stop-and-Wait ARQ protocol for reliable transmission of frames. Frames are of size 1000 bytes and the transmission rate at the sender is 80 Kbps (1 Kbps = 1000 bits/second). Size of an acknowledgement is 100 bytes and the transmission rate at the receiver is 8 Kbps. The one-way propagation delay is 100 milliseconds.

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

Solution: Time taken to transmit

$$1 \text{ frame} = \frac{8000}{80 \times 10^3} = 0.1 \text{ sec}$$

1-way propagation delay = 100 msec.

Round-trip delay = 2 * 100 msec

= 0.2 msec.

Size of acknowledgment = 100 bytes

Transmission rate at the receiver = 8 Kbps.

8×10^3 bits $\rightarrow$ 1sec

100×8 bits $\rightarrow$?

$$\text{Time to transmit one ack} = \frac{800}{8 \times 10^3}$$

= 0.1 sec.

$$\text{Throughput} = \frac{1}{T}$$

T = Transmission time + Propagation delay + Acknowledgment delay

$= 0.1 + 0.2 + 0.1 = 0.4$ sec.

$$\text{Throughput} = \frac{1}{0.4} = 2.5 \text{ frames/sec.}$$

One frame = 1000 bytes.

2.5 frames = 2500 bytes/sec.

Hence, the correct Answer is (2500).

GATE 2016 Solved Paper
CSIT: Computer Science and Information Technology
Set – 2

Number of Questions: 65 **Total Marks:100.0**

Wrong answer for MCQ will result in negative marks, (–1/3) for 1 Mark Questions and (–2/3) for 2 Marks Question.

General Aptitude

Number of Questions: 10 **Section Marks: 15.0**

Question 1 to Question 5 carry 1 mark each and Question 6 to Question 10 carry 2 marks each.

Question Number: 1 **Question Type: MCQ**

The man who is now Municipal Commissioner worked as _____.

(A) the security guard at a university

(B) a security guard at the university

(C) a security guard at university

(D) the security guard at the university

Solution: The reference is to a particular person who worked as a security guard.

Hence, the correct option is (B).

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

Nobody knows how the Indian cricket team is going to cope with the difficult and seamer-friendly wickets in Australia.

Choose the option which is closest in meaning to the underlined phrase in the above sentence.

(A) put up with

(B) put in with

(C) put down to

(D) put up against

Solution: To cope with something or someone is to bear with something or someone.

Hence, the correct option is (D).

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

Find the odd in the following group of words.

Mock, deride, praise, jeer

(A) mock (B) deride

(C) praise (D) jeer

Solution: Mock, deride, and jeer convey the same meaning. Praise is the odd one out.

Hence, the correct option is (C).

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

Pick the odd one from the following options.

(A) CADBE (B) JHKIL

(C) XVYWZ (D) ONPMQ

Solution: Each group contains five consecutive letters from the English alphabet. The arrangement within the group is similar in (A), (B) and (C), but different in (D).

Hence, (D) is the odd one.

Hence, the correct option is (D).

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

In a quadratic function, the value of the product of the roots ($\alpha\,\beta$) is 4. Find the value of $\dfrac{\alpha^n+\beta^n}{\alpha^{-n}+\beta^{-n}}$

(A) n^4 (B) 4^n

(C) 2^{2n-1} (D) 4^{n-1}

Solution: Let the quadratic equation be $ax^2 + bx + c = 0$. The roots of quadratic equation are α, β

$$\therefore \qquad \alpha+\beta=\frac{-b}{a}$$

and $$\alpha\beta=\frac{c}{a}.$$

As per problem $\alpha\beta = 4$

$$\frac{\alpha^n+\beta^n}{\alpha^{-n}+\beta^{-n}}=\frac{\alpha^n+\beta^n}{\alpha^n+\beta^n}\ \alpha^n\,\beta^n=(\alpha\beta)^n=4^n.$$

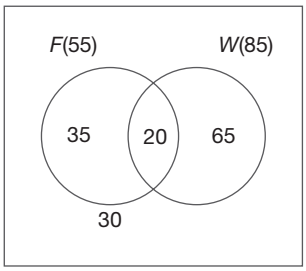
Hence, the correct option is (B).

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

Among 150 faculty members in an institute, 55 are connected with each other through Facebook® and 85 are connected through WhatsApp®. 30 faculty members do not have Facebook® or WhatsApp® accounts. The number of faculty members connected only through Facebook® accounts is _____.

(A) 35 (B) 45 (C) 65 (D) 90

Solution: Consider the Venn diagram given below in which F represents Facebook and W represents WhatsApp.



As 30 faculty members have neither account, 120 have accounts. As 55 have a Facebook account and 85 have a WhatsApp account,

Faculty members who have only either account = 55 + 85 – 120 = 20.

The number of faculty members who have only a Facebook account is 55 – 20 = 35.

Hence, the correct option is (A).

Question Number: 7 Question Type: MCQ

Computers were invented for performing only high-end useful computations. However, it is no understatement that they have taken over our world today. The internet, for example, is ubiquitous. Many believe that the internet itself is an unintended consequence of the original invention. With the advent of mobile computing on our phones, a whole new dimension is now enabled. One is left wondering if all these developments are good or, more importantly, required.

Which of the statement (s) below is/are logically valid and can be inferred from the above paragraph?

(i) The author believes that computers are not good for us.

(ii) Mobile computers and the internet are both intended inventions.

(A) (i) only

(B) (ii) only

(C) Both (i) and (ii)

(D) Neither (i) nor (ii)

Solution: Statement (i) is not valid because the author is expressing doubt whether computers are good. Author is not concluding that the computers are not good.

Statement (ii) is not valid. Because according to the author many people think internet is an unintended consequence, but did not make such comment about mobile computers.

Hence, neither (i) nor (ii) is valid.

Hence, the correct option is (D).

Question Number: 8 Question Type: MCQ

All hill-stations have a lake. Ooty has two lakes.

Which of the statement(s) below is/are logically valid and can be inferred from the above sentences?

(i) Ooty is not a hill-station.

(ii) No hill-station can have more than one lake.

(A) (i) only

(B) (ii) only

(C) Both (i) and (ii)

(D) Neither (i) nor (ii)

Solution: Hence, neither statement (i) nor statement (ii) is logically valid.

Hence, the correct option is (D).

Question Number: 9 Question Type: MCQ

In a 2×4 rectangle grid shown below, each cell is a rectangle. How many rectangles can be observed in the grid?

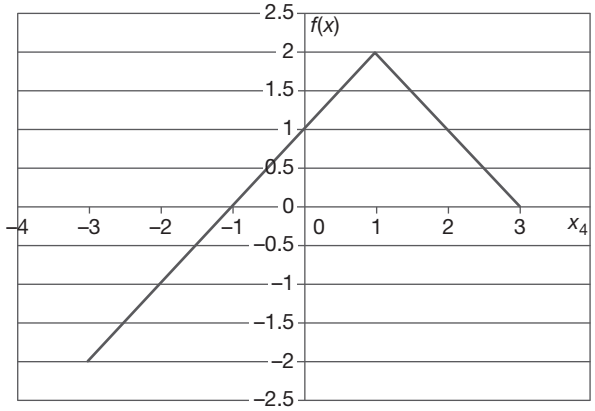
(A) 21 (B) 27 (C) 30 (D) 36

Solution: To select a rectangle from the grid, from the 5 vertical lines we have to select 2 and from the 3 horizonal lines we have to select 2. The number of ways in which this can be done is

$$^5C_2 \, ^3C_2 = 10(3) = 30 \text{ ways.}$$

Hence, the correct option is (C).

Question Number: 10 Question Type: MCQ



Choose the correct expression for $f(x)$ given in the graph.

(A) $f(x) = 1 - |x - 1|$ (B) $f(x) = 1 + |x - 1|$

(C) $f(x) = 2 - |x - 1|$ (D) $f(x) = 2 + |x - 1|$

Solution: The graph shows a V which opens downwards. The mod expression has to be preceded by a negative sign (we reject B, D) at the vertex of the V, i.e., at $x = 1$, y is 2. We accept C and reject A.

Hence, the correct option is (C).

Computer Science and Information Technology

Number of Questions: 55 **Section Marks: 85.0**

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

Question Number: 11 **Question Type: NAT**

Consider the following expressions

(i) false (ii) Q (iii) true

(iv) PVQ (v) ⌉QVP

The number of expressions given above that are logically implied by P ∧ (P ⇒ Q) is _____.

Solution: P ∧ (P → Q) ⇒ Q (modus ponens)

P ∧ (P → Q) ⇒ Q ⇒ P ∨ Q (Addition)

∴ P ∧ (P →Q) ⇒ True

Consider P ∧ (P → Q → (~ Q ∨ P)

⌉ Q ∨ P is false only when P is false and Q is true.

In that case P ∧ (P → Q) is false.

∴ P ∧ (P → Q) → (⌉ Q ∨ P) is a tautology.

Hence the number of expressions among (i), (ii), (iii), (iv) and (v) that are tautologically implied by

P ∧ (P → Q) is 4.

Hence, the correct Answer is (4).

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

Let $f(x)$ be a polynomial and $g(x) = f'(x)$ be its derivative. If the degree of $(f(x) + f(-x)$ is 10, then the degree of $(g(x) - g(-x))$ is ____.

Solution: Since $f(x) + f(-x)$ is a polynomial of degree 10, therefore

$\frac{d}{dx}[f(x) + f(-x)]$ will be a polynomial of degree 9.

$\Rightarrow$ $f'(x) + f'(-x)(-1)$ is a polynomial degree 9.

$\Rightarrow$ $g(x) - g(-x)$ is a polynomial of degree 9.

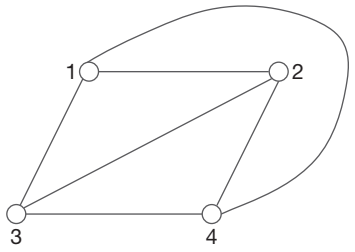
Hence, the correct Answer is (9).

Question Number: 13 **Question Type: NAT**

The minimum number of colours that is sufficient to vertex-colour any planar graph is _____.

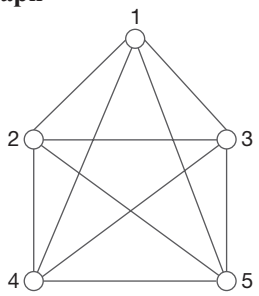
Solution: Any planar graph can be colored with 4-colors.

Planar graph



4-colors

Non planar graph



4-colors are not sufficient.

Hence, the correct Answer is (4).

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

Consider the systems, each consisting of m linear equations in n variables.

I. If $m < n$, then all such systems have a solution

II. If $m > n$, then none of these systems has a solution

III. If $m = n$, then there exists a system which has a solution

Which one of the following is correct?

(A) I, II and III are true

(B) Only II and III are true

(C) Only III is true

(D) None of them is true

Solution:

∴ I is False

∴ II is False.

And in a system of 3 linear equations in 3 unknowns say, $A\,X = B$.

If $\rho(A) = \rho([A/B])$, then the system has a solution.

Hence III is true.

Hence, the correct option is (C).

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

Suppose that a shop has an equal number of LED bulbs of two different types. The probability of an LED bulb lasting more than 100 hours given that it is of Type 1 is 0.7, and given that it is of Type 2 is 0.4. The probability that an LED bulb chosen uniformly at random lasts more than 100 hours is _____.

Solution: If we consider B1 and B_2 are the events of choosing a Type 1 and Type 2 LED bulbs respectively.

Probability of choosing bulb type 1 will be $P(B_1) = 0.5$

Probability of choosing bulb type 2 will be $P(B_2) = 0.5$

Let A denote the event of choosing an LED bulb that lasts more than 100 hours.

$\therefore \quad P(A/B_1) = 0.7 \quad \text{and} \quad P(A/B_2) = 0.4$

The probability that an LED bulb chosen uniformly at random lasts more than 100 hours

$$\begin{aligned} P(A) &= P(B_1) \cdot P(A/B_1) + P(B_2) \cdot P(A/B_2) \\ &= 0.5 \times 0.7 + 0.5 \times 0.4 \\ &= 0.55. \end{aligned}$$

Hence, the correct Answer is (0.55).

Question Number: 16 **Question Type: NAT**

Suppose that the Eigen values of matrix A are 1, 2, 4. The determinant of $(A^{-1})^T$ is _____.

Solution: Suppose that the Eigen values of matrix A are 1, 2 and 4.

The Eigen values of A^{-1} are 1, $\frac{1}{2}$ and $\frac{1}{4}$

Therefore, the Eigen values of $(A^{-1})^T$ are 1, $\frac{1}{2}$ and $\frac{1}{4}$

The determinant of $(A^{-1})^T$ = The product of the Eigen values of $(A^{-1})^T$

$$\begin{aligned} &= 1 \times \frac{1}{2} \times \frac{1}{4} \\ &= \frac{1}{8} = 0.125. \end{aligned}$$

Hence, the correct Answer is (0.124 to 0.126).

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

Consider an 8-bit ripple-carry adder for computing the sum of A and B, where A and B are integers represented in 2's complement form. If the decimal value of A is one, the decimal value of B that leads to the longest latency for the sum to stabilize is _____ .

Solution: To have longest latency, the carry should propagate from all bits. Input A is 1, so other input should have 1 1 1 1 1 1 1 1. (In 2's complement form) its value is decimal = –1.

Hence, the correct Answer is (–1.0).

Question Number: 18 **Question Type: MCQ**

Let $x_1 \oplus x_2 \oplus x_3 \oplus x_4 = 0$ where x_1, x_2, x_3, x_4 are boolean variables, and $\oplus$ is the XOR operator. Which one of the following must always be true?

(A) $x_1 x_2 x_3 x_4 = 0$ (B) $x_1 x_3 + x_2 = 0$

(C) $\bar{x}_1 \oplus \bar{x}_3 = \bar{x}_2 \oplus \bar{x}_4$ (D) $x_1 + x_2 + x_3 + x_4 = 0$

Solution: XOR of x_1, x_2, x_3, x_4 is zero means, it will have even number of 1's.

E.g.: 0000, 0011, 0110, 1100, 0101, 1010, 1001, 1111, these combinations are true for choice (c).

$$x_1^1 \oplus x_3^1 = x_2^1 \oplus x_4^1$$

Hence, the correct option is (C).

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

Let X be the number of distinct 16-bit integers in 2's complement representation. Let Y be the number of distinct 16-bit integers in sign magnitude representation. Then, $x - y$ is _____ .

Solution: *For X:* The range is -2^{15} to $2^{15} - 1$ i.e., there will be 65536 numbers.

For *Y:* The range is $-(2^{15} - 1)$ to $2^{15} - 1$.

i.e., there will be 65535 numbers.

Now

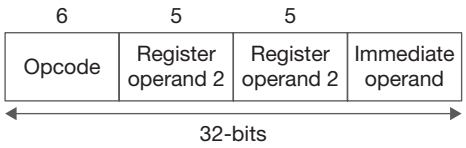
$\therefore \quad X - Y = 65536 - 65535 = 1.$

Hence, the correct Answer is (1).

Question Number: 20 **Question Type: NAT**

A processor has 40 distinct instructions and 24 general purpose registers. A 32-bit instruction word has an opcode, two register operands and an immediate operand. The number of bits available for the immediate operand field is ____.

Solution:



As there are 40 distinct instructions, the opcode length will be 6 ($40 \approx 64 = 2^6$).

As there are 24 registers, the length of register operands will be 5 ($24 \approx 32 = 2^5$).

$\therefore$ Immediate operand length = $32 - (6 + 5 + 5)$

$= 16$-bits

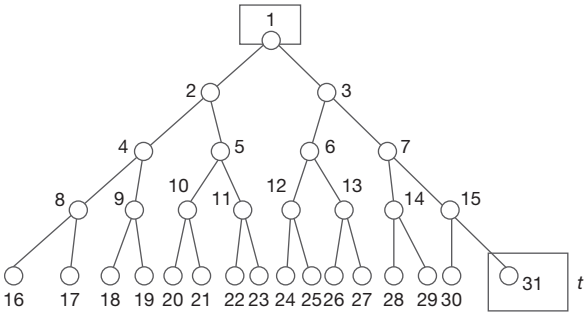
Hence, the correct Answer is (16).

Question Number: 21 **Question Type: NAT**

Breadth First Search (BFS) is started on a binary tree beginning from the root vertex. There is a vertex t at a distance four from the root. If t is the n-th vertex in this BFS traversal, then the maximum possible value of n is _____.

Solution: Vertex 't' at a distance four from the root.

Example:



t is the nth vertex in the BFS traversal, maximum possible value of n is 31.

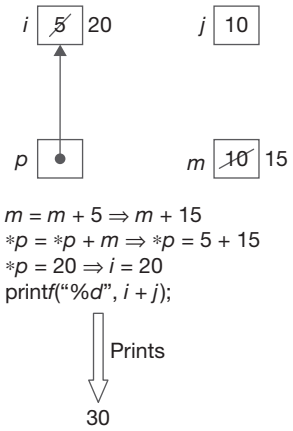
Hence, the correct Answer is (31).

Question Number: 22 **Question Type: NAT**

The value printed by the following program is ___.

```
void f (int* p, int m) {
m = m +5;
*p = *p + m;
return;
}
void main () {
int i = 5, j = 10;
f(&i, j);
print f ("%d", i +j);
}
```

Solution:



Hence, the correct Answer is (30).

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

Assume that the algorithms considered here sort the input sequences in ascending order. If the input is already in ascending order, which of the following are true?

I. Quick sort runs in $\Theta(n^2)$ time
II. Bubble sort runs in $\Theta(n^2)$ time
III. Merge sort runs in $\Theta(n)$ time
IV. Insertion sort runs in $\Theta(n)$ time

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

Solution: On ascending order of elements, quick sort gives, time complexity $\theta(n^2)$ and insertion sort gives, time complexity $\theta(n)$.

Hence, the correct option is (D).

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

The Floyd-Warshall algorithm for all-pair shortest paths computation is based on

(A) Greedy paradigm.
(B) Divide-and-Conquer paradigm.
(C) Dynamic programming paradigm.
(D) Neither greedy nor divide-and-conquer nor dynamic programming paradigm.

Solution: Floyd-warshall algorithm for all-pair shortest paths computation is based on dynamic programming paradigm.

Hence, the correct option is (C).

Question Number: 25 Question Type: MCQ

N items are stored in a sorted doubly linked list. For a *delete* operation, a pointer is provided to the record to be deleted. For a *decrease-key* operation, a pointer is provided to the record on which the operation is to be performed.

An algorithm performs the following operations on the list in this order: Θ (*N*) *delete*, O (log *N*) *insert*, O (log *N*) *find*, and Θ (*N*) *decrease-key*. What is the time complexity of all these operations put together?

(A) O ($\log^2 N$) (B) O(N)

(C) O(N^2) (D) Θ ($N^2 \log N$)

Solution: Time complexity = O(N)

Total time complexity = $(N + N \log N + N \log N + N)$

$= (2N + 2N \log N) = 2(N + N \log N)$

$= N + N \log N \leq C * N^2$

$= N + N \log N \in O(N^2)$

Hence, the correct option is (C).

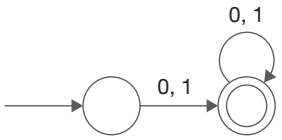
Question Number: 26 Question Type: NAT

The number of states in the minimum sized DFA that accepts the language defined by the regular expression $(0 + 1)^* (0 + 1) (0 + 1)^*$ is _____ .

Solution: Given regular expression,

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

The minimized DFA will be as below:



∴ Two states required.

Hence, the correct Answer is (2).

Question Number: 27 Question Type: MCQ

Language L_1 is defined by the grammar: $S_1 \rightarrow aS_1b|\in$

Language L_2 is defined by the grammar: $S_2 \rightarrow abS_2|\in$

Consider the following statements:

P: L_1 is regular

Q: L_2 is regular

Which one of the following is TRUE?

(A) Both P and Q are true

(B) P is true and Q is false

(C) P is false and Q is true

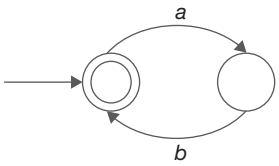
(D) Both P and Q are false

Solution: L_1 accepts strips which are in the form of

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

This is not regular.

The DFA for the language generated by this grammar is



∴ L_2 is regular.

∴ P is false and Q is true.

Hence, the correct option is (C).

Question Number: 28 Question Type: MCQ

Consider the following types of languages: L_1: Regular, L_2: Context-free, L_3: Recursive, L_4: Recursively enumerable. Which of the following is/are TRUE?

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

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

III. $L^*_1 \cap L_2$ is context–free.

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

(A) I only (B) I and III only

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

Solution:

(i) $\overline{L}_3 \cup L_4$ is recursively enumerable.

As L_3 is recursive, $\overline{L}_3$ is also recursive.

Every recursive language is recursively enumerable.

Recursively enumerable languages are closed under union.

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

(ii) $\overline{L}_2 \cup L_3$ is recursive.

L_2 is CFL. $\overline{L}_2$ is not necessarily CFL but $\overline{L}_2$ is recursive.

As L_3 is recursive, $L_2 \cup L_3$ is recursive. (∵ Recursive languages are closed under union).

(iii) $L_1^* \cap L_2$ is context-free

L_1^* is regular as regular languages are closed under closure.

L_2 is context-free.

Intersection of regular and CFL is CFL.

(iv) $L_1 \cup \overline{L}_2$ is context-free.

$\overline{L}_2$ may or may not be CFL.

So $L_1 \cup \overline{L}_2$ may or may not be context-free.

$\therefore$ I, II and III are true.

Hence, the correct option is (D).

Question Number: 29 **Question Type: MCQ**

Match the following:

(P) Lexical analysis	(i) Leftmost derivation
(Q) Top down parsing	(ii) Type checking
(R) Semantic analysis	(iii) Regular expressions
(S) Runtime environments	(iv) Activation records

(A) P ↔ i, Q ↔ ii, R ↔ iv, S ↔ iii

(B) P ↔ iii, Q ↔ i, R ↔ ii, S ↔ iv

(C) P ↔ ii, Q ↔ iii, R ↔ i, S ↔ iv

(D) P ↔ iv, Q ↔ i, R ↔ ii, S ↔ iii

Solution:

P – iii, because regular expressions are used for the construction of lexical analysis.

Q – i, because top down parsing uses left most derivation for parsing the string.

R – ii. because semantic analysis is used for type checking.

S – iv. because runtime environments make use of activation records.

Hence, the correct option is (B).

Question Number: 30 **Question Type: MCQ**

In which one of the following page replacement algorithms it is possible for the page fault rate to increase even when the number of allocated frames increases?

(A) LRU (Least Recently Used)

(B) OPT (Optimal Page Replacement)

(C) MRU (Most Recently Used)

(D) FIFO (First In First Out)

Solution: Given statement resembles the definition of Belady's anomaly. FIFO is affected with Belady's anomaly.

Hence, the correct option is (D).

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

B+ Trees are considered balanced because

(A) The lengths of the paths from the root to all leaf nodes are all equal.

(B) The lengths of the paths from the root to all leaf nodes differ from each other by at most 1.

(C) The number of children of any two non - leaf sibling nodes differs by at most 1.

(D) The number of records in any two leaf nodes differs by at most 1.

Solution: B^+-trees has a constraint that makes the tree always balanced which is that the length of paths from root to all the leaf nodes is equal.

Hence, the correct option is (A).

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

Suppose a database schedule S involves transactions $T_1, \ldots T_n$. Construct the precedence graph of S with vertices representing the transactions and edges representing the conflicts. If S is serializable, which one of the following orderings of the vertices of the precedence graph is guaranteed to yield a serial schedule?

(A) Topological order.

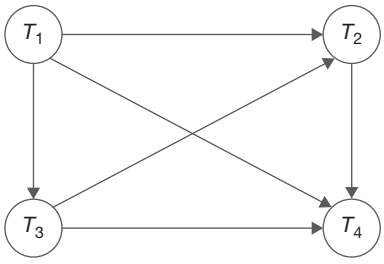
(B) Depth-first order.

(C) Breadth-first order.

(D) Ascending order of transaction indices.

Solution: S is serializable, means precedence graph should not contain any cycles.

Example: consider 4 transactions



Topological ordering:

$$T_1, T_3, T_2, T_4$$

Depth First order might give T_1, T_2, T_4, T_3

Breadth First order might give T_1, T_3, T_4, T_2

Ascending order of transaction indices T_1, T_2, T_3, T_4

$\therefore$ Topological ordering is valid for any precedence graph.

Hence, the correct option is (A).

Question Number: 33 Question Type: MCQ

Anarkali digitally signs a message and sends it to Salim. Verification of the signature by Salim requires

(A) Anarkali's public key.

(B) Salim's public key.

(C) Salim's private key.

(D) Anarkali's private key.

Solution: Anarkali digitally signs a message and sends it to Salim. For this Anarkali uses her private key. To verify this Salim requires Anarkali's public key.

Hence, the correct option is (A).

Question Number: 34 Question Type: MCQ

In an Ethernet local area network, which one of the following statements is true?

(A) A station stops to sense the channel once it starts transmitting a frame.

(B) The purpose of the jamming signal is to pad the frames that are smaller than the minimum frame size.

(C) A station continues to transmit the packet even after the collision is detected.

(D) The exponential back off mechanism reduces the probability of collision on retransmissions.

Solution: The exponential backoff algorithm reduces the probability of collision on retransmission. This statement is true.

Hence, the correct option is (D)

Question Number: 35 Question Type: MCQ

Identify the correct sequence in which the following packets are transmitted on the network by a host when a browser requests a webpage from a remote server, assuming that the host has just been restarted.

(A) HTTP GET request, DNS query, TCP SYN

(B) DNS query, HTTP GET request, TCP SYN

(C) DNS query, TCP SYN, HTTP GET request

(D) TCP SYN, DNS query, HTTP GET request

Solution: We know that when a browser requests a webpage from a remote server, the packets to be transmitted are

1. Client sends DNS query for remote server.
2. To get connection, client will send TCP SYN packet.
3. After connection is established, the client requests data from server using HTTP GET request.

Hence, the correct option is (C).

Question Number: 36 Question Type: MCQ

A binary relation R on $N \times N$ is defined as follows: *(a, b) R (c, d)* if $a \leq c$ or $b \leq d$. Consider the following propositions:

P: R is reflexive

Q: R is transitive

Which one of the following statements is true?

(A) Both P and Q are true.

(B) P is true and Q is false.

(C) P is false and Q is true.

(D) Both P and Q are false.

Solution: We know that $a \leq a$ and $b \leq b$

$$\Rightarrow (a, b)\ R\ (a, b), \forall\ (a, b) \in N \times N$$

Thus relation R is reflexive.

$\Rightarrow$ P is true.

For Q consider this example:

We know that

$$(4, 10)\ R\ (7, 6) \qquad (\because\ 4 \leq 7)$$

and $$(7, 6)\ R\ (3, 9) \qquad (\because\ 6 \leq 9)$$

But $$(4, 10)\ \not{R}\ (3, 9) \qquad (\because\ 4 \not\leq 3 \text{ and } 10 \not\leq 9)$$

Thus relation R is not transitive.

Hence Q is false.

Hence, the correct option is (B).

Question Number: 37 Question Type: MCQ

Which one of the following well-formed formulae in predicate calculus is not valid?

(A) $(\forall x\ p(x) \Rightarrow \forall xq(x)) \Rightarrow (\exists x \neg p(x) \vee \forall xq(x))$

(B) $(\exists x\ p(x) \vee \exists x\ q(x)) \Rightarrow \exists x\ (p(x) \vee q(x)))$

(C) $\exists x(p(x) \wedge q(x)) \Rightarrow (\exists xp(x) \wedge \exists xq(x))$

(D) $\forall x(p(x) \vee q(x)) \Rightarrow (\forall xp(x) \vee \forall xq(x))$

Solution: $\forall x(p(x) \vee q(x)) \Rightarrow (\forall xp(x) \vee \forall xq(x))$

This formulae is not valid.

Hence, the correct option is (D).

Question Number: 38 Question Type: MCQ

Consider a set U of 23 different compounds in a Chemistry lab. There is a subset S of U of 9 compounds, each of which reacts with exactly 3 compounds of U.

Consider the following statements:

I. Each compound in $U \backslash S$ reacts with an odd number of compounds.

II. At least one compound in $U \backslash S$ reacts with an odd number of compounds.

III. Each compound in $U \backslash S$ reacts with an even number of compounds.

Which one of the above statements is always true**?**

(A) Only I (B) Only II

(C) Only III (D) None

Solution: We know that in any undirected graph, there are even numbers of odd vertices.

There exists atleast one compound in $U \backslash S$ that reacts with odd number of compounds.

Hence, the correct option is (B).

Question Number: 39 Question Type: NAT

The value of the expression $13^{99} \pmod{17}$, in the range 0 to 16, is _____.

Solution: Using Fermat's theorem, if p is a prime number and p is not a divisor of a, then $a^{p-1} = 1 \pmod{p}$

Here take $a = 13$ and $p = 17$

$$\therefore \quad 13^{17-1} = 1 \pmod{17}$$

$$\Rightarrow \quad 13^{16} = 1 \pmod{17} \qquad (1)$$

Consider

$$13^{99} \pmod{17} = 13^{96+3} \pmod{17}$$

$$= (13^{16})^6 \, 13^3 \pmod{17}$$

$$= (13^6)^6 \pmod{17} \, 13^3 \pmod{17}$$

$$= 1^6 . 13^3 \pmod{17} \qquad \text{(using (1))}$$

$$= 2197 \pmod{17}$$

= The remainder obtained when 2,197 is divided by 17

= 4

Hence, the correct Answer is (4).

Question Number: 40 Question Type: NAT

Suppose the functions F and G can be computed in 5 and 3 nanoseconds by functional units U_F and U_G, respectively. Given two instances of U_F and two instances of U_G, it is required to implement the computation $F(G(X_i))$ for $1 \le i \le 10$. Ignoring all other delays, the minimum time required to complete this computation is _____ nanoseconds.

Solution: To perform $F(G(1))$, $F(G(2))$, … $F(G(10))$ it will take 25 ns but 12 ns of this can be done in parallel with $G(3)$, $G(4)$ … $G(10)$.

Extra time for calculating F functions

$$= 25 - 12 = 13 \text{ ns}$$

$\therefore$ Minimum time required = 15 ns + 13 ns

$$= 28 \text{ ns}$$

Hence, the correct Answer is (28).

Question Number: 41 Question Type: NAT

Consider a processor with 64 registers and an instruction set of size twelve. Each instruction has five distinct fields, namely, opcode, two source register identifiers, one destination register identifier, and a 12-bit immediate value. Each instruction must be stored in memory in a byte - aligned fashion. If a program has 100 instructions, the amount of memory (in bytes) consumed by the program text is ___.

Solution: Instruction format as given in the problem is

4	6	6	6	12
Opcode	Source register 1	Source register 2	Dest. Register	Immediate value

As there are 64 registers, register fields will have 6-bit length. Instruction set size is 12, the opcode will have $4 (12 \approx 16 = 2^4)$ bit length.

Instruction size = 34-bits.

Each instruction must be stored in byte-aligned fashion.

In byte-aligned fashion, each instruction requires 5 bytes.

($\because 5 \times 8 = 40\text{-bits} \simeq 34\text{-bits}$)

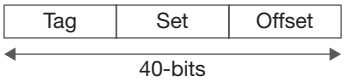
For a program of 100 instructions, memory required = 5×100 bytes = 500 bytes

Hence, the correct Answer is (500).

Question Number: 42 Question Type: NAT

The width of the physical address on a machine is 40 bits. The width of the tag field in a 512 KB 8-way set associative cache is ____ bits.

Solution:



Assume that block size = 2^x

$\therefore$ Offset requires x-bits.

Number of sets in cache $= \frac{2^{19}}{8 \times 2^{x}} = 2^{16-x}$

Number of bits required for set field is $16 - x$.

$$\text{Tag} = 40 - (16 - x + x) = 24\text{-bits}$$

Hence, the correct Answer is (24).

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

Consider a 3 GHz (gigahertz) processor with a three-stage pipeline and stage latencies τ_1, τ_2 and τ_3 such that $\tau_1 = 3\tau_2/4 = 2\tau_3$. If the longest pipelines stage is split into two pipeline stages of equal latency, the new frequency is ____ GHz, ignoring delays in the pipeline registers.

Solution: Cycle time $= \frac{1}{3 \times 10^9}$

The stage latencies will be,

$$\tau_1, \frac{4\tau_1}{3}, \frac{\tau_1}{2}$$

The maximum stage delay is the cycle time.

i.e., $$\frac{4\tau_1}{3} = \frac{1}{3 \times 10^9}$$

$\Rightarrow$ $$\tau_1 = \frac{3}{4} \times \frac{1}{3 \times 10^9}$$

$\Rightarrow$ $$\tau_1 = 0.25 \text{ nsec}$$

$$\tau_2 = \frac{4\tau_1}{3} = 0.33 \text{ nsec}$$

$$\tau_3 = \frac{\tau_1}{2} = 0.125 \text{ nsec}$$

The longest stage delay is split into two equal stage delays for a new processor. So new stage delays will be 0.25, 0.165, 0.165, 0.125 nsec.

Maximum stage delay is 0.25

$\Rightarrow$ Cycle time = 0.25 nsec

$\Rightarrow$ $\text{Frequency} = \frac{1}{0.25 \times 10^{-9}} = 4$ GHz.

Hence, the correct Answer is (4).

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

A complete binary min-heap is made by including each integer in [1, 1023] exactly once. The depth of a node in the heap is the length of the path from the root of the heap to that node. Thus, the root is depth 0. The maximum depth at which integer 9 can appear is _____.

Solution: There are 1023 elements i.e., 1, …, 1023. The maximum number of elements at depth 'd' in complete binary tree is $2^{d+1} - 1$.

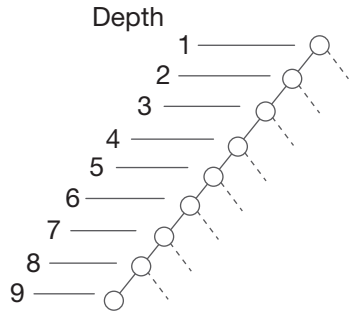
$$2^{d+1} - 1 = 1023$$

$$2^{d+1} = 1023 + 1$$

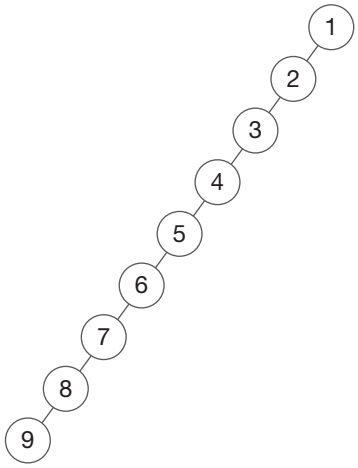
$$d + 1 = 10$$

$$d = 9$$

There will be a depth of 9 for min-heap of 1023 elements.



The longest path in min-heap is shown above, so the node 9 can be placed at depth 8.



Hence, the correct Answer is (8).

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

The following function computes X^Y for positive integers X and Y.

```
int exp (int X, int Y)
{
int res = 1, a = X, b = Y;
while (b! = 0)
```

```
{
if (b%2 = = 0) {a = a*a; b = b/2;}
else  {res = res *a; b = b -1;}
}
return res;
}
```

Which one of the following conditions is true before every iteration of the loop?

(A) $X^Y = a^b$ (B) $(\text{res} * a)^Y = (\text{res}* X)^b$

(C) $X^Y = \text{res} * a^b$ (D) $X^Y = (\text{res}* a)^b$

Solution: $X^Y = \text{res} * a^b$ will be true before every iteration of the loop.

Hence, the correct option is (C).

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

Consider the following New–order strategy for traversing a binary tree:

- Visit the root;
- Visit the right subtree using New – order;
- Visit the left subtree using New – order;

The New – order traversal of the expression tree corresponding to the reverse polish expression

3 4 * 5 – 2 ^ 6 7 * 1 + – is given by:

(A) + – 1 6 7 * 2 ^ 5 – 3 4 *

(B) – + 1 * 6 7 ^ 2 – 5 * 3 4

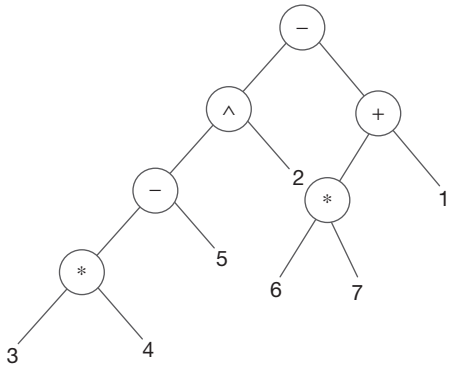
(C) – + 1 * 7 6 ^ 2 – 5 * 4 3

(D) 1 7 6 * + 2 5 4 3 * – ^ –

Solution: Post fix expression is

34 * 5 – 2 ^ 67 * 1 + –

This expression is post order of the expression tree. The expression tree of the above expression is



The new-order traversal for the above tree is

– + 1 * 7 6 ^ 2 – 5 * 4 3

Hence, the correct option is (C).

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

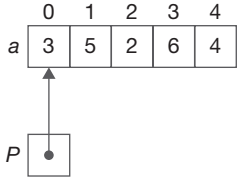
Consider the following program:

```
int f (int *p, int n)
{
if (n < = 1) return 0;
else return max (f (p +1, n – 1), p
[0] – p [1] );
}
int main ()
{
int a[ ] = {3,5,2,6,4};
printf ("%d", f(a,5));
}
```

Note: *max (x,y) returns the maximum of x and y.*

The value printed by this program is _____

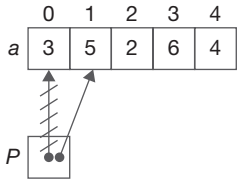
Solution:



When P is pointing to a

$P[0] = 3, P[1] = 5, P[2] = 2, P[3] = 6, P[4] = 3$

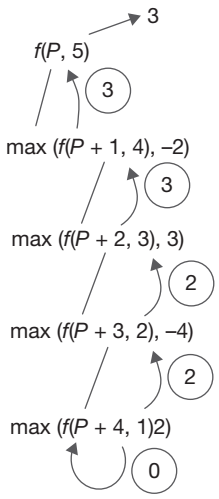
When P is pointing to $a[1]$ ($P \rightarrow P + 1$)



Then $P[0] = 5, P[1] = 2, P[2] = 6, P[3] = 4$

$*P = P + 1$

Similarly, when $*P = P + 2$ and $*P = P + 3$



It prints 3.

Hence, the correct Answer is (3).

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

Let A_1, A_2, A_3 and A_4 be four matrices of dimensions 10×5, 5×20, 20×10 and 10×5 respectively. The minimum number of scalar multiplications required to find the product $A_1A_2A_3A_4$ using the basic matrix multiplication method is _____.

Solution: Possible order of evaluation

(i) $((A_1 \times A_2) \times A_3) \times A_4)$

(ii) $(A_1 \times A_2) \times (A_3 \times A_4)$

(iii) $A_1 \times (A_2 \times (A_3 \times A_4))$

(iv) $(A_1 \times (A_2 \times A_3)) \times A_4$

(v) $A_1 \times ((A_2 \times A_3) \times A_4)$

(i) $A_1 \times A_2 = [\text{result 1}]_{10 \times 20} = 10 \times 5 \times 20 = 1000.$

$[\text{result 1}]_{10 \times 20} \times [A_3]_{20 \times 10} = [\text{result 2}]_{10 \times 10} = 10 \times 20 \times 10 = 2000$

$[\text{result 2}]_{10 \times 10} \times [A_4]_{10 \times 5} = 10 \times 10 \times 5 = 500$

Total multiplications = 1000 + 2000 + 500 = 3500

(ii) $A_1 \times A_2 = 1000$

$A_3 \times A_4 = 20 \times 10 \times 5 = 1000$

$[A_1 \times A_2]_{10 \times 20} * [A_3 \times A_4]_{20 \times 5} = 10 \times 20 \times 5 = 1000$

Total multiplications = 1000 + 1000 + 1000 = 3000

(iii) $A_3 \times A_4 = 1000$

$[A_2]_{5 \times 20} \times [A_3 \times A_4]_{20 \times 5} = [\text{result 1}]_{5 \times 5} = 5 \times 20 \times 5 = 500$

$[A_1]_{10 \times 5} \times [\text{result 1}]_{5 \times 5} = 10 \times 5 \times 5 = 250$

Total multiplications = 1000 + 500 + 250 = 1750

(iv) $A_2 \times A_3 = [\text{result 1}]_{5 \times 10} = 5 \times 20 \times 10 = 1000$

$[\text{result 2}]_{10 \times 10} = [A_1]_{10 \times 5} \times [\text{result 1}]_{5 \times 10} = 10 \times 5 \times 10 = 500$

$[\text{result 2}]_{10 \times 10} \times [A_4]_{10 \times 5} = 10 \times 10 \times 5 = 500$

Total multiplications = 1000 + 500 + 500 = 2000

(v) $(A_2 \times A_3) = [\text{result 1}]_{5 \times 10} = 5 \times 20 \times 10 = 1000$

$[\text{result 2}]_{5 \times 5} = [\text{result 1}]_{5 \times 10} \times [A_4]_{10 \times 5} = 5 \times 10 \times 5 = 250$

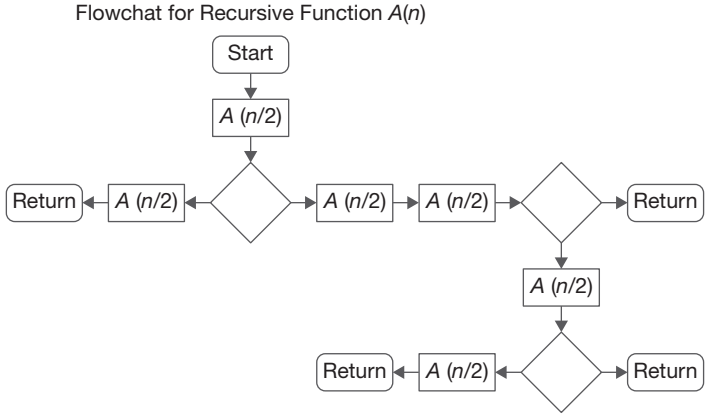
$[A_1]_{10 \times 5} \times [\text{result 2}]_{5 \times 5} = 10 \times 5 \times 5 = 250$

Total multiplications = 1000 + 250 + 250 = 1500

Hence, the correct Answer is (1500).

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

The given diagram shows the flowchart for a recursive function $A(n)$. Assume that all statements, except for the recursive calls, have O (1) time complexity. If the worst case time complexity of this function is O ($n\alpha$), then the least possible value (accurate up to two decimal positions) of α is ____.



Solution: If we consider the maximum depth of the recursive function, and the recurrence relation would be:

$$T(n) = 5T\left(\frac{n}{2}\right) + 1$$

Apply Master theorem on the above recurrence relation.

$$T(n) = 5T\left(\frac{n}{2}\right) + 1$$

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

$$f(n) \text{ Vs } n^{\log_b^a}$$

$$1 \text{ Vs } n^{\log_2^5}$$

$f(n) < n^{\log_b^a}$ (case 1 of master theorem)

$$O(n^{\log_b^a}) = O(n^{\log_2^5}) = O(n^{2.32})$$

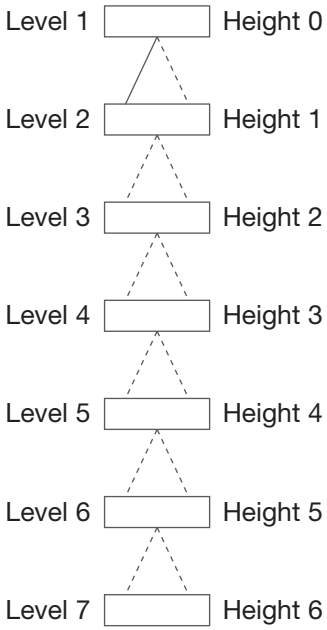
Hence, the correct Answer is (2.2 to 2.4).

Question Number: 50 Question Type: NAT

The number of ways in which the numbers 1, 2, 3, 4, 5, 6, 7 can be inserted in an empty binary search tree, such that the resulting tree has height 6 is ____.

Note: The height of a tree with a single node is 0.

Solution: Binary search tree of height 6 with seven numbers (height of single node is 0) contain seven levels with each level containing only one node.



At each level (other than at root-level 1) the node can be placed either as left child or as right child i.e., there are 2 ways to place a node at each level (other than level 1).

The total number of structures formed = $2 \times 2 \times 2 \times 2 \times 2 \times 2$

$= 2^6$

= 64 structures

For every structure the elements can be placed in only one way to form binary search tree. Hence, total 64 BST's can be formed.

Hence, the correct Answer is (64).

Question Number: 51 Question Type: MCQ

In an adjacency list representation of an undirected simple graph $G = (V, E)$, each edge (u, v) has two adjacency list entries: $[v]$ in the adjacency list of u and $[u]$ in the adjacency list of v. These are called twins of each other. A twin pointer is a pointer from an adjacency list entry to its twin. If $|E| = m$ and $|V| = n$, and the memory size is not a constraint, what is the time complexity of the most efficient algorithm to set the twin pointer in each entry in each adjacency list?

(A) $\Theta(n^2)$ (B) $\Theta(n + m)$

(C) $\Theta(m^2)$ (D) $\Theta(n^4)$

Solution: To represent a graph, if we use matrix the time complexity of the most efficient algorithm to set the twin pointer will be $O(n^2)$.

– If we use adjacency list, it will be 2(edges + vertices) = 2 $(m + n) = \theta\ (m + n)$.

Hence, the correct option is (B).

Question Number: 52 Question Type: MCQ

Consider the following two statements:

I. If all states of an NFA are accepting states then the language accepted by the NFA is $\Sigma*$.

II. There exists a regular language A such that for all languages B, $A \cap B$ is regular.

Which one of the following is correct?

(A) Only I is true

(B) Only II is true

(C) Both I and II are true

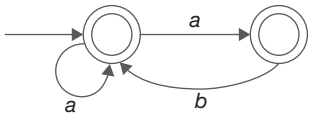
(D) Both I and II are false

Solution:

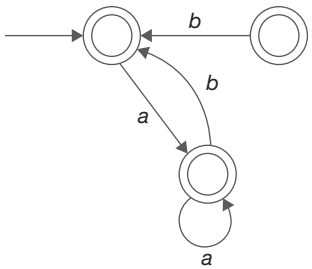
I. If all the states of an NFA are accepting states then the language accepted by the NFA is $\Sigma*$.

This is not always correct. (In some cases, every transition is not included).

For example, consider below NFA.



The DFA equivalent to this NFA is given below:



This does not represent Σ*.

∴ I is false.

II. There exists a regular language A such that for all languages B, $A \cap B$ is regular.

This statement is always correct.

Example: $A = \phi$ (A is regular)

$$B = \{a^n b^n / n \geq 0\}$$

$A \cap B = \phi$, which is regular.

For any B, $A \cap B = \phi$, which is regular.

∴ II is correct.

Hence, the correct option is (B).

Question Number: 53 Question Type: MCQ

Consider the following languages:

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

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

Which one of the following is true?

(A) Both L_1 and L_2 are context-free.

(B) L_1 is context-free while L_2 is not context–free.

(C) L_2 is context-free while L_1 is not context -free.

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

Solution: The PDA can be designed which pushes a's, b's on stack and pops a's, b's for every c as L_1 is context-free.

Since, L_2 is not context-free.

$\{a^n b^n \mid n \geq 1\}$ is context-free.

But checking the equality of a's, b's with n c's is not possible with the stack memory of PDA.

Hence, the correct option is (B).

Question Number: 54 Question Type: MCQ

Consider the following languages.

$L_1 = \{\langle M \rangle \mid M$ takes at least 2016 steps on some input$\}$,

$L_2 = \{\langle M \rangle \mid M$ takes at least 2016 steps on all inputs$\}$ and

$L_1 = \{\langle M \rangle \mid M$ accepts $\varepsilon\}$.

Where for each Turing machine M, $\langle M \rangle$ denotes a specific encoding of M. Which one of the following is true?

(A) L_1 is recursive and L_2, L_3 are not recursive.

(B) L_2 is recursive and L_1, L_3 are not recursive.

(C) L_1, L_2 are recursive L_3 is not recursive.

(D) L_1, L_2, L_3 are recursive.

Solution: From given information L_1 is recursive. It is decidable. L_1 accepts strings which takes atleast 2016 steps on some input.

The machines says 'yes' for some input which has atleast 2016 steps, for other string it says 'no'.

From given information L_2 is decidable and recursive also.

Machines says 'yes' for all the strings which take atleast 2016 steps. And says 'no' for an input which has below 2016 steps.

L_3 is undecidable. Empty tape acceptance problem is undecidable, and so L_3 is not recursive.

Hence, the correct option is (C).

Question Number: 55 Question Type: MCQ

Which one of the following grammars is free from left recursion?

(A) $S \rightarrow AB$
$A \rightarrow Aa/b$
$B \rightarrow c$

(B) $S \rightarrow Ab/Bb/c$
$A \rightarrow Bd/\varepsilon$
$B \rightarrow e$

(C) $S \rightarrow Aa/B$
$A \rightarrow Bb/Sc/\varepsilon$
$B \rightarrow d$

(D) $S \rightarrow Aa/Bb/c$
$A \rightarrow Bd/\varepsilon$
$B \rightarrow Ae/\varepsilon$

Solution: If left most variable of right hand side of production is same as the variable at left hand side of production then the grammar is said to be left recursive.

Option (B) is free from left recursion.

Hence, the correct option is (B).

Question Number: 56 Question Type: MCQ

A student wrote two context - free grammars G1 and G2 for generating a single C-like array declaration. The dimension of the array is at least one.

For example, int a [10] [3];

The grammars use D as the start symbol, and use six terminal symbols int; id [ ] num.

Grammar G1	**Grammar G2**
D → int L;	D → int L;
L → id [E	L → id E
E → num]	E → E [num]
E → num] [E	E → [num]

Which of the grammars correctly generate the declaration mentioned above?

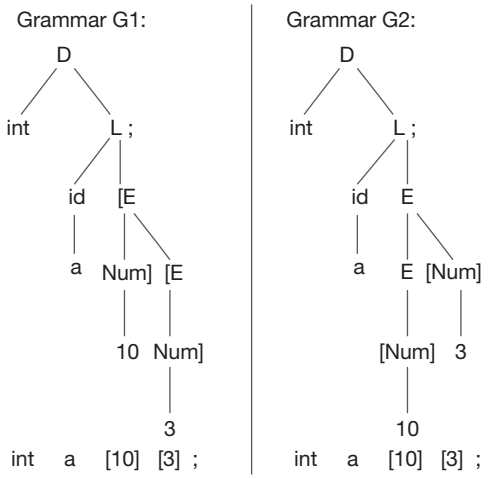
(A) Both G1 and G2

(B) Only G1

(C) Only G2

(D) Neither G1 nor G2

Solution: int a[10][3];



Using both grammars G_1 and G_2, we can generate the string int a [10] [3].

Hence, the correct option is (A).

Question Number: 57 Question Type: NAT

Consider the following processes, with the arrival time and the length of the CPU burst given in milliseconds. The scheduling algorithm used is preemptive shortest remaining-time first.

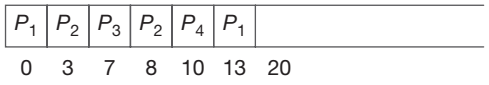
Process	Arrival Time	Burst Time
P_1	0	10
P_2	3	6
P_3	7	1
P_4	8	3

The average turn around time of these processes is ____ milliseconds.

Solution:

Process id	Arrival time	Burst time	Completion time	Turn around time
P_1	0	10	20	20
P_2	3	6	10	7
P_3	7	1	8	1
P_4	8	3	13	5

Gantt chart:



Turn around time (P_i) = Completion time (P_i) – Arrival time (P_i)

$$\text{Average T.A.T} = \frac{20+7+1+5}{4} = \frac{33}{4} = 8.25$$

Hence, the correct Answer is (8.2 to 8.3).

Question Number: 58 Question Type: MCQ

Consider the following two-process synchronization solution.

```
Process 0                Process 1
---------                ---------
Entry: loop while        Entry: loop while
(turn = = 1);            (turn = = 0);
(Critical section)       (Critical section)
Exit: turn = 1;          Exist: turn = 0;
```

The shared variable turn is initialized to zero. Which one of the following is true?

(A) This is a correct two-process synchronization solution.

(B) This solution violates mutual exclusion requirement.

(C) This solution violates progress requirement.

(D) This solution violates bounded wait requirement.

Solution: The given solution guarantees the mutual exclusion principle. There can be only one process in critical section at any time (either process 0 or process 1).

But it does not guarantee progress requirement.

No process running outside the critical section should block another process which is interested in executing critical section.

Initially, turn = 0 (given in solution) suppose P_0 and P_1 are in the system, now process P_0 is not interested in executing critical section (C.S), it is executing non-critical section.

P_1 is interested in executing C.S but it is not allowed in C.S as P_0 is blocking P_1 ($\because$ turn = 0), Though C.S is free and P_0 is executing N.C.S.

P_1 gets chance only when P_0 complete its C.S and vice versa.

The above solution simulates strict alternation procedure. Therefore, the above solution doesn't guarantee progress.

Hence, the correct option is (C).

Question Number: 59 Question Type: NAT

Consider a non-negative counting semaphore *S*. The operation *P* (*S*) decrements *S* and *V*(*S*) increments *S*. During an execution, 20 *P*(*S*) operations and 12 *V*(*S*) operations are issued in some order. The largest initial value of *S* for which at least one *P*(*S*) operation will remain blocked is _____.

Solution: Counting semaphore:

After performing the P(S) operations if the value of S is −1 then the process gets blocked

If *S* = 0 then the performing of down(*S*) (*P*(*S*)) operation by a process results in blocked state.

If we consider the value of *S* as 0.

If 20 *P*(*S*) and 12 *V*(*S*) operations are performed on *S* in any order, it results in −8.

We need to choose the value of *S* such that, the resulting value should be −1 (given atleast one process should be blocked after performing above operations)

So the value of *S* should be 7.

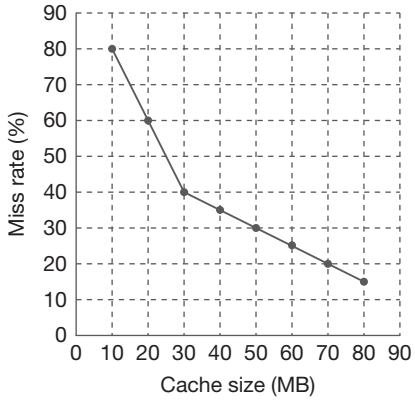
($\because$ −8 + 7 = −1)

Hence, the correct Answer is (7).

Question Number: 60 Question Type: NAT

A file system uses an in-memory cache to cache disk blocks. The miss rate of the cache is shown in the figure. The latency to read a block from the cache is 1 ms and to read a block from the disk is 10 ms. Assume that the cost of checking whether a block exists in the cache is negligible. Available cache sizes are in multiples of 10 MB.

The smallest cache size required to ensure an average read latency of less than 6 ms is ____ MB.



Solution: Average access time = Hit ratio * cache access time + (1–hit ratio) * (disk access time + cache access time)

Let, Hit ratio = H

$$6 = H * 1 + (1 - H)(10 + 1)$$

$$\Rightarrow \quad 10H = 5$$

$$\Rightarrow \quad H = \frac{1}{2} = 0.5 = 50\%$$

$$\text{Hit ratio} = 50\%$$

$$\Rightarrow \quad \text{Miss ratio} = 100\% - 50\% = 50\%$$

We need an average latency less than 6 ms. So, required miss rate will be 40%, whose cache size is 30 MB.

Hence, the correct Answer is (30).

Question Number: 61 **Question Type: MCQ**

Consider the following database schedule with two transactions T_1 and T_2.

$S = r_2(X); r_1(X); r_2(Y); w_1(X); r_1(Y); w_2(X); a_1; a_2$

Where $r_i(Z)$ denotes a *read* operation by transaction T_i on a variable Z, $w_i(Z)$ denotes a *write* operation by T_i on a variable Z and a_i denotes an *abort* by transaction T_i.

Which one of the following statements about the above schedule is true?

(A) S is non – recoverable.

(B) S is recoverable, but has a cascading abort.

(C) S does not have a cascading abort.

(D) S is strict.

Solution:

	T1	T2
1.		$r_2(X)$
2.	$r_1(X)$	
3.		$r_2(Y)$
4.	$w_1(X)$	
5.	$r_1(Y)$	
6.		$w_2(X)$
7.	a_1	
8.		a_2

There is no RW - conflict in the schedule, so it is recoverable.

– T_2 is not reading any data item which is updated by T_1.

– Abort operation performed by T_1 does not give any effect to abort operation performed by T_2.

– So the abort operations are not cascading aborts.

Hence, the correct option is (C).

Question Number: 62 **Question Type: NAT**

Consider the following database table water_ schemes:

water_schemes		
scheme_no	**District name**	**Capacity**
1	Ajmer	20
1	Bikaner	10
2	Bikaner	10
3	Bikaner	20
1	Churu	20
2	Churu	20
1	Dungargarh	10

The number of tuples returned by the following SQL query is _____.

```
with total (name, capacity) as
   select district _ name, sum
   (capacity)
   from water _ schemes
   group by district _ name
with total _avg (capacity) as
   select avg (capacity)
   from total
select name
   from total, total _ avg
   where total . capacity ≥ total_
   avg. capacity
```

Solution:

Total:

District-name	Sum(Capacity)
Ajmer	20
Bikaner	40
Churu	30
Dungargarh	10

Total - avg:

Avg(Capacity)
25

```
Select name
from total, total – avg
Where total. Capacity ≥ total - avg.
capacity
```

Ajmer 20 ≥ 25 ✗

Bikaner 40 ≥ 25 ✓

Churu 30 ≥ 25 ✓

Dungargarh 10 ≥ 25 ✗

Output:

Name
Bikaner
Churu

Hence, the correct Answer is (2).

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

A network has a data transmission bandwidth of 20×10^6 bits per second. It uses CSMA/CD in the MAC layer. The maximum signal propagation time from one node to another node is 40 microseconds. The minimum size of a frame in the network is ___ bytes.

Solution: Transmission bandwidth

$$= 20 \times 10^6 \text{ bps}$$

Propagation time = 40 μsec

Minimum size of frame = bandwidth * 2 * propagation delay

$$= 20 * 10^6 * 2 * 40 \times 10^{-6}$$

$$= 1600 \text{ bits}$$

$$= \frac{1600}{8} \text{ bytes}$$

$$= 200 \text{ bytes.}$$

Hence, the correct Answer is (200).

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

For the IEEE 802.11 MAC protocol for wireless communication, which of the following statements is/ are true?

I. At least three non-overlapping channels are available for transmissions.

II. The RTS-CTS mechanism is used for collision detection.

III. Unicast frames are ACKed.

(A) All I, II and III (B) I and III only

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

Solution: At least 3 non-overlapping channels are available for the IEEE 802.11 MAC protocol for wireless communication.

RTS - CTS mechanism is used for collision avoidance, not for detection.

In 802.11, unicast frames are acknowledged.

Hence, the correct option is (B).

Question Number: 65 **Question Type: NAT**

Consider a 128×10^3 bits/second satellite communication link with one way propagation delay of 150 milliseconds. Selective retransmission (repeat) protocol is used on this link to send data with a frame size of 1 kilobyte. Neglect the transmission time of acknowledgement. The minimum number of bits required for the sequence number field to achieve 100% utilization is _____.

Solution: Link utilization of selective repeat protocol is

$$\text{Link utilization} = \frac{\text{Window size}}{1 + 2 * a}$$

Where

$$a = \frac{T_{\text{Propagation delay}}}{T_{\text{Transmission delay}}}$$

$$T_{\text{Propagation delay}} = 150 \text{ msec.}$$

$$T_{\text{Transmission delay}} = \frac{1024 \times 8}{128 \times 10^3} = 64 \text{ msec}$$

$$a = \frac{150}{64} = 2.34375$$

Window size = 1 * (1 + 2 * 2.34375) = 5.6875

In selective repeat, the sending and receiving window sizes must be equal and half the maximum sequence number.

2* window size = maximum sequence number

$\Rightarrow$ Maximum sequence number = 2 * 5.6875 = 11.375

$\therefore$ Minimum number of bits required to generate this maximum sequence number is 4. ($\because$ $2^4 = 16 \simeq 11.375$)

Hence, the correct Answer is (4).