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GATE 2016

Detailed Solutions For
Computer Science and Information Technology

Date: 06-02-2016
Afternoon Session

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General Aptitude

Q.1 – Q.5 carry one mark each

01. 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

01. Ans: (B)

Sol: Option (A) and (D) cannot be the answer because of the word 'the security'.

02. 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

02. Ans: (A)

Sol: 'cope with' means put up with.

03. Find the odd one in the following group of words.

mock, deride, praise, jeer

(A) mock (B) deride

(C) praise (D) jeer

03. Ans: (C)

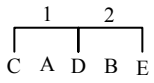
Sol: 'mock, deride and jeer' are synonyms which means mockery. Therefore the odd one is 'praise'.

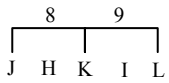
04. Pick the odd one from the following options.

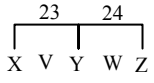
(A) CADBE (B) JHKIL

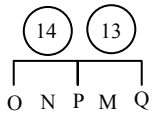
(C) XVYWZ (D) ONPMQ

04. Ans: (D)

Sol: (A) 

(B) 

(C) 

(D) 

In options A, B and C, the letters skipped between consecutive pair of letters in the English alphabet is in increasing order (i,e) A and B, H and I and V and W but in option 'D' N and M are present instead of M and N so, option 'D' is odd one from the group.

05. 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}

05. Ans: (B)

Sol:

$$\frac{\alpha^n+\beta^n}{\alpha^{-n}+\beta^{-n}}=\frac{\alpha^n+\beta^n}{\frac{1}{\alpha^n}+\frac{1}{\beta^n}}$$

$$\frac{\alpha^n+\beta^n}{\frac{\beta^n+\alpha^n}{\alpha^n+\beta^n}}=\alpha^n\times\beta^n$$

$$\alpha^n\times\beta^n=(\alpha\times\beta)^n$$

$$=(4)^n$$

Q.6 – Q.10 carry two marks each

06. 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

06. Ans: (A)

Sol: Total faculty members = 150

The faculty members having facebook account = FB = 55

The faculty members having whatsApp = W = 85

The faculty members do not have face book (or) WhatsApp accounts = 30

The faculty members having any account = 150 – 30 = 120

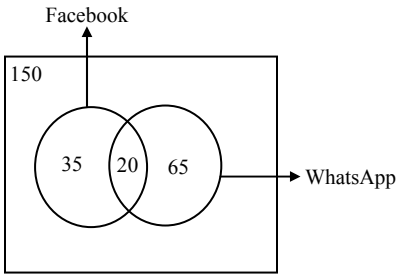
The faculty members having both the accounts = (FB + W) – 120

= (55 + 85) – 120

= 20

$\therefore$ The number of faculty members connected only through Facebook accounts = 55 – 20

= 35



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07. 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)

07. Ans: (B)

Sol: 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.

08. 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.

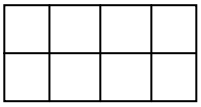
(A) (i) only (B) (ii) only

(C) both (i) and (ii) (D) neither (i) nor (ii)

08. Ans: (D)

Sol: 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.

09. 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

09. Ans: (C)

Sol: 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

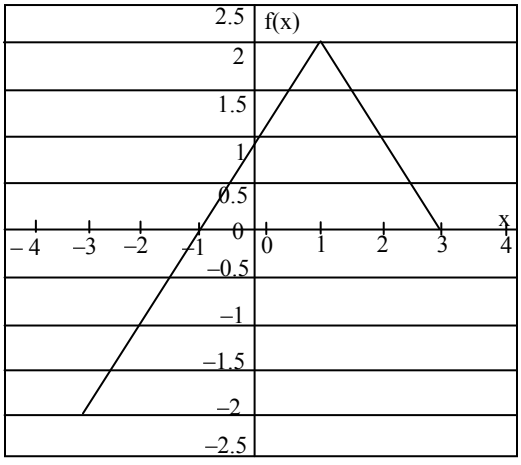
Six figured rectangles = 2

Eight figured rectangles = 1

Total No. of rectangles = 30

$\therefore$ The No. of rectangles observed in the given grid = 30.

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|

10. Ans: (C)

Sol: @ x = 3 from given graph f(x) must be equals to zero

Option A

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

@ x = 3

$f(x) = 1 - |3 - 1|$

$= 1 - 2 = -1$

So, it is not

Option B

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

@ x = 3

$f(x) = 1 + |3 - 1|$

$= 1 + 2 = 3$

So, it is not

Option C

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

@ x = 3

$f(x) = 2 - |3 - 1|$

$= 2 - 2 = 0$

So, it is true

Option D

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

@ x = 3

$f(x) = 2 - |3 - 1|$

$= 2 + 2 = 4$ So, it is not

Q.1 - Q.25 carry one mark each

01. 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_____.

01. Ans: 3

Sol: i. $P \wedge (P \rightarrow Q) \Rightarrow Q$ ii. $P \wedge (P \rightarrow Q) \Rightarrow P \vee Q$

iii. $P \wedge (P \rightarrow Q) \Rightarrow \sim Q \vee P$

(OR)

The expressions ii, iii, and iv are logically implied by $P \wedge (P \rightarrow Q)$.

Q follows from $P \wedge (P \rightarrow Q)$ by the rule of modus ponens.

The expression true is followed by any proposition.

$(P \vee Q)$ follows from Q by simplification.

02. 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_____.

02. Ans: 9

Sol: 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 a polynomial of degree 9

(OR)

If degree of $\{f(x) + f(x)\} = 10$, then the largest even exponent of x in $f(x) = 10$. Now, the largest odd exponent of x in $g(x) = 9$

$\therefore$ degree of $\{g(x) - g(-x)\} = 9$

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

03. Ans: 4

Sol: Every planar graph 4 – colorable.

(OR)

By 4 – color theorem, Every planar graph is 4 – colorable

04. 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

04. Ans: (C)

Sol: 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 $y = 1$

$\therefore$ III is true

05. 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___.

05. Ans: 0.55

Sol: 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

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

(OR)

The probability that the bulb is type I and lasting more than 100 hrs $= \frac{1}{2}(0.7)$

The probability that the bulb is type II and lasting more than 100 hrs $= \frac{1}{2}(0.4)$

Required probability $= \frac{1}{2}(0.7) + \frac{1}{2}(0.4) = 0.55$

06. Suppose that the eigen values of matrix A are 1, 2, 4. The determinant of $(A^{-1})^T$ is_____.

06. Ans: 0.125

Sol: $\lambda = 1, 2, 4$

$|A| = 1 \times 2 \times 4 = 8 \qquad \Rightarrow |A^{-1}| = \frac{1}{|A|} = \frac{1}{8}$

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

(OR)

Eigen values of A are 1, 2, 4

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

$$\left|A^{-1}\right| = 1.\left(\frac{1}{2}\right).\left(\frac{1}{4}\right) = \frac{1}{8}$$

$$\left|A^{-1}\right|^{T} = \left|A^{-1}\right| = \frac{1}{8} = 0.125$$

07. 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_____.

07. Ans: –1

Sol: 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

08. 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) $x_1x_2x_3x_4 = 0$ (B) $x_1x_3 + x_2 = 0$

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

08. Ans: (C)

Sol: For all cases option A, B, D not satisfy.

09. 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_____.

09. Ans: 1

Sol: 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 $+1 \Rightarrow -2, -1, 0, +1 \Rightarrow x = 4$

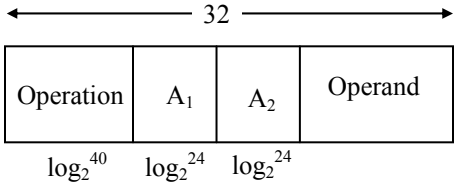
$n = 2$ in sign magnitude $\Rightarrow -1$ to $+1 \Rightarrow y = 3$

$x - y = 1$

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_____.

10. Ans: 16

Sol:



$\therefore$ 32 – 16 = 16

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_____.

11. Ans: 31

Sol: 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.

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);
}
```

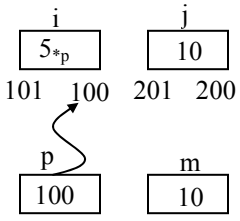
12. Ans: 30

Sol: m = m + 5; // m = 15

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

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

i + j = 20 + 10 = 30



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

13. Ans: (D)

Sol: 1. Quicksort will take worst case, if the input is in ascending order i.e $\Theta(n^2)$

2. Insertion sort takes $\Theta(n)$

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.

14. Ans: (C)

Sol: Dynamic programming

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)

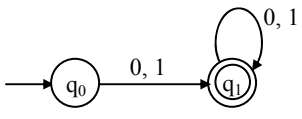
(C) $O(N^2)$ (D) $\Theta(N^2 \log N)$

15. Ans: (C)

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 _____.

16. Ans: 2

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



The number of states in minimal DFA is 2

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

17. Ans: (C)

Sol: L_1: $S_1 \rightarrow aS_1\, b \mid \varepsilon$

L_2: $S_2 \rightarrow abS_2 \mid \varepsilon$

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

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

P is false and Q is true

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

18. Ans: (D)

Sol: 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

$\Rightarrow L_1 \cup \overline{L}_2$ is CFL is not possible

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

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 $\leftrightarrow$ i , Q $\leftrightarrow$ ii, R $\leftrightarrow$ iv, S $\leftrightarrow$ iii

(B) P $\leftrightarrow$ iii, Q $\leftrightarrow$ i, R $\leftrightarrow$ ii, S $\leftrightarrow$ iv

(C) P $\leftrightarrow$ ii, Q $\leftrightarrow$ iii, R $\leftrightarrow$ i, S $\leftrightarrow$ iv

(D) P $\leftrightarrow$ iv, Q $\leftrightarrow$ i, R $\leftrightarrow$ ii, S $\leftrightarrow$ iii

19. Ans: (B)

Sol: Matching the following

P ↔ iii

Q ↔ i

R ↔ ii

S → iv

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)

20. Ans: (D)

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.

21. Ans: (A)

Sol: A Tree is balanced, if the length of the paths from the root to all leaf nodes are all equal.

22. Suppose a database schedule S involves transactions T_1, ..., 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

22. Ans: (A)

Sol: If a schedule is serializable, the topological order of a graph (precedence graph) yields a serial schedule.

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

23. Ans: (A)

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

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.

24. Ans: (D)

Sol: The concept of binary exponential backoff algorithm
The exponential backoff mechanism reduces the probability of collision on retransmissions

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

25. Ans: (C)

Sol: 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.26 - Q.55 carry two marks each

26. A binary relation R on N×N is defined as follows: (a,b)R(c,d) if a≤c or b≤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.

26. Ans: (A)

Sol: Reflexive: (a, a) R(a, a)

Since $a \le a$, and $a \le a$

Transitive: (a, b) R (c, d) and (c, d) R(m, n) then (a, b) R(m, n)

Suppose (a, b) R(c, d)

$\Rightarrow a \le c$ and $b \le d$

and (c, d) R(m, n)

$\Rightarrow c \le m, d \le n$

Since $a \le c$, and $c \le m$ so $a \le m$

$b \le d$ and $d \le n$, so $b \le n$

$\therefore$ (a, b) R(m, n)

(OR)

P: we have $a \le a$ and $b \le b$

$\Rightarrow$ (a, b) R(a, b)

$\Rightarrow$ R is reflexive

$\therefore$ P is true

Q: Let (a, b) R(c, d) and (c, d) R (e, f)

$\Rightarrow \{a \le c \text{ and } b \le d\}$ and $\{ c \le e \text{ and } d \le f\}$

$\Rightarrow \{a \le e \text{ and } b \le f\}$

$\Rightarrow$ (a, b) R (e, f)

$\Rightarrow$ R is transitive

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) $\forall x (p(x) \vee q(x)) \Rightarrow (\forall x p(x) \vee \forall x q(x))$

27. Ans: (D)

Sol: (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 a 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.

$\therefore$ (D) is not valid.

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\S reacts with an odd number of compounds.

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

III. Each compound in U\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

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EC

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28. Ans: (B)

Sol: 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.

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

29. Ans: 4

Sol: 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)

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.

30. Ans: 30

Sol: 5*G + 3*F = 3*5 + 5*3 = 30 ns

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_____.

31. Ans: 500

Sol: One instruction needs 34 bit,

So number of bytes needed = 5

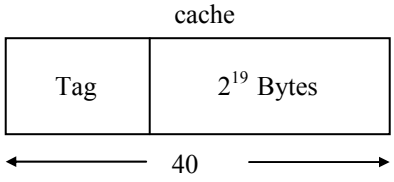
Program size = 100

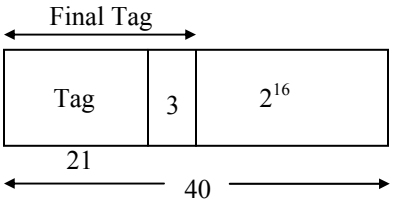
$\therefore$ Size of the memory in bytes = 500

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

32. Ans: 24

Sol:





It uses 8 way set associative

$\therefore$ Tag size = 24 bits.

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.

33. Ans: 4

Sol:

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

Old pipe line Clock frequency is 3GHz if time is t_2.

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 $(3/4)t_2 \rightarrow \frac{4}{3} \times 3$ GHz = 4 GHz

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_____.

34. Ans: 8

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

35. Ans: (C)

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

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

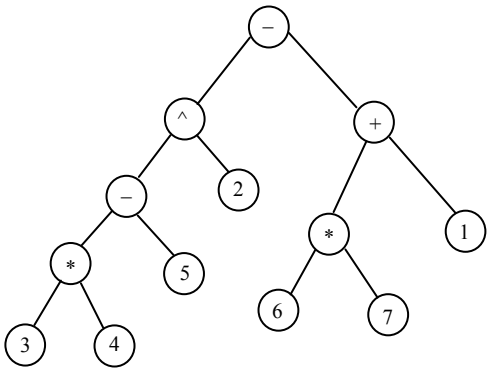
(C) – + 1 * 7 6 ^ 2 – 5 * 4 3

(D) 1 7 6 * + 2 5 4 3 * – ^ –

36. Ans: (C)

Sol: Converse preorder

1. Root
2. RST
3. LST



37. Consider the following program:

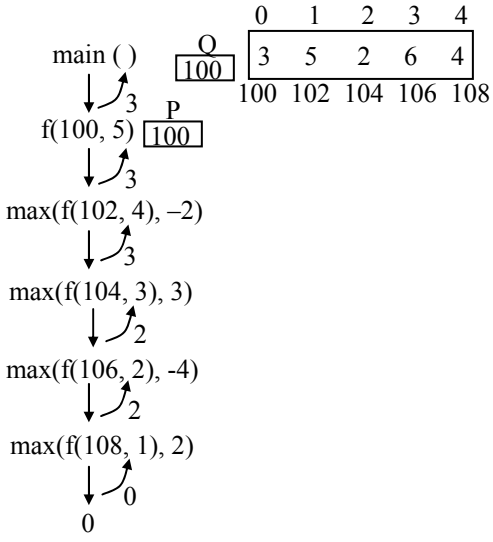
```
int f(int *p, int n)
{
  if (n <= 1) return 0;
  else
        return max(f(p+1,n–1), p[0] – p[1]);
}
int main()
{
  int a[ ] = {3,5,2,6,4};
  printf("%d", f(a,5));
}
```

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

The value printed by this program is_____.

37. Ans: 3

Sol:



38. 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_____.

38. Ans: 1500

Sol: 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 $d_0 = 10$, $d_1 = 5$, $d_2 = 20$, $d_3 = 10$, $d_4 = 5$

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

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

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

(OR)

There are 5 possible cases

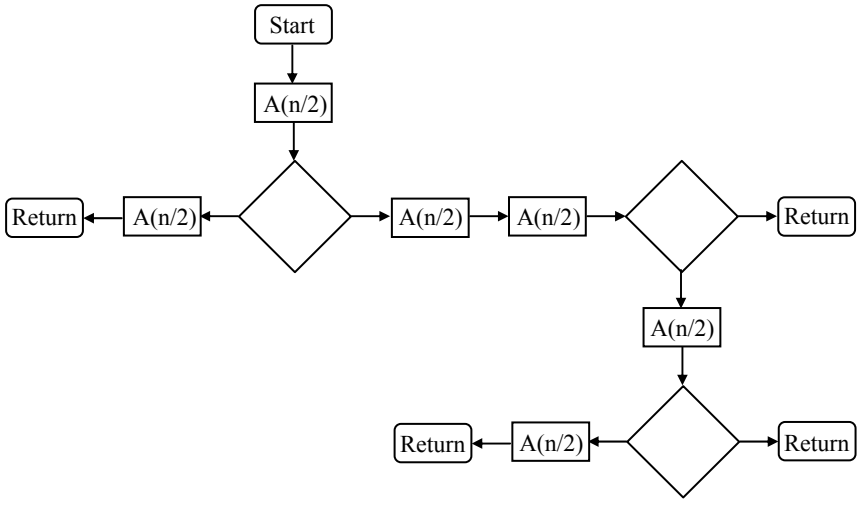
A(B(C D)), A((BC)D), ((AB)C)D, (A(BC))D, (AB)(CD).

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

$\therefore$ Minimum number of scalar multiplications = 1500

39. 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 _____.

Flow chart for Recursive Function A(n)



39. Ans: 2.32

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

40. Ans: 64

Sol: Formula is 2^n, here n is 6

$2^6 = 64$

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) $\Theta(n^4)$

41. Ans: (B)

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

42. Ans: (D)

Sol: Both I and II are false.

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.

43. Ans: (B)

Sol: L_1: $\{a^n b^m c^{n+m} \mid m, n \geq 1\}$ – CFL

L_2: $\{a^n b^n c^{2n} \mid n \geq 1\}$ – CSL

L_1 is CFL but L_2 is Not CFL

44. Consider the following languages.

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

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

L_3 = {<M> | M accepts ε},

where for each Turing machine M, <M> denotes a specific encoding of M.

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

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

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

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

(D) L_1, L_2, L_3 are recursive

44. Ans: (C)

Sol: L_1 is Recursive

L_2 is Recursive

L_3 is Not Recursive

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

(A) S → AB
A → Aa | b
B → c

(B) S → Ab | Bb | c
A → Bd | ε
B → e

(C) S → Aa | B
A → Bb | Sc | ε
B → d

(D) S → Aa | Bb | c
A → Bd | ε
B → Ae | ε

45. Ans: (B)

Sol: S → Ab | Bb | ∈
A → Bd | ∈
B → e
} Generates finite language

No Recursion at all

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 → 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

46. Ans: (A)

Sol: **G_1:**

$D \rightarrow$ int L;

$L \rightarrow$ id [E

$E \rightarrow$ num]

$E \rightarrow$ num][E

G_2:

$D \rightarrow$ int L;

$L \rightarrow$ id E

$E \rightarrow E$[num]

$E \rightarrow$ [num]

int a[10] [3];

From G_1:

$D \rightarrow$ int L;

$\rightarrow$ int id [E];

$\rightarrow$ int a [num];

(OR)

$D \rightarrow$ int L;

$\rightarrow$ int a[E];

$\rightarrow$ int a [num] [E

$\rightarrow$ int a [num] [num]

$\rightarrow$ int a [10] [3];

From G_2:

$D \rightarrow$ int L;

$\rightarrow$ int id E;

$\rightarrow$ int a E[num];

$\rightarrow$ int a [num] [num];

$\rightarrow$ int a [10] [3];

$\therefore$ Both G_1 & G_2 generates the string.

int a[10] [3];

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
P1	0	10
P2	3	6
P3	7	1
P4	8	3

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

47. Ans: 8.25

48. Consider the following two-process synchronization solution.

Process 0

Entry: loop while (turn == 1);

(critical section)

Exit: turn = 1;

Process 1

Entry: loop while (turn == 0);

(critical section)

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.

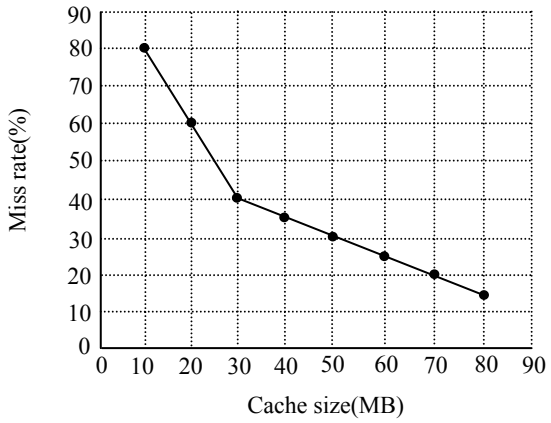
(D) This solution violates bounded wait requirement.

48. Ans: (C)

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_____.

49. Ans: 7

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.

50. Ans: 30

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

51. Ans: (C)

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

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

52. Ans: 2

Sol:

The result of the query is: **name**

Bikaner

churu

Total	
name	**capacity**
Ajmeer	20
Bikaner	40
Churu	30
Dungargarh	10

Total_avg
capacity
25

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.

53. Ans: 200

Sol: 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

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

54. Ans: (B)

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

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 _____.

55. Ans: 4

Sol: 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) = 128×10^3 bps

Propagation delay (T_P) = 150 msec

Packet size(L) = 1 kilobyte

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

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

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

$$T_t = 64 \text{ msec}$$

W_S = sender window size

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

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

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

$$Ws = 5.6875$$

$W_S + W_R$ = Available sequence numbers for SR $W_S = W_R$

$$ASN = 2 \times W_S$$

$$ASN = 2 \times 5.6875$$

$$ASN = 11.375$$

No. of bits in the sequence number = $\lceil \log_2 ASN \rceil$

$$= \lceil \log_2^{11.375} \rceil$$

$$= 4$$