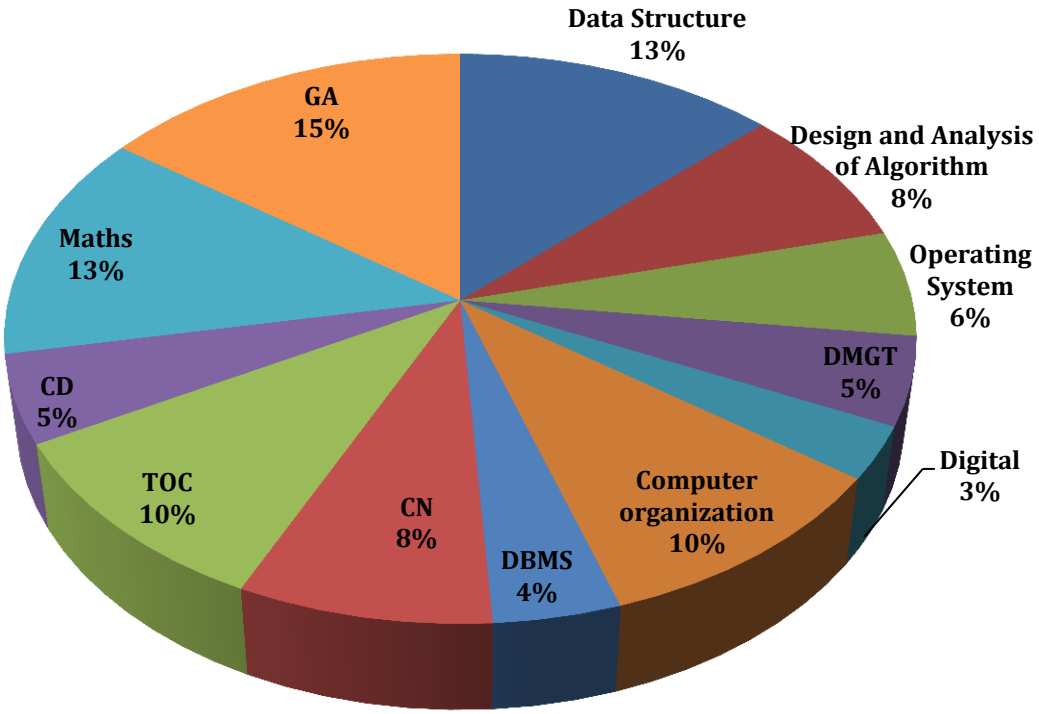
ANALYSIS OF GATE 2016
Computer Science and Information Technology



GATE-2016_CS_6-Feb _2 PM:5PM(Afternoon)

SUBJECT	NO OF QUESTION	Topics Asked in Paper	Level of Toughness	Total Marks
Data Structure	1 M: 3 2 M: 5	Algorithm Analysis; Stacks and Queues ; Height Balanced Trees ; Queues; Heaps.,Quick Short ,C Proframming,	Tough	13
Design and Analysis of Algorithm	1 M: 2 2 M: 3	Sorting Algorithms; Complexity Selections Sort ;merge sort	Moderate	8

Operating System	1 M: 2 2 M: 2	Disc Scheduling; Paging Algorithm;Critical Sections ;Optimal Replacement;	Easy	6
DMGT	1 M: 1 2 M: 2	Recurssion;Generations ;Graph;	Conceptual	5
Digital	1 M: 1 2 M: 1	JK Flip flop,Multiplexer;Combinational & Seq. circuits;	Easy	3
Computer organization	1 M: 2 2 M: 4	Pipeline;DMA cantroller ;I/O System ;Catch memory ;file system;	Tough	10
DBMS	1 M: 2 2 M: 1	Normalization ;Transaction & Concrency Control ;	Easy	4
Computer Network	1 M: 2 2 M:3	Tokan Rings;Stop & Wait;Data link Layer Protocol;Applications Layer;	Moderate	8
Theory of Computation	1 M: 4 2 M: 3	Regular Grammer & Expression, recursively enumerable,Push Down automata	Conceptual	10
Compiler Design	1 M: 1 2 M: 2	Regular Grammer & Regular Language,Sentex directed Translation;Dynamic Scoping .	Easy	5
Mathematics	1 M: 5 2 M: 4	Probability; Maximum colors sufficient to color planar graphs;Degree of polynomial Logically interference;System of linear equations;matrix -eigen value	Moderate	13
GA	1 M: 5 2 M: 5	Time & Work ; Venn Diagram ; Verbal Ability ; Probability & Distrubution;	Easy	15
Total	**65**		Moderate	**100**

Faculty Feedback: Few questions came from New Syllabus; General Ability was pretty easy; many question from DSA& CO& TOC qualifying is easy but scoring is tough. Practice previous question papers will be beneficial.

GATE 2016 Examination

Computer Science and Information Technology

Test Date: 06/02/2016

Test Time: 2:00 PM to 5:00 PM

Subject Name: COMPUTER SCIENCE AND INFORMATION TECHNOLOGY

Section: General Aptitude

Q NO. 1

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

[Ans. B]
The man who is now municipal commissioner worked as a security guard at the university

Q NO. 2

Nobody knows how the Indian cricket team is going to <u>cope with</u> 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

[Ans. A]
Nobody knows how the Indian cricket team is going to put up with difficult and seamer friendly wickets in Australia

Q NO. 3

Find the odd one in the following group of words.

mock, deride, praise, jeer

(A) mock (B) deride (C) praise (D) jeer

[Ans. C]

Mock, Deride, Jeer all are synonyms

Q NO. 4

Pick the odd one from the following options.

(A) CADBE (B) JHKIL (C) XVYWZ (D) ONPMQ

[Ans. D]

In option A, B, C 2nd letter and 1st letter is 2. In option D it is 1.

Q NO. 5

In a quadratic function, the value of the product of the roots (α, β) is 4. Find the value of

$$\frac{\alpha^n + \beta^n}{\alpha^{-n} + \beta^{-n}}$$

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

[Ans. B]

Let $n = 1$, then $\dfrac{\alpha^n + \beta^n}{\alpha^{-n} + \beta^{-n}} = \dfrac{\alpha^n + \beta^n}{\frac{1}{\alpha^n} + \frac{1}{\beta^n}} = \alpha^n\beta^n = 4^n = \alpha\beta = 4$

$\therefore$ $n = 2$, then $\dfrac{\alpha^2 + \beta^2}{\alpha^{-2} + \beta^{-2}} = \alpha^2\beta^2 = 4^2$

$\therefore$ $n = 3$, then $\dfrac{\alpha^3 + \beta^3}{\frac{1}{\alpha^3} + \frac{1}{\beta^3}} = \alpha^3\beta^3 = 4^3$

So, for n, solution is 4^n

Q NO. 6

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

[Ans. A]

150 faculty member, 30 don't have Facebook or whatsapp. Thus, 120 are connected by whatsapp or Facebook. Among then, 85 connected through whatsapp, the, (120 – 85)= 35 connected only through Facebook

Q NO. 7

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)

[Ans. D]

The first and second sentences tell us that computers are invented for computation and internet for intended invention. These sentences lead to option ii so option (B) is the right inference.

Q NO. 8

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)

[Ans. D]

Statement (i) is not true because Ooty is a hill station due Ooty has two lakes statement (ii) is also not true, because in given statements, for hill station one lake is compulsory but not mentioned about number of lakes.

Q NO. 9

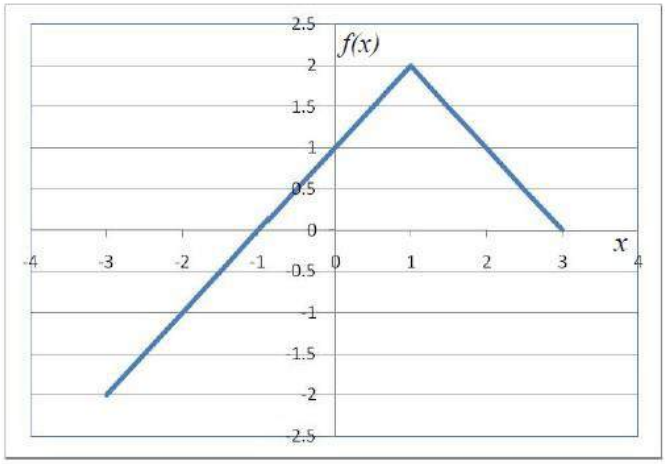
In a 2 × 4 rectangle grid shown below, each cell is a rectangle. How many rectangles can be observed in the grid?

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

[Ans. C]

In given 2 × 4 rectangle grid, the following type of rectangles are present.
One figured rectangles = 8
Two figured rectangles = 10
Three figured rectangles = 4
Four figured rectangles = 5
Six figured rectangles = 2
Eight figured rectangles = 1
Total No. of rectangles = 30
∴ The No. of rectangles observed in the given grid = 30.

Q NO. 10



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

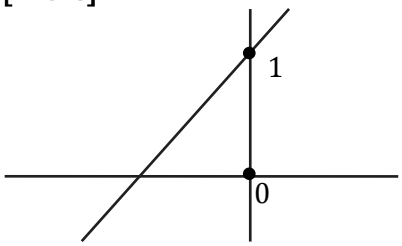
(A) $f(x) = 1 - |x - 1|$

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

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

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

[Ans. C]



At $x = 0$ $f(0) = 1$
Put $x = 0$ in all options. You will get
$f(x) = 2 - |x - 1| = 1|_{x=0}$
Rest of the option do not match

Section: Technical

Q NO. 1

Consider the following expressions:

(i) *false*

(ii) Q

(iii) *true*

(iv) $P \vee Q$

(v) $\neg Q \vee P$

The number of expressions given above that are logically implied by $P \wedge (P \Rightarrow Q)$ is _____ .

[Ans. *] Range: 4 to 4

Q NO. 2

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 _____ .

[Ans. *] Range: 9 to 9

If f(x) is a polynomial of degree 'n'

Then $f'(x)$ is a polynomial of degree $(n - 1)$

$f(x) + f(-x)$ is a polynomial of degree 10

$\therefore g(x) - g(-x)$ is polynomial of degree 9

Q NO. 3

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

[Ans. *] Range: 4 to 4

By 4-color theorem, every planar graph is 4-colorable

Q NO. 4

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

[Ans. C]

(i) Consider 2 equations in 3 variables

$x - y + z = 1$

$-x + y - z = 2$

This system has no solution (inconsistent)

$x = 1$ and $y = 1$

$\therefore$ I is false

(ii) Consider 3 equations in two variables.

$x + y = 2$

$x - y = 0,$

$3x + y = 4$

This system has a unique solution

$\therefore$ II is false

(iii) Consider a system with 2 equations and 2 variables

$x + y = 2$ and $x - y = 0$

The system has a solution $x = 1$ and $y = 1$

$\therefore$ Option (C) is true

Q NO. 5

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 _____ .

[Ans. *] Range: 0.55 to 0.55

A → event of selection of type-1 bulb

B → event of selection of type-2 bulb

E → event of selection of bulb glow for more than 100 hrs

$$\text{We require } P(A)P(E/A) + P(B)P(E/B) = \frac{1}{2} \times 0.7 + \frac{1}{2} \times 0.4 = 0.55$$

Q NO. 6

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

[Ans. *] Range: 0.124 to 0.126

$\lambda = 1, 2, 4$

$|A| = 1 \times 2 \times 4 = 8$

$\Rightarrow |A^{-1}| = \frac{1}{|A|} = \frac{1}{8}$

$$\therefore \left|(A^{-1})^T\right| = |A^{-1}| = \frac{1}{8}$$

Q NO. 7

Consider an eight-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 _____ .

[Ans. *] Range: -1 to -1

When all bits in 'B' register is '1', then only it gives highest delay.

∴ '–1' in 8 bit notation of 2's complement is 1111 1111

Q NO. 8

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) $x_1 + x_2 + x_3 + x_4 = 0$

[Ans. C]

For all cases option A, B and D not satisfies.

Q NO. 9

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 _____ .

[Ans. *] Range: 1 to 1

The range (or) distinct values
For 2's complement $\Rightarrow -(2^{n-1})$ to $+ (2^{n-1} - 1)$
For sign magnitude $\Rightarrow -(2^{n-1} - 1)$ to $+ (2^{n-1} - 1)$
Let, $n = 2 \Rightarrow$ in 2's complement
$-(2^{2-1})$ to $(2^{2-1} - 1)$
-2 to $+1 \Rightarrow -2, -1, 0, +1 \Rightarrow x = 4$
$n = 2$ in sign magnitude $\Rightarrow -1$ to $+1 \Rightarrow y = 3$
$x - y = 1$

Q NO. 10

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 _____ .

[Ans. *] Range: 16 to 16

$\longleftarrow 32 \longrightarrow$

Operation	A_1	A_2	Operand
$\log_2^{40}$	$\log_2^{24}$	$\log_2^{24}$	
6	5	5	xxx

$\therefore 32 - 16 = 16$

Q NO. 11

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 _____ .

[Ans. *] Range: 31 to 31

Maximum possible happens when we have complete tree and our 't' node is the last leaf node at height 4
So, $1 + 2 + 4 + 8 + 16 = 31$ is the 't' node

Q NO. 12

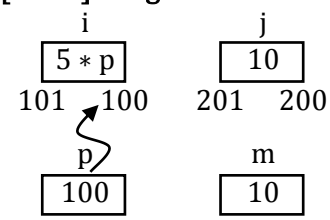
The value printed by the following program is _____ .

```
void f(int* p, int m){
   m = m + 5;
   *p = *p + m;
   return;
}

void main(){
   int i=5, j=10;

   f(&i, j);
   printf("%d", i+j);
}
```

[Ans. *] Range: 30 to 30



$m = m + 5; //m = 15$

$*p = *p + m; //*p = 5 + 15$

$*p = 20$ (i.e., $i = 20$)

$i + j = 20 + 10 = 30$

Q NO. 13

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. Quicksort runs in $\Theta(n^2)$ time

II. Bubblesort runs in $\Theta(n^2)$ time

III. Mergesort 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

[Ans. D]

(i) Quicksort will take worst case, if the input is in ascending order i.e. $\Theta(n^2)$

(ii) Insertion sort takes $\Theta(n)$

Q NO. 14

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.

[Ans. C]

Q NO. 15

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: $\Theta(N)$ *delete*, $O(\log N)$ *insert*, $O(\log N)$ *find*, and $\Theta(N)$ *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) $\Theta(N^2 \log N)$

[Ans. C]

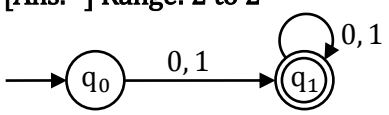
Q NO. 16

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 _____ .

[Ans. *] Range: 2 to 2



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

The number of states in minimal DFA is 2

Q NO. 17

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

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

Consider the following statements:

P: L_1 is regular

Q: L_2 is regular

Which one of the following is **TRUE**?

(A) Both P and Q are true

(B) P is true and Q is false

(C) P is false and Q is true

(D) Both P and Q are false

[Ans. C]

L_1: $S_1 \rightarrow aS_1\, b|\varepsilon$

L_2: $S_2 \rightarrow abS_2\, |\varepsilon$

L_1: $\{a^n\, b^n | n > 0\} \rightarrow$ CFL

L_2: $(ab)^* \rightarrow$ RL

P is false and Q is true

Q NO. 18

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

[Ans. D]

L_1: Regular
L_2: CFL
L_3: Recursive language
L_4: REL

(i) $\overline{L_3}$ is Recursive
$\overline{L_3} \cup L_4$ is REL

(ii) $\overline{L_2}$ is recursive
$\overline{L_3}$ is recursive
$\Rightarrow \overline{L_2} \cup L_3$ is also recursive

(iii) L_1^* is regular
L_2 is CFL
$\Rightarrow L_1^* \cap L_2$ is CFL

Since, CFL is closed under the intersection with RL
$\therefore$ RL $\cap$ CFL is CFL

(iv) L_1 is RL
$\overline{L_2}$ is recursive
$\Rightarrow L_1 \cap \overline{L_2}$ is CFL is not possible

$\therefore$ (i), (ii) and (iii) are correct

Q NO. 19

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

[Ans. B]

Q NO. 20

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)

[Ans. D]

Q NO. 21

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 differ by at most 1.

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

[Ans. A]

A Tree is balanced, if the lengths of the paths from the root to all leaf nodes are all equal

Q NO. 22

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

[Ans. A]

If a schedule is serializable, the topological order of a graph (Precedence graph) yields a serial schedule

Q NO. 23

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.

[Ans. A]

Sign is sender's private key and the receiver side the verification is done with sender public key

Q NO. 24

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 backoff mechanism reduces the probability of collision on retransmissions.

[Ans. D]
The concept of binary exponential back-off algorithm.
The exponential back-off mechanism reduces the probability of collision on retransmissions

Q NO. 25

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

[Ans. C]
The concept to be followed
Step 1: The client (browser) initiates a DNS query for remote server. It may be that they already have this server in their DNS cache, in which case the client may simply send a TCP SYN directly to the application server.
Step 2: The client will next send a connection request to the application server. This will be a TCP SYN packet, the first in the TCP three-way handshake.
Step 3: Next, after the TCP connection has been established, the client will request data from the server. In the web-based application, the client performs an HTTP GET

Q NO. 26

A binary relation R on $\mathbb{N} \times \mathbb{N}$ 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.

[Ans. B]

Q NO. 27

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

(A) $(\forall x\, p(x) \Rightarrow \forall x\, q(x)) \Rightarrow (\exists x \neg p(x) \vee \forall x\, q(x))$
(B) $(\exists x\, p(x) \vee \exists x\, q(x)) \Rightarrow \exists x\, (p(x) \vee q(x))$
(C) $\exists x\, (p(x) \wedge q(x)) \Rightarrow (\exists x\, p(x) \wedge \exists x\, q(x))$
(D) $\forall x\, (p(x) \vee q(x)) \Rightarrow (\forall x\, p(x) \vee \forall x\, q(x))$

[Ans. D]

(A) The well-formed formula (wff) is valid, because L.H.S $\Leftrightarrow$ R.H.S
(B) The wff is valid, because L.H.S $\Leftrightarrow$ R.H.S.
(C)

1.	$\exists x\{p(x) \wedge q(x)\}$	Premise
2.	$p(a) \wedge q(a)$	(1), E.S
3.	$p(a)$	(2), simplification
4.	$q(a)$	(2), simplification
5.	$\exists x\, p(x)$	(3), E.G
6.	$\exists x\, q(x)$	(4), E.G
7.	$\exists x\, p(x) \wedge \exists x q(x)$	(5), (6) conjunction

Proved

(D) Let, p(x): x is politician
And q(x); x is a sportsman
Let, U = {Sachin Tendulkar, M.S. Dhoni, Rahul Gandhi}
Be the universe of discourse.
Here antecedent of the implication is true but consequent is false.
∴ Option D is not valid

Q NO. 28

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 $U \setminus S$ reacts with an odd number of compounds.

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

III. Each compound in $U \setminus S$ 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

[Ans. B]

Let us denote the problem by a non-directed graph with 23 vertices (compounds). If two compounds react with each other, then there exists an edge between the corresponding vertices. In the graph, we have 9 vertices with degree 3(odd degree). By sum of degrees of vertices theorem atleast one of the remaining vertices should have odd degree.

Q NO. 29

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

[Ans. *] Range: 4 to 4

By 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, 17 is a prime number and 17 is not a divisor of 13.

$\therefore 13^{16} = 1 \pmod{p}$

$(13)^{99} = (13)^{96}.(13)^3 = (13^{16})^6.2197 = 1^6.2197 \pmod{17}$

$\therefore 13^{99} \pmod{17} = 2197 \pmod{17} = 4$

(The remainder obtained by dividing 2197 with 17)

Q NO. 30

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 $1 \leq i \leq 10$. Ignoring all other delays, the minimum time required to complete this computation is _____ nanoseconds.

[Ans. *] Range: 28 to 28

Q NO. 31

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 twelve-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 _____ .

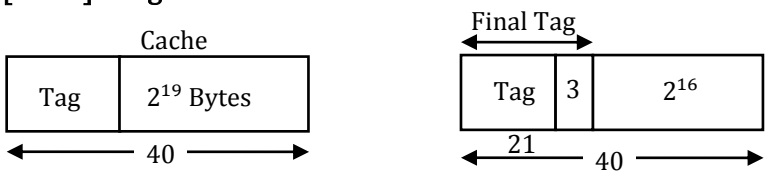
[Ans. *] Range: 500 to 500

One instruction needs 34 bit,
So number of bytes needed = 5
Program size = 100
∴ Size of the memory in bytes = 500

Q NO. 32

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.

[Ans. *] Range: 24 to 24



It uses 8 way set associative
∴ Tag size = 24 bits

Q NO. 33

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 pipeline stage is split into two pipeline stages of equal latency, the new frequency is _____ GHz, ignoring delays in the pipeline registers.

[Ans. *] Range: 4 to 4

Stage 1 (t_1)	Stage 2 (t_2)	Stage 3 (t_3)
$(3/4)\ t_2$	$1t_2$	$(3/8)t_2$

Old pipe line Clock frequency is 3GHz if time is t2.

Stage 1 (t_1)	Stage 21 (t_{21})	Stage 22 (t_{22})	Stage 3 (t_3)
$(3/4)t_2$	$(t_2/2)$	$(t_2/2)$	$(3/8)t_2$

Clock frequency of new pipeline with time $\left(\frac{3}{4}\right) t_2 \rightarrow \frac{4}{3} \times 3 \text{ GHz} = 4\text{GHz}$

Q NO. 34

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 at depth 0. The maximum depth at which integer 9 can appear is _____.

[Ans. *] Range: 8 to 8

Q NO. 35

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) $(res * a)^Y = (res * X)^b$

(C) $X^Y = res * a^b$

(D) $X^Y = (res * a)^b$

[Ans. C]

$$X^Y = res * a^b$$

Q NO. 36

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

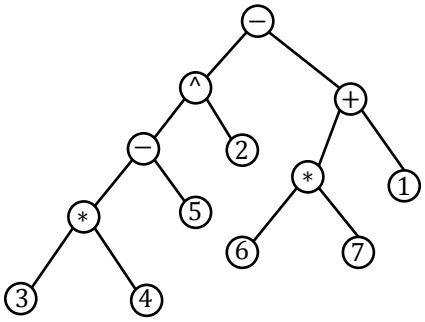
(C) - + 1 * 7 6 ^ 2 - 5 * 4 3

(D) 1 7 6 * + 2 5 4 3 * - ^ -

[Ans. C]

Converse preorder

1. Root
2. RST
3. LST



Q NO. 37

Consider the following program:

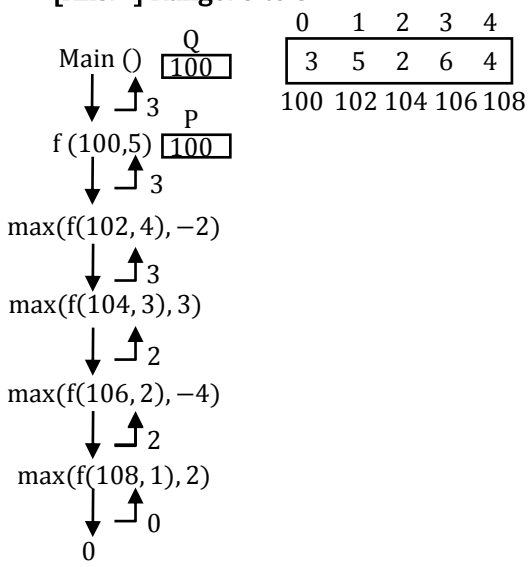
```
int f(int *p, int n)
{
   if (n <= 1) return 0;
   else return max(f(p+1,n-1),p[0]-p[1]);
}

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 _____ .

[Ans. *] Range: 3 to 3



Q NO. 38

Let A_1, A_2, A_3, and A_4 be four matrices of dimensions $10 \times 5, 5 \times 20, 20 \times 10$, 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 _____ .

[Ans. *] Range: 1500 to 1500

Let m_{14} denote minimum number of scalar multiplication to multiply sequence $M_1M_2M_3M_4$

Where, $M_1 = A, M_2 = B, M_3 = C, M_4 = D$

Let $d_0 = 10, d_1 = 5, d_2 = 20, d_3 = 10, d_4 = 5$

$\therefore\ m_{11} = m_{22} = m_{33} = m_{44} = 0$

$m_{12} = 1000\ m_{23} = 1000\ m_{34} = 1000\ m_{13} = 1500\ m_{24} = 1250$

$$m_{14} = \min\begin{Bmatrix} m_{11} + m_{21} + d_o \times d_1 \times d_4 \\ m_{12} + m_{34} + d_1 \times d_2 \times d_4 \\ m_{13} + m_{44} + d_0 \times d_3 \times d_4 \end{Bmatrix} = 1500$$

(OR)

There are 5 possible cases

A(B(C D)), A((BC)D), ((AB)C)D, (A(BC))D, (AB)(CD).

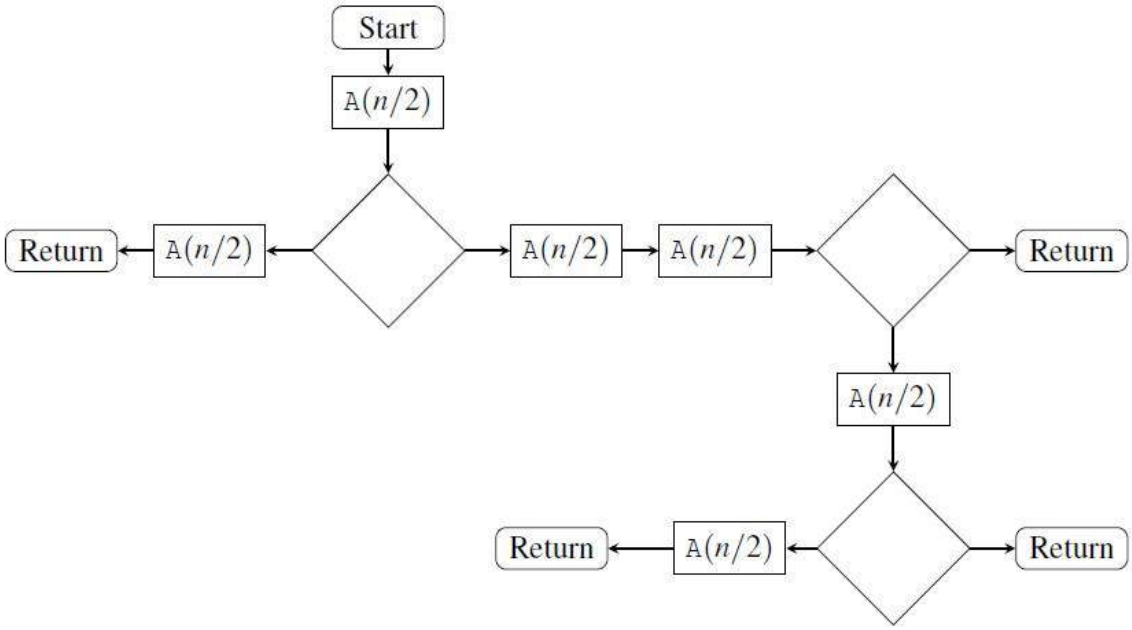
The scalar multiplications required are 1750, 1500, 3500, 2000, 3000 respectively.

$\therefore$Minimum number of scalar multiplications = 1500

Q NO. 39

The given diagram shows the flowchart for a recursive function $\mathtt{A}(n)$. 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 _____ .

Flowchart for Recursive Function $\mathtt{A}(n)$



[Ans. *] Range: 2.2 to 2.4

Q NO. 40

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.

[Ans. *] Range: 64 to 64

Formula is 2^n, here n is 6

$2^6 = 64$

Q NO. 41

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) $\Theta(n^4)$

[Ans. B]

Q NO. 42

Consider the following two statements:

I. If all states of an NFA are accepting states then the language accepted by the NFA is Σ^*.

II. There exists a regular language A 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

[Ans. B]

Q NO. 43

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.

[Ans. B]

$L_1: \{a^n\, b^m c^{n+m} | m, n \geq 1\} - \text{CFL}$

$L_2 = \{a^n b^n c^{2n} |\ n \geq 1\} - \text{CFL}$

L_1 is CFL but L_2 is Not CFL

Q NO. 44

Consider the following languages.

$$\begin{aligned} L_1 &= \{\langle M \rangle \mid M \text{ takes at least 2016 steps on some input}\}, \\ L_2 &= \{\langle M \rangle \mid M \text{ takes at least 2016 steps on all inputs}\} \text{ and} \\ L_3 &= \{\langle M \rangle \mid M \text{ accepts } \varepsilon\}, \end{aligned}$$

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 and L_3 is not recursive

(D) L_1, L_2, L_3 are recursive

[Ans. C]

L_1 is Recursive

L_2 is Recursive

L_3 is Not Recursive

Q NO. 45

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

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

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

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

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

[Ans. B]

$$\left.\begin{array}{r} s \rightarrow Ab \mid Bb \mid \in \\ A \rightarrow Bd \mid \in \\ B \rightarrow e \end{array}\right\} \text{Generates finite language}$$

No recursion at all

Q NO. 46

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**
$D \rightarrow \textbf{int}\, L;$	$D \rightarrow \textbf{int}\, L;$
$L \rightarrow \textbf{id}\, [E$	$L \rightarrow \textbf{id}\, E$
$E \rightarrow \textbf{num}]$	$E \rightarrow E[\textbf{num}]$
$E \rightarrow \textbf{num}]\,[E$	$E \rightarrow [\textbf{num}]$

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**

[Ans. A]

G_1	G_2
D → int L;	D → int L;
L → id [E	L → id E
E → num]	E → E[num]
E → num][E	E → [num]

int a [10] [3];

From G_1:

D → int L;
→ int id [E];
→ int a [num];

[OR]

D → int L;
→ int a [E];
→ int a [num][E
→ int a [num][num]
→ int a [10][3];

From G_2:

D → int L;
→ int id E;
→ int a E[num];
→ int a [num][num];
→ int a [10][3];

∴ Both G_1 & G_2 generates the string
int a [10] [3];

Q NO. 47

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.

[Ans. *] Range: 8.2 to 8.3

Q NO. 48

Consider the following two-process synchronization solution.

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

[Ans. C]

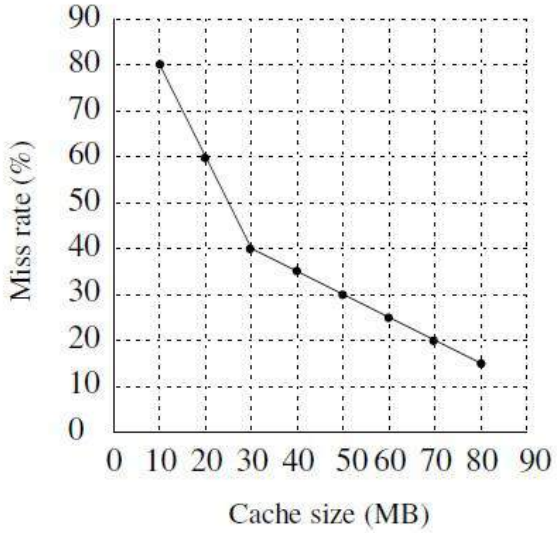
Q NO. 49

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 _____ .

[Ans. *] Range: 7 to 7

Q NO. 50

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.

[Ans. *] Range: 30 to 30

Q NO. 51

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

[Ans. C]

As there is no dirty-read in the given schedule, the schedule is both recoverable and cascadeless.

Q NO. 52

Consider the following database table named *water_schemes* :

water_schemes		
scheme_no	**district_name**	**capacity**
1	Ajmer	20
1	Bikaner	10
2	Bikaner	10
3	Bikaner	20
1	Churu	10
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
```

[Ans. *] Range: 2 to 2

The result of the query is: <u>name</u>

Bikaner

churu

Total	
Name	Capacity
Ajmeer	20
Bikaner	40
Churu	30
Dungargarh	10

Total_avg
Capacity
25

Q NO. 53

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.

[Ans. *] Range: 200 to 200

$L = ?$
$B = 20$ Mbps
$T_p = 40$ micro sec
$T_x = L/B = 100$ ms
$T_x = 2T_p$
$L_{min} = 2T_P B = 2(40).(20)/8 = 200$ Bytes

Q NO. 54

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

[Ans. B]

RTS and CTS mechanism is used for collision avoidance, not collision detection

Q NO. 55

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 _____ .

[Ans. *] Range: 4 to 4

5 step problem

1. Calculate RTT $= 2(T_p)$
2. Calculate BR, window size in bits
3. Calculate W = window in packets = BR/L
4. For selective repeat, ASN is set to 2W
5. Sequence number, k

Bandwidth (B) $= 128\times 10^3$ bps

Propagation delay $(T_p) = 150$ msec

Packet size (L) = 1 kilobyte

Transmission delay $(T_t) = \frac{L}{B}$

$$T_t = \frac{1 \times 8 \times 10^3 \text{ bits}}{128 \times 10^3 \text{ bps}}$$

$$\Rightarrow T_t = \frac{1}{16}\text{sec}$$

$T_t = 64$ msec

W_S = sender window size

$$\eta = \frac{W_c \times T_t}{T_t + 2T_p}$$

$$1 = \frac{W_S \times 64}{64 + 2 \times 150}$$

$$\frac{364}{64} = W_S$$

$W_S = 5.6875$

$W_S + W_R$ = Available sequence numbers for Selective retransmission $W_S = W_R$

$ASN = 2 \times W_S$

$ASN = 2 \times 5.6875$

$ASN = 11.375$

$$\text{No. of bits in the sequence number} = [\log_2 ASN]$$
$$= [\log_2^{11.375}]$$
$$= 4$$