

**GATE Previous Year
Solved Paper
Computer Science
& Engineering**

**(2011, 2012, 2013,
2015, 2016, 2017, 2018)**

**GATE Previous Year
Solved Paper
Computer Science
(Fully Solved)**

(2011)

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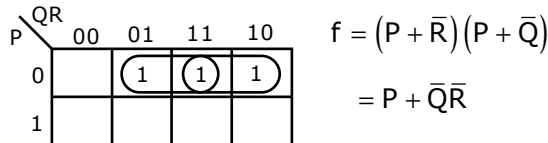
Q. No. 1 – 25 Carry One Mark Each

1. The simplified SOP (Sum of Product) form of the Boolean expression $(P + \bar{Q} + \bar{R}) \cdot (P + \bar{Q} + R) \cdot (P + Q + \bar{R})$ is

- (A) $(\bar{P}Q + \bar{R})$ (B) $(P + \bar{Q}\bar{R})$ (C) $(\bar{P}Q + R)$ (D) $(PQ + R)$

Answer: - (B)

Exp: -



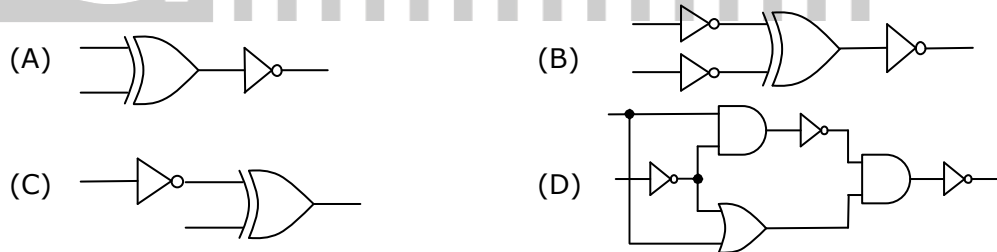
Alternate method

$$(P + \bar{Q} + \bar{R}) \cdot (P + \bar{Q} + R) \cdot (P + Q + \bar{R}) = \overline{\overline{(P + \bar{Q} + \bar{R}) \cdot (P + \bar{Q} + R) \cdot (P + Q + \bar{R})}}$$

$$= \overline{\overline{PQR} + \overline{PQR} + \overline{PQR}} = \overline{\overline{P}Q(R + \bar{R}) + \overline{P}Q\bar{R}} = \overline{\overline{P}Q + \overline{P}Q\bar{R}} = \overline{\overline{P}(Q + \bar{Q}R)}$$

$$= \overline{\overline{P}(Q + R)} = P + \bar{Q}\bar{R}$$

2. Which one of the following circuits is NOT equivalent to a 2-input XNOR (exclusive NOR) gate?



Answer: - (D)

Exp: - All options except option 'D' gives EX-NOR gates

3. The minimum number of D flip-flops needed to design a mod-258 counter is

- (A) 9 (B) 8 (C) 512 (D) 258

Answer: - (A)

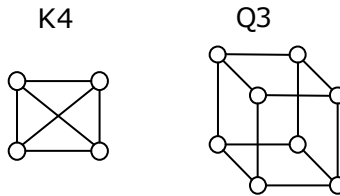
Exp: - $2^n \geq 258 \Rightarrow n = 9$

4. A thread is usually defined as a 'light weight process' because an operating system (OS) maintains smaller data structures for a thread than for a process. In relation to this, which of the followings is TRUE?

- (A) On per-thread basis, the OS maintains only CPU register state
- (B) The OS does not maintain a separate stack for each thread
- (C) On per-thread basis, the OS does not maintain virtual memory state
- (D) On per thread basis, the OS maintains only scheduling and accounting information

Answer: - (A)

5. K4 and Q3 are graphs with the following structures

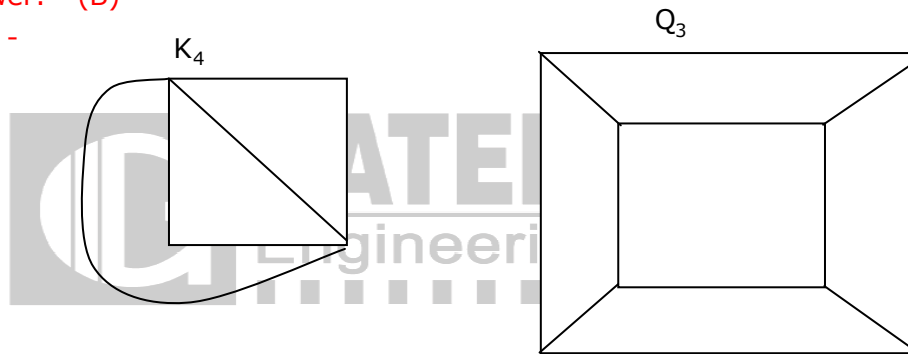


Which one of the following statements is TRUE in relation to these graphs?

- (A) K4 is planar while Q3 is not
- (B) Both K4 and Q3 are planar
- (C) Q3 is planar while K4 is not
- (D) Neither K4 nor Q3 is planar

Answer: - (B)

Exp: -



∴ Both K_4 and Q_3 are planar

6. If the difference between the expectation of the square of random variable ($E[X^2]$) and the square of the expectation of the random variable ($(E[X])^2$) is denoted by R then

- (A) $R = 0$
- (B) $R < 0$
- (C) $R \geq 0$
- (D) $R > 0$

Answer: - (C)

7. The lexical analysis for a modern computer language such as Java needs the power of which one of the following machine models in a necessary and sufficient sense?

- (A) Finite state automata
- (B) Deterministic pushdown automata
- (C) Non-Deterministic pushdown automata

(D) Turing machine

Answer: - (A)

Exp: - Lexical Analysis is implemented by finite automata

8. Let the page fault service time be 10ms in a computer with average memory access time being 20ns. If one page fault is generated for every 10^6 memory accesses, what is the effective access time for the memory?

(A) 21ns (B) 30ns (C) 23ns (D) 35ns

Answer: - (B)

Exp: - P = page fault rate

EA = p × page fault service time

+ (1 - p) × Memory access time

$$= \frac{1}{10^6} \times 10 \times 10^6 + \left(1 - \frac{1}{10^6}\right) \times 20 \cong 29.9 \text{ ns}$$

9. Consider a hypothetical processor with an instruction of type LW R1, 20(R2), which during execution reads a 32-bit word from memory and stores it in a 32-bit register R1. The effective address of the memory location is obtained by the addition of constant 20 and the contents of register R2. Which of the following best reflects the addressing mode implemented by this instruction for the operand in memory?

(A) Immediate Addressing (B) Register Addressing
(C) Register Indirect Scaled Addressing (D) Base Indexed Addressing

Answer: - (D)

Exp: - Here 20 will act as base and content of R₂ will be index

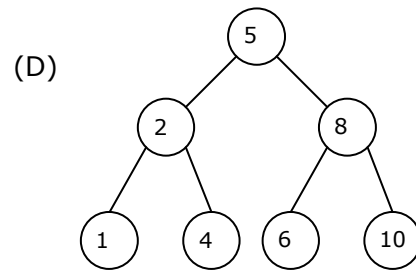
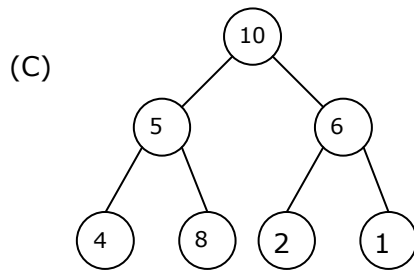
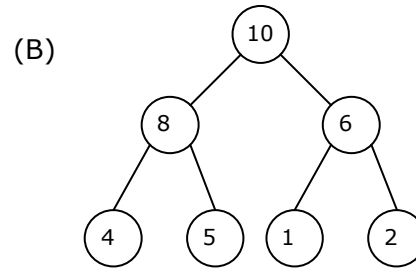
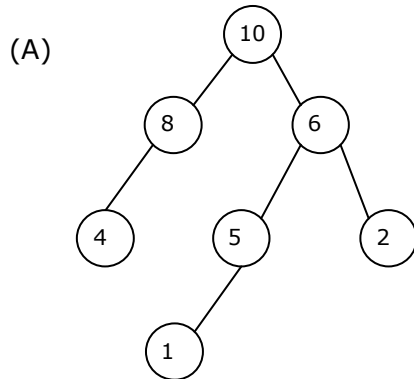
10. What does the following fragment of C-program print?

```
char c[ ] = "GATE2011";  
char *p = c;  
printf("%s", p+p[3]-p[1]);
```

(A) GATE2011 (B) E2011 (C) 2011 (D) 011

Answer: - (C)

11. A max-heap is a heap where the value of each parent is greater than or equal to the value of its children. Which of the following is a max-heap?



Answer: - (B)

Exp: - Heap is a complete binary tree

12. An algorithm to find the length of the longest monotonically increasing sequence of numbers in an array $A[0 : n - 1]$ is given below.

Let L_i denote the length of the longest monotonically increasing sequence starting at index i in the array

Initialize $L_{n-1} = 1$

For all i such that $0 \leq i \leq n - 2$

$$L_i = \begin{cases} 1 + L_{i+1} & \text{if } A[i] < A[i + 1] \\ 1 & \text{Otherwise} \end{cases}$$

Finally the length of the longest monotonically increasing sequence is $\text{Max}(L_0, L_1, \dots, L_{n-1})$. Which of the following statements is TRUE?

- (A) The algorithm uses dynamic programming paradigm
- (B) The algorithm has a linear complexity and uses branch and bound paradigm
- (C) The algorithm has a non-linear polynomial complexity and uses branch and bound paradigm
- (D) The algorithm uses divide and conquer paradigm.

Answer: - (A)

13. Let P be a regular language and Q be a context free language such that $Q \subseteq P$. (For example, let P be the language represented by the regular expression p^*q^* and Q be $\{p^nq^n \mid n \in \mathbb{N}\}$). Then which of the following is ALWAYS regular?

- (A) $P \cap Q$
- (B) $P - Q$
- (C) $\Sigma^* - P$
- (D) $\Sigma^* - Q$

Answer: - (C)

Exp: - Σ^* - P is the complement of P so it is always regular,

since regular languages are closed under complementation

14. In a compiler, keywords of a language are recognized during
(A) parsing of the program (B) the code generation
(C) the lexical analysis of the program (D) dataflow analysis

Answer: - (C)

Exp: - Any identifier is also a token so it is recognized in lexical Analysis

15. A layer-4 firewall (a device that can look at all protocol headers up to the transport layer) CANNOT
(A) block entire HTTP traffic during 9:00PM and 5:00AM
(B) block all ICMP traffic
(C) stop incoming traffic from a specific IP address but allow outgoing traffic to the same IP address
(D) block TCP traffic from a specific user on a multi-user system during 9:00PM and 5:00AM

Answer: - (A)

Exp: - Since it is a layer 4 firewall it cannot block application layer protocol like HTTP.

16. If two fair coins are flipped and at least one of the outcomes is known to be a head, what is the probability that both outcomes are heads?
(A) 1/3 (B) 1/4 (C) 1/2 (D) 2/3

Answer: - (A)

Exp: - Sample space = {HH, HT, TH}

$$\text{Required probability} = \frac{1}{3}$$

17. Consider different activities related to email.
m1: Send an email from a mail client to a mail server
m2: Download an email from mailbox server to a mail client
m3: Checking email in a web browser
Which is the application level protocol used in each activity?
(A) m1:HTTP m2:SMTP m3:POP (B) m1:SMTP m2:FTP m3:HTTP
(C) m1: SMTP m2: POP m3: HTTP (D) m1: POP m2: SMTP m3:IMAP

Answer: - (C)

Exp: - Sending an email will be done through user agent and message transfer agent by SMTP, downloading an email from mail box is done through POP, checking email in a web browser is done through HTTP

18. A company needs to develop a strategy for software product development for which it has a choice of two programming languages L1 and L2. The number of lines of code (LOC) developed using L2 is estimated to be twice the LOC developed with L1. the product will have to be maintained for five years. Various parameters for the company are given in the table below.

Parameter	Language L1	Language L2
Man years needed for development	LOC / 10000	LOC / 10000
Development Cost per year	Rs. 10,00,000	Rs. 7,50,000
Maintenance time	5 years	5 years
Cost of maintenance per year	Rs. 1,00,000	Rs. 50,000

Total cost of the project includes cost of development and maintenance. What is the LOC for L1 for which the cost of the project using L1 is equal to the cost of the project using L2?

- (A) 4000 (B) 5000 (C) 4333 (D) 4667

Answer: - (B)

Exp: - LOC $L_1 = x$
 $L_2 = 2x$

Total cost of project

$$\frac{x}{10000} \times 1000000 + 5 \times 100000 = \frac{2x}{10000} \times 750000 + 50000 \times 5$$

$$100x + 500000 = 150x + 250000$$

$$\Rightarrow 50x = 500000 - 250000$$

$$\therefore x = \frac{250000}{50} \Rightarrow x = 5000$$

19. Let the time taken to switch between user and kernel modes of execution be t_1 while the time taken to switch between two processes be t_2 . Which of the following is TRUE?

- (A) $t_1 > t_2$
(B) $t_1 = t_2$
(C) $t_1 < t_2$
(D) Nothing can be said about the relation between t_1 and t_2

Answer: - (C)

Exp: - Process switching also involves mode changing.

20. A company needs to develop digital signal processing software for one of its newest inventions. The software is expected to have 40000 lines of code. The company needs to determine the effort in person-months needed to develop this software using the basic COCOMO model. The multiplicative factor for this model is given as 2.8 for the software development on embedded systems, while the exponentiation factor is given as 1.20. What is the estimated effort in person-months?

- (A) 234.25 (B) 932.50 (C) 287.80 (D) 122.40

Answer: - (A)

Exp: - Effort person per month

$$= \alpha \cdot (kDSI)^B$$

KDSI = Kilo LOC

$$= 2.8 \times (40)^{1.20}$$

$$= 2.8 \times 83.6511$$

$$= 234.22 \text{ person per month}$$

21. Which of the following pairs have DIFFERENT expressive power?
- (A) Deterministic finite automata (DFA) and Non-deterministic finite automata (NFA)
 - (B) Deterministic push down automata (DPDA) and Non-deterministic push down automata (NPDA)
 - (C) Deterministic single-tape Turing machine and Non-deterministic single tape Turing machine
 - (D) Single-tape Turing machine and multi-tape Turing machine

Answer: - (B)

Exp: - NPDA is more powerful than DPDA.

Hence answer is (B)

22. HTML (Hyper Text Markup Language) has language elements which permit certain actions other than describing the structure of the web document. Which one of the following actions is NOT supported by pure HTML (without any server or client side scripting) pages?
- (A) Embed web objects from different sites into the same page
 - (B) Refresh the page automatically after a specified interval
 - (C) Automatically redirect to another page upon download
 - (D) Display the client time as part of the page

Answer: - (D)

23. Which of the following is NOT desired in a good Software Requirement Specifications (SRS) document?
- (A) Functional Requirements
 - (B) Non Functional Requirements
 - (C) Goals of Implementation
 - (D) Algorithms for Software Implementation

Answer: - (D)

24. A computer handles several interrupt sources of which the following are relevant for this question.
- Interrupt from CPU temperature sensor
 - Interrupt from Mouse

Interrupt from Keyboard

Interrupt from Hard Disk

(A) Interrupt from Hard Disk

(B) Interrupt from Mouse

(C) Interrupt from Keyboard

(D) Interrupt from CPU temp sensor

Answer: - (D)

25. Consider a relational table with a single record for each registered student with the following attributes.

1. Registration_Number: Unique registration number for each registered student

2. UID: Unique Identity number, unique at the national level for each citizen

3. BankAccount_Number: Unique account number at the bank. A student can have multiple accounts or joint accounts. This attributes stores the primary account number

4. Name: Name of the Student

5. Hostel_Room: Room number of the hostel

Which of the following options is INCORRECT?

(A) BankAccount_Number is a candidate key

(B) Registration_Number can be a primary key

(C) UID is a candidate key if all students are from the same country

(D) If S is a superkey such that $S \cap \text{UID}$ is NULL then $S \cup \text{UID}$ is also a superkey

Answer: - (A)

Exp: - In case two students hold joint account then BankAccount_Num will not uniquely determine other attributes.

Q. No. 26 – 51 Carry Two Marks Each

26. Which of the given options provides the increasing order of asymptotic complexity of functions f_1, f_2, f_3 and f_4 ?

$$f_1(n) = 2^n; f_2(n) = n^{3/2}; f_3(n) = n \log_2 n; f_4(n) = n^{\log_2 n}$$

(A) f_3, f_2, f_4, f_1

(B) f_3, f_2, f_1, f_4

(C) f_2, f_3, f_1, f_4

(D) f_2, f_3, f_4, f_1

Answer: - (A)

Let $n = 1024$

$$f_1(n) = 2^{1024}$$

$$f_2(n) = 2^{15}$$

$$f_3(n) = 10 \times 2^{10}$$

$$f_4(n) = 1024^{10} = 2^{100}$$

$\therefore f_3, f_2, f_4, f_1$ is the required increasing order

27. Four matrices M_1, M_2, M_3 and M_4 are dimensions $p \times q, q \times r, r \times s$ and $s \times t$ respectively can be multiplied in several ways with different number of total scalar multiplications. For example When multiplied as $((M_1 \times M_2) \times (M_3 \times M_4))$ the total number of scalar multiplications is $pqr + rst + prt$. When multiplied as $((M_1 \times M_2) \times M_3) \times M_4$, the total number of scalar multiplications is $pqr + prs + pst$.
- If $p=10, q=100, r=20, s=5$ and $t=80$, then the minimum number of scalar multiplications needed is
- (A) 248000 (B) 44000 (C) 19000 (D) 25000

Answer: - (C)

Exp: - Multiply as $(M_1 \times (M_2 \times M_3)) \times M_4$

The total number of scalar multiplication is

$$= qrs + pqs + pst$$

$$= 10000 + 5000 + 4000 = 19000$$

28. Consider a relational table r with sufficient number of records, having attributes A_1, A_2, \dots, A_n and let $1 \leq p \leq n$. Two queries Q_1 and Q_2 are given below.

$Q_1: \pi_{A_1 \dots A_n} (\sigma_{A_p=c} (r))$ where c is a const

$Q_2: \pi_{A_1 \dots A_n} (\sigma_{c_1 \leq A_p \leq c_2} (r))$ where c_1 and c_2 are constants

The database can be configured to do ordered indexing on A_p or hashing on A_p . Which of the following statements is TRUE?

- (A) Ordered indexing will always outperform hashing for both queries
 (B) Hashing will always outperform ordered indexing for both queries
 (C) Hashing will outperform ordered indexing on Q_1 , but not on Q_2
 (D) Hashing will outperform ordered indexing on Q_2 , but not on Q_1 .

Answer: - (C)

29. Consider the matrix as given below.

$$\begin{bmatrix} 1 & 2 & 3 \\ 0 & 4 & 7 \\ 0 & 0 & 3 \end{bmatrix}$$

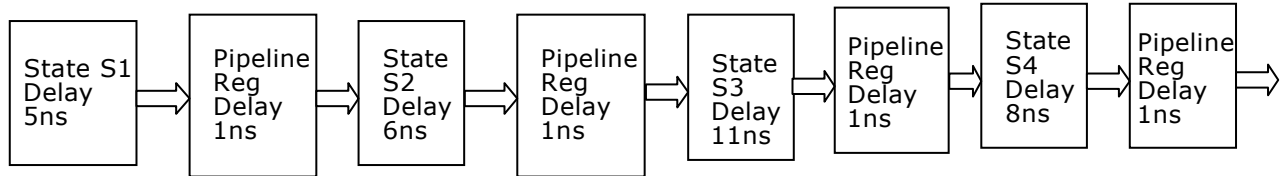
Which one of the following provides the CORRECT values of eigenvalues of the matrix?

- (A) 1,4,3 (B) 3,7,3 (C) 7,3,2 (D) 1,2,3

Answer: - (A)

Exp: - Given matrix is upper triangular matrix and its diagonal elements are its eigen values = 1, 4, 3

30. Consider an instruction pipeline with four stages (S1, S2, S3 and S4) each with combinational circuit only. The pipeline registers are required between each stage and at the end of the last stage. Delays for the stages and for the pipeline registers are as given in the figure.



What is the approximate speed up of the pipeline in steady state under ideal conditions when compared to the corresponding non-pipeline implementation?

- (A) 4.0 (B) 2.5 (C) 1.1 (D) 3.0

Answer: - (B)

Exp: - $\frac{(5 + 6 + 11 + 8)}{(11 + 1)} = \frac{30}{12} = 2.5$

31. Definition of a language L with alphabet {a} is given as following

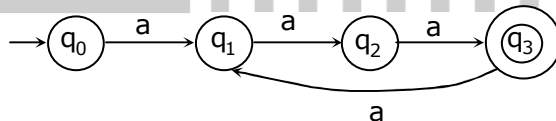
$$L = \{a^{nk} \mid k > 0, \text{ and } n \text{ is a positive integer constant}\}$$

What is the minimum number of states needed in a DFA to recognize L?

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

Answer: - (B)

Exp: - Let n = 3 and k=1



(n + 1) states

32. An 8KB direct mapped write-back cache is organized as multiple blocks, each of size 32-bytes. The processor generates 32-bit addresses. The cache controller maintains the tag information for each cache block comprising of the following.

1 Valid bit

1 Modified bit

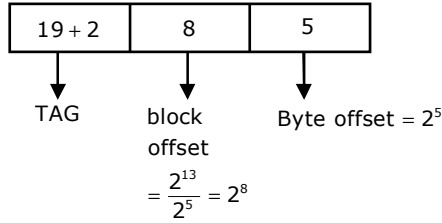
As many bits as the minimum needed to identify the memory block mapped in the cache.

What is the total size of memory needed at the cache controller to store meta-data (tags) for the cache?

- (A) 4864 bits (B) 6144bits (C) 6656bits (D) 5376bits

Answer: - (D)

Exp: -



Required answer = $256 \times (19 + 2) = 5376$ bits

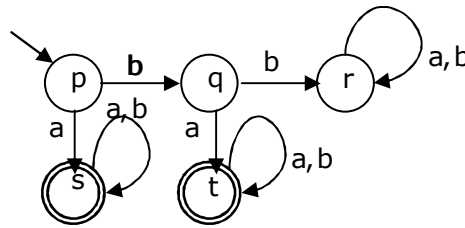
33. An application loads 100 libraries at startup. Loading each library requires exactly one disk access. The seek time of the disk to a random location is given as 10ms. Rotational speed of disk is 6000rpm. If all 100 libraries are loaded from random locations on the disk, how long does it take to load all libraries? (The time to transfer data from the disk block once the head has been positioned at the start of the block may be neglected)

- (A) 0.50s (B) 1.50s (C) 1.25s (D) 1.00s

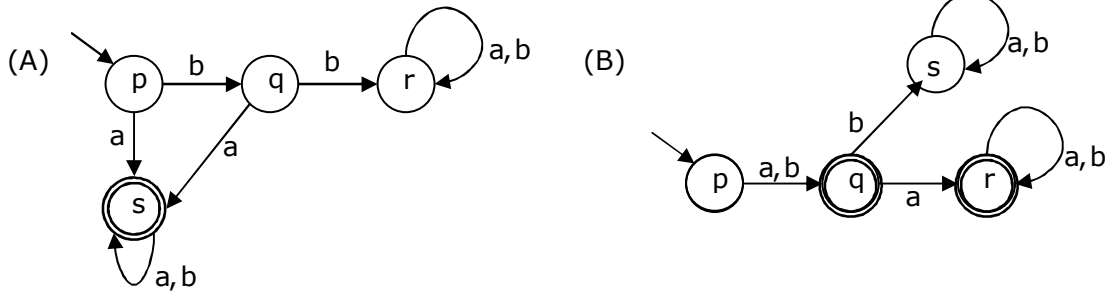
Answer: - (B)

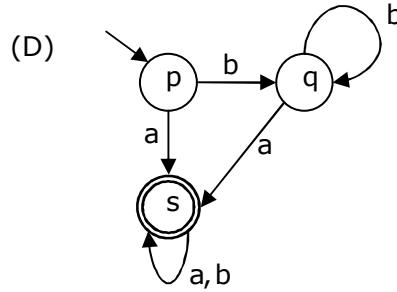
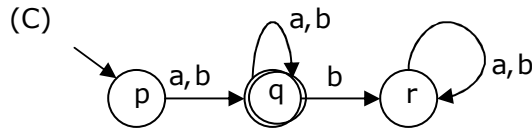
Exp: - 6000 rotations _____ 60 sec
 1 rotation _____ 10 ms
 \therefore Rotational latency = 5ms
 Time for one disk access = 15 ms
 Time to load all libraries = $15 \times 100 = 1500$ ms = 1.5 sec

34. A deterministic finite automation (DFA) D with alphabet $\Sigma = \{a,b\}$ is given below



Which of the following finite state machines is a valid minimal DFA which accepts the same language as D?





Answer: - (A)

Exp: - Options B and C will accept the string b

Option - D will accept the string "bba"

Both are invalid strings.

So the minimized DFA is option A

35. The following is comment written for a C function

```
/* This function computes the roots of a quadratic equation
a.x^2+b.x+c=0. The function stores two real roots
in *root1 and *root2 and returns the status of validity of
roots. It handles four different kinds of cases.
```

- (i) When coefficient a is zero irrespective of discriminant
- (ii) When discriminant is positive
- (iii) When discriminant is zero
- (iv) When discriminant is negative

Only in cases (ii) and (iii), the stored roots are valid.

Otherwise 0 is stored in the roots. the function returns 0 when the roots are valid and -1 otherwise.

The function also ensures root1 >= root2.

```
int get_QuadRoots(float a, float b, float c, float *root1, float *root2);
*/
```

A software test engineer is assigned the job of doing black box testing. He comes up with the following test cases, many of which are redundant.

Test Case	Input set			Expected Output set		
	a	b	C	Root1	Root2	Return Value
T1	0.0	0.0	7.0	0.0	0.0	-1
T2	0.0	1.0	3.0	0.0	0.0	-1
T3	1.0	2.0	1.0	-1.0	-1.0	0
T4	4.0	-12.0	9.0	1.5	1.5	0
T5	1.0	-2.0	-3.0	3.0	-1.0	0
T6	1.0	1.0	4.0	0.0	0.0	-1

Which one of the following options provide the set of non-redundant tests using equivalence class partitioning approach from input perspective for black box testing?

- (A) T1,T2,T3,T6
- (B) T1,T3,T4,T5
- (C) T2,T4,T5,T6
- (D) T2,T3,T4,T5

Answer: - (C)

Exp: - T_1 and T_2 checking same condition $a = 0$ hence, any one of T_1 and T_2 is redundant.

T_3, T_4 : in both case discriminant $(D)=b^2 - 4ac = 0$. Hence any one of it is redundant.

T_5 : $D > 0$

T_6 : $D < 0$

36. Database table by name Loan_Records is given below.

Borrower	Bank_Manager	Loan_Amount
Ramesh	Sunderajan	10000.00
Suresh	Ramgopal	5000.00
Mahesh	Sunderajan	7000.00

What is the output of the following SQL query?

```
SELECT count(*)
FROM(
(SELECT Borrower, Bank_Manager FROM Loan_Records) AS S
NATURAL JOIN
(SELECT Bank_Manager, Loan_Amount FROM Loan_Records) AS T
);
(A) 3 (B) 9 (C) 5 (D) 6
```

Answer: - (C)

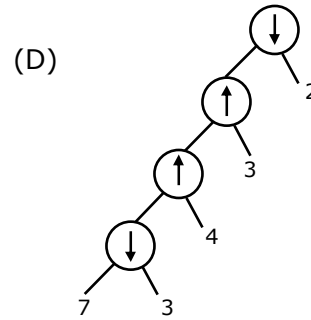
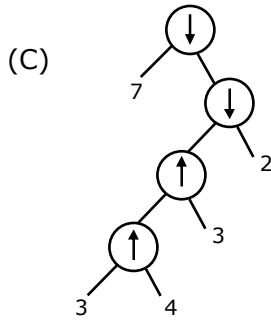
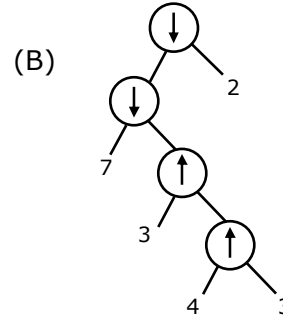
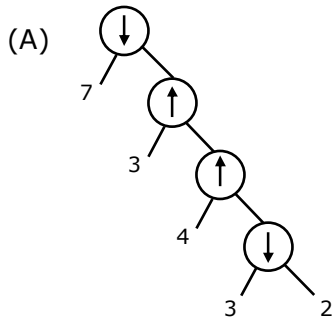
Exp: - S

Borrower	Bank_Manager	Bank_Manager	Loan_Amount
Ramesh	Sunderajan	Sunderajan	10000.00
Suresh	Ramgopal	Ramgopal	5000.00
Mahesh	Sunderjan	Sunderjan	7000.00

After executing the given query, the output would be

Borrower	Bank_Manager	Load_Amount
Ramesh	Sunderajan	10000.00
Ramesh	Sunderajan	7000.00
Suresh	Ramgopal	5000.00
Mahesh	Sunderajan	10000.00
Mahesh	Sunderajan	7000.00

37. Consider two binary operators ' \uparrow ' and ' \downarrow ' with the precedence of operator \downarrow being lower than that of the operator \uparrow . Operator \uparrow is right associative while operator \downarrow , is left associative. Which one of the following represents the parse tree for expression $(7 \downarrow 3 \uparrow 4 \uparrow 3 \downarrow 2)$?



Answer: - (B)

Exp: - $7 \downarrow 3 \uparrow 4 \uparrow 3 \downarrow 2$

$\Rightarrow 7 \downarrow 3 \uparrow (4 \uparrow 3) \downarrow 2$ as \uparrow is right associative

$\Rightarrow 7 \downarrow (3 \uparrow (4 \uparrow 3)) \downarrow 2$

$\Rightarrow (7 \downarrow (3 \uparrow (4 \uparrow 3))) \downarrow 2$ as \downarrow is left associative

38. Consider the languages L1, L2 and L3 as given below

$$L1 = \{0^p 1^q \mid p, q \in \mathbb{N}\}$$

$$L2 = \{0^p 1^q \mid p, q \in \mathbb{N} \text{ and } p = q\} \text{ and}$$

$$L3 = \{0^p 1^q 0^r \mid p, q, r \in \mathbb{N} \text{ and } p = q = r\}$$

Which of the following statements is NOT TRUE?

- (A) Push Down Automata (PDA) can be used to recognize L1 and L2
- (B) L1 is a regular language
- (C) All the three languages are context free
- (D) Turing machines can be used to recognize all the languages

Answer: - (C)

Exp: - L1: regular language
L2: context free language
L3: context sensitive language

39. On a non-pipelined sequential processor, a program segment, which is a part of the interrupt service routine, is given to transfer 500 bytes from an I/O device to memory.

Initialize the address register

Initialize the count to 500

LOOP: Load a byte from device

Store in memory at address given by address register

Increment the address register

Decrement the count

If count != 0 go to LOOP

Assume that each statement in this program is equivalent to a machine instruction which takes one clock cycle to execute if it is a non-load/store instruction. The load-store instructions take two clock cycles to execute.

The designer of the system also has an alternate approach of using the DMA controller to implement the same transfer. The DMA controller requires 20 clock cycles for initialization and other overheads. Each DMA transfer cycle takes two clock cycles to transfer one byte of data from the device to the memory.

What is the approximate speedup when the DMA controller based design is used in place of the interrupt driven program based input-output?

- (A) 3.4 (B) 4.4 (C) 5.1 (D) 6.7

Answer: - (A)

Exp: - No. of clock cycles required by using load-store approach = $2 + 500 \times 7 = 3502$
and that of by using DMA = $20 + 500 \times 2 = 1020$

$$\text{Required speed up} = \frac{3502}{1020} = 3.4$$

40. We are given a set of n distinct elements and an unlabeled binary tree with n nodes. In how many ways can we populate the tree with the given set so that it becomes a binary search tree?

- (A) 0 (B) 1 (C) n! (D) $\frac{1}{n+1} \cdot {}^{2n}C_n$

Answer: - (D)

41. Which one of the following options is CORRECT given three positive integers x, y and z, and a predicate

$$P(x) = \neg(x = 1) \wedge \forall y (\exists z (x = y * z) \Rightarrow (y = x) \vee (y = 1))$$

- (A) P(x) being true means that x is a prime number

- (B) P(x) being true means that x is a number other than 1
- (C) P(x) is always true irrespective of the value of x
- (D) P(x) being true means that x has exactly two factors other than 1 and x

Answer: - (A)

42. Given $i = \sqrt{-1}$, what will be the evaluation of the definite integral

$$\int_0^{\pi/2} \frac{\cos x + i \sin x}{\cos x - i \sin x} dx ?$$

- (A) 0
- (B) 2
- (C) -i
- (D) i

Answer: - (D)

Exp: - $\int_0^{\pi/2} \frac{e^{ix}}{e^{-ix}} dx = \int_0^{\pi/2} e^{2ix} dx$

$$= \left(\frac{e^{2ix}}{2i} \right)_0^{\pi/2} = \frac{1}{2i} [e^{i\pi} - 1] = \frac{1}{2i} [\cos \pi + i \sin \pi - 1] = \frac{1}{2i} [-1 + 0 - 1] = \frac{-2}{2i} = \frac{-1}{i} \times \frac{i}{i} = \frac{-i}{-1} = i$$

43. Consider a database table T containing two columns X and Y each of type integer. After the creation of the table, one record (X= 1, Y=1) is inserted in the table.

Let MX and MY denote the respective maximum values of X and Y among all records in the table at any point in time. Using MX and MY, new records are inserted in the table 128 times with X and Y values being MX+1, 2*MY+1 respectively. It may be noted that each time after the insertion, values of MX and MY change.

What will be the output of the following SQL query after the steps mentioned above are carried out?

SELECT Y FROM T WHERE X=7;

- (A) 127
- (B) 255
- (C) 129
- (D) 257

Answer: - (A)

Exp: -

X	Y
1	1
2	3
3	7
4	15
5	31
6	63
7	127

44. Consider a finite sequence of random values $X = [x_1, x_2, \dots, x_n]$. Let μ_x be the mean and σ_x be the standard deviation of X . Let another finite sequence Y of equal length be derived from this as $y_i = a * x_i + b$, where a and b are positive constants. Let μ_y be the mean and σ_y be the standard deviation of this sequence. Which one of the following statements is INCORRECT?
- (A) Index position of mode of X in X is the same as the index position of mode of Y in Y .
- (B) Index position of median of X in X is the same as the index position of median of Y in Y .
- (C) $\mu_y = a\mu_x + b$
- (D) $\sigma_y = a\sigma_x + b$

Answer: - (D)

45. A deck of 5 cards (each carrying a distinct number from 1 to 5) is shuffled thoroughly. Two cards are then removed one at a time from the deck. What is the probability that the two cards are selected with the number on the first card being one higher than the number on the second card?
- (A) 1/5 (B) 4/25 (C) 1/4 (D) 2/5

Answer: - (A)

Exp: - (2,1), (3,2), (4,3), (5,4)

$$\text{Required probability} = \frac{4}{5 \times 4} = \frac{4}{20} = \frac{1}{5}$$

46. Consider the following table of arrival time and burst time for three processes P0, P1 and P2.

Process	Arrival time	Burst Time
P0	0 ms	9 ms
P1	1 ms	4ms
P2	2 ms	9ms

The pre-emptive shortest job first scheduling algorithm is used. Scheduling is carried out only at arrival or completion of processes. What is the average waiting time for the three processes?

- (A) 5.0 ms (B) 4.33 ms (C) 6.33 ms (D) 7.33 ms

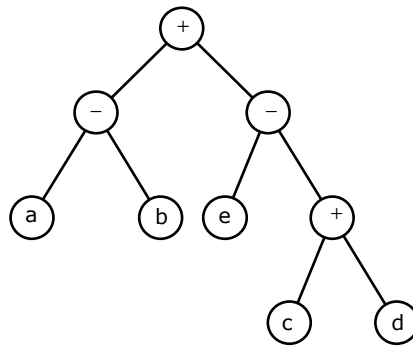
Answer: - (A)

Exp: -



$$\text{Average waiting time} = \frac{4 + 11}{3} = 5 \text{ ms}$$

47. Consider evaluating the following expression tree on a machine with load-store architecture in which memory can be accessed only through load and store instructions. The variables a, b, c, d and e are initially stored in memory. The binary operators used in this expression tree can be evaluated by the machine only when the operands are in registers. The instructions produce result only in a register. If no intermediate results can be stored in memory, what is the minimum number of registers needed to evaluate this expression?



(A) 2

(B) 9

(C) 5

(D) 3

Answer: - (D)

Exp: - Load R₁, a ; R₁ ← M[a]

Load R₂, b ; R₂ ← M[b]

Sub R₁, R₂ ; R₁ ← R₁ - R₂

Load R₂, c ; R₂ ← M[c]

Load R₃, d ; R₃ ← M[d]

Add R₂, R₃ ; R₂ ← R₂ + R₃

Load R₃, e ; R₃ ← M[e]

Sub R₃, R₂ ; R₃ ← R₃ - R₂

Add R₁, R₃ ; R₁ ← R₁ + R₃

Total 3 Registers are required minimum

Common Data Questions: 48 & 49

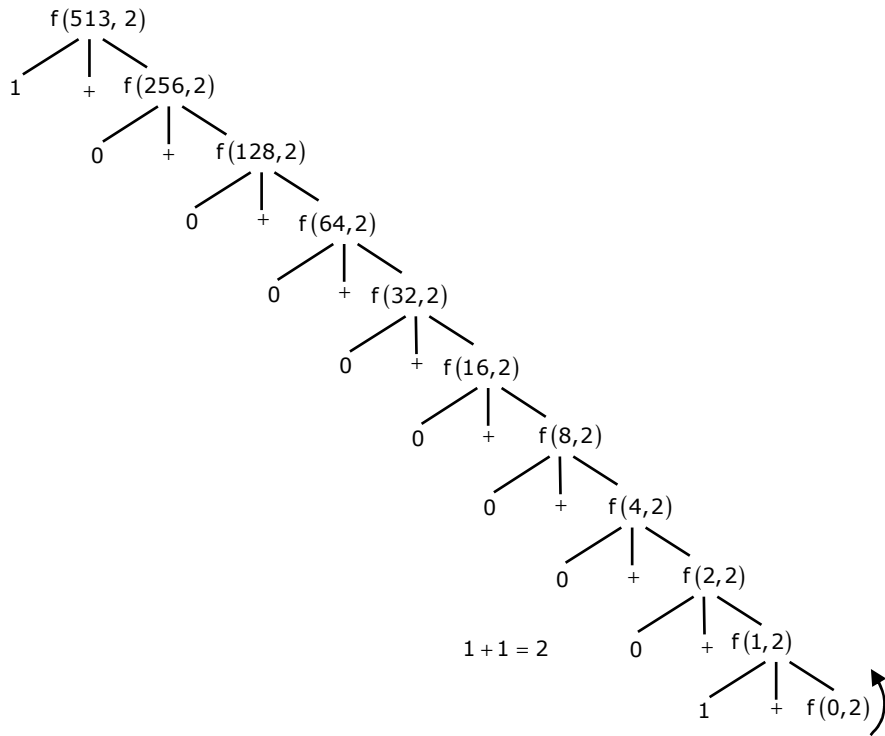
Consider the following recursive C function that takes two arguments

```
unsigned int foo(unsigned int n, unsigned int r) {
    if (n > 0) return (n%r) + foo (n/r, r);
    else return 0;
}
```

48. What is the return value of the function foo when it is called as foo (513, 2)?
 (A) 9 (B) 8 (C) 5 (D) 2

Answer: - (D)

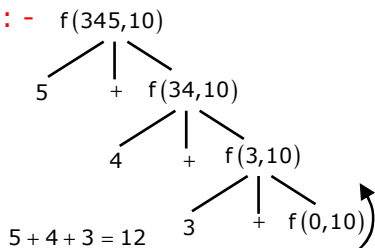
Exp: -



49. What is the return value of the function foo when it is called as foo (345, 10)?
 (A) 345 (B) 12 (C) 5 (D) 3

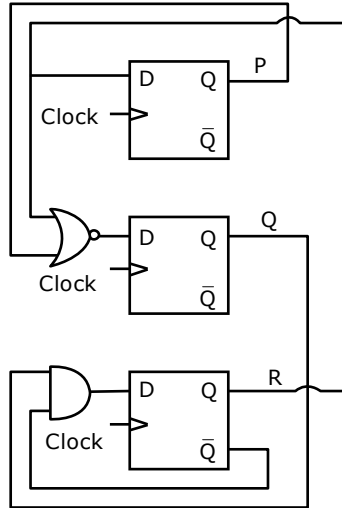
Answer: - (B)

Exp: -



Common Data Questions: 50 & 51

Consider the following circuit involving three D-type flip-flops used in a certain type of counter configuration.



50. If all the flip-flops were reset to 0 at power on, what is the total number of distinct outputs (states) represented by PQR generated by the counter?
 (A) 3 (B) 4 (C) 5 (D) 6

Answer: - (B)
 Exp: -

CLOCK	Inputs			Outputs		
	$D_1 = R$	$D_2 = \overline{(P + R)}$	$D_3 = Q \overline{R}$	P	Q	R
1	0	1	0	0	1	0
2	0	1	1	0	1	1
3	1	0	0	1	0	0
4	0	0	0	0	0	0

So Total number of distinct outputs is 4

51. If at some instance prior to the occurrence of the clock edge, P, Q and R have a value 0, 1 and 0 respectively, what shall be the value of PQR after the clock edge?
 (A) 000 (B) 001 (C) 010 (D) 011

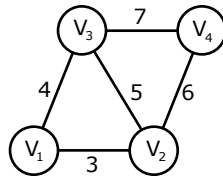
Answer: - (D)

Exp: -From the Table Shown in the explanation of question 50, if first state is 010 next State is 011

Linked Answer Questions: Q.52 to Q.55 Carry Two Marks Each

Statement for Linked Answer Questions: 52 & 53

An undirected graph $G(V,E)$ contains $n (n > 2)$ nodes named v_1, v_2, \dots, v_n . Two nodes v_i, v_j are connected if and only if $0 < |i - j| \leq 2$. Each edge (v_i, v_j) is assigned a weight $i + j$. A sample graph with $n = 4$ is shown below



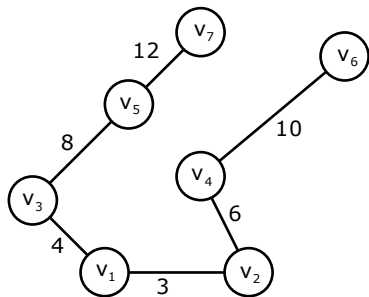
52. What will be the cost of the minimum spanning tree (MST) of such a graph with n nodes?
- (A) $\frac{1}{12}(11n^2 - 5n)$ (B) $n^2 - n + 1$
 (C) $6n - 11$ (D) $2n + 1$

Answer: - (B)

53. The length of the path from v_5 to v_6 in the MST of previous question with $n = 10$ is
- (A) 11 (B) 25 (C) 31 (D) 41

Answer: - (C)

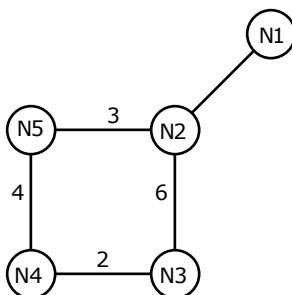
Exp: -



$$12 + 8 + 4 + 3 + 6 + 10 = 31$$

Statement for Linked Answer Questions: 54 & 55

Consider a network with five nodes, N1 to N5, as shown below



The net work uses a Distance Vector Routing protocol. Once the routes have stabilized, the distance vectors at different nodes are as following

- N1 : (0, 1, 7, 8, 4)
- N2 : (1, 0, 6, 7, 3)
- N3 : (7, 6, 0, 2, 6)
- N4 : (8, 7, 2, 0, 4)
- N5 : (4, 3, 6, 4, 0)

Each distance vector is the distance of the best known path at that instance to nodes, N1 to N5, where the distance to itself is 0. Also, all links are symmetric and the cost is identical in both directions. In each round, all nodes exchange their distance vectors with their respective neighbors. Then all nodes update their distance vectors. In between two rounds, any change in cost of a link will cause the two incident nodes to change only that entry in their distance vectors

54. The cost of link N2-N3 reduces to 2 in (both directions). After the next round of updates, what will be the new distance vector at node, N3?
- (A) (3, 2, 0, 2, 5)
 - (B) (3, 2, 0, 2, 6)
 - (C) (7, 2, 0, 2, 5)
 - (D) (7, 2, 0, 2, 6)

Answer: - (A)

Exp: -

	N ₃	
N ₁	3	→ 1 + 2
N ₂	2	
N ₃	0	
N ₄	2	
N ₅	5	→ 2 + 3

55. After the update in the previous question, the link N1-N2 goes down. N2 will reflect this change immediately in its distance vector as cost, ∞. After the NEXT ROUND of update, what will be the cost to N1 in the distance vector of N3?
- (A) 3
 - (B) 9
 - (C) 10
 - (D) ∞

Answer: - (C)

Exp: - N_3 has neighbors N_2 and N_4

N_2 has made entry ∞

N_4 has the distance of 8 to N_1

N_3 has the distance of 2 to N_4

So $2 + 8 = 10$

Q. No. 56 – 60 Carry One Mark Each

56. If $\text{Log}(P) = (1/2)\text{Log}(Q) = (1/3)\text{Log}(R)$, then which of the following options is TRUE?

(A) $P^2 = Q^3R^2$ (B) $Q^2 = PR$ (C) $Q^2 = R^3P$ (D) $R = P^2Q^2$

Answer: - (B)

Exp:- $\log P = \frac{1}{2}\log Q = \frac{1}{3}\log(R) = k$

$\therefore P = b^k, Q = b^{2k}, R = b^{3k}$

Now, $Q^2 = b^{4k} = b^{3k} b^k = PR$

57. Choose the most appropriate word(s) from the options given below to complete the following sentence.

I contemplated _____ Singapore for my vacation but decided against it.

(A) To visit (B) having to visit (C) visiting (D) for a visit

Answer: - (C)

Exp: - Contemplate is a transitive verb and hence is followed by a gerund. Hence the correct usage of contemplate is verb+ ing form.

58. Choose the most appropriate word from the options given below to complete the following sentence.

If you are trying to make a strong impression on your audience, you cannot do so by being understated, tentative or _____.

(A) Hyperbolic (B) Restrained
(C) Argumentative (D) Indifferent

Answer: - (B)

Exp: - The tone of the sentence clearly indicates a word that is similar to understated is needed for the blank. Alternatively, the word should be antonym of strong (fail to make strong impression). Therefore, the best choice is restrained which means controlled/reserved/timid.

59. Choose the word from the options given below that is most nearly opposite in meaning to the given word: **Amalgamate**

(A) Merge (B) Split (C) Collect (D) Separate

Answer: - (B)

Exp: - Amalgamate means combine or unite to form one organization or structure. So the best option here is split. Separate on the other hand, although a close synonym, it is too general to be the best antonym in the given question while Merge is the synonym; Collect is not related.

60. Which of the following options is the closest in the meaning to the word below:

Inexplicable

(A) Incomprehensible

(B) Indelible

(C) Inextricable

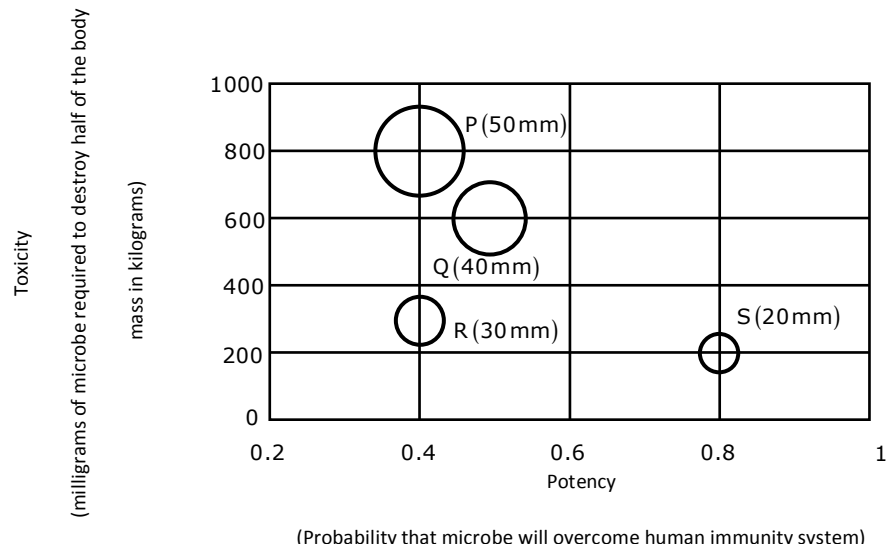
(D) Infallible

Answer: - (A)

Exp: - Inexplicable means not explicable; that cannot be explained, understood, or accounted for. So the best synonym here is incomprehensible.

Q. No. 61 – 65 Carry Two Marks Each

61. P, Q, R and S are four types of dangerous microbes recently found in a human habitat. The area of each circle with its diameter printed in brackets represents the growth of a single microbe surviving human immunity system within 24 hours of entering the body. The danger to human beings varies proportionately with the toxicity, potency and growth attributed to a microbe shown in the figure below



A pharmaceutical company is contemplating the development of a vaccine against the most dangerous microbe. Which microbe should the company target in its first attempt?

(A) P

(B) Q

(C) R

(D) S

Answer: - (D)

Exp: - By observation of the table, we can say S

	P	Q	R	S
Requirement	800	600	300	200
Potency	0.4	0.5	0.4	0.8

62. The variable cost (V) of manufacturing a product varies according to the equation $V = 4q$, where q is the quantity produced. The fixed cost (F) of production of same product reduces with q according to the equation $F = 100/q$. How many units should be produced to minimize the total cost (V+F)?

- (A) 5 (B) 4 (C) 7 (D) 6

Answer: (A)

Exp: - Checking with all options in formula: $(4q+100/q)$ i.e. (V+F). Option A gives the minimum cost.

63. A transporter receives the same number of orders each day. Currently, he has some pending orders (backlog) to be shipped. If he uses 7 trucks, then at the end of the 4th day he can clear all the orders. Alternatively, if he uses only 3 trucks, then all the orders are cleared at the end of the 10th day. What is the minimum number of trucks required so that there will be no pending order at the end of the 5th day?

- (A) 4 (B) 5 (C) 6 (D) 7

Answer: - (C)

Exp: - Let each truck carry 100 units.

$$2800 = 4n + e \quad n = \text{normal}$$

$$3000 = 10n + e \quad e = \text{excess/pending}$$

$$\therefore n = \frac{100}{3}, e = \frac{8000}{3}$$

$$5\text{days} \Rightarrow 500x = \frac{5 \cdot 100}{3} + \frac{8000}{3}$$

$$\Rightarrow 500x = \frac{8500}{3} \Rightarrow x > 5$$

Minimum possible = 6

64. A container originally contains 10 litres of pure spirit. From this container 1 litre of spirit is replaced with 1 litre of water. Subsequently, 1 litre of the mixture is again replaced with 1 litre of water and this process is repeated one more time. How much spirit is now left in the container?

- (A) 7.58 litres (B) 7.84 litres (C) 7 litres (D) 7.29 litres

Answer: - (D)

$$\text{Exp:- } 10 \left(\frac{10-1}{10} \right)^3 = 10 \left(\frac{9}{10} \right)^3 = \frac{729}{1000}$$

$$\therefore \frac{729}{1000} \times 1 = 7.29 \text{ litres}$$

65. **Few school curricula include a unit on how to deal with bereavement and grief, and yet all students at some point in their lives suffer from losses through death and parting.**

Based on the above passage which topic would not be included in a unit on bereavement?

- (A) how to write a letter of condolence
- (B) what emotional stages are passed through in the healing process
- (C) what the leading causes of death are
- (D) how to give support to a grieving friend

Answer: - (C)

Exp: - The given passage clearly deals with how to deal with bereavement and grief and so after the tragedy occurs and not about precautions. Therefore, irrespective of the causes of death, a school student rarely gets into details of causes—which is beyond the scope of the context. Rest all are important in dealing with grief.



**GATE Previous Year
Solved Paper
Computer Science
(Fully Solved)**

(2012)

Q.No. 1-25 Carry One Mark Each

1. Which of the following problems are decidable?
1) Does a given program ever produce an output?
2) If L is context-free language, then, is \bar{L} also context-free?
3) If L is regular language, then, is \bar{L} also regular?
4) If L is recursive language, then, is \bar{L} also recursive?
(A) 1,2,3,4 (B) 1,2 (C) 2,3,4 (D) 3,4

Answer: (D)

Exp:- CFL's are not closed under complementation. Regular and recursive languages are closed under complementation.

2. Given the language $L = \{ab, aa, baa\}$, which of the following strings are in L^* ?
1) abaabaaabaa
2) aaaabaaaa
3) baaaaabaaaab
4) baaaaabaa
(A) 1,2 and 3 (B) 2,3 and 4 (C) 1,2 and 4 (D) 1,3 and 4

Answer: (C)

Exp:- $L = \{ab, aa, baa\}$

Let $S_1 = ab$, $S_2 = aa$ and $S_3 = baa$

abaabaaabaa can be written as $S_1S_2S_3S_1S_2$

aaaabaaaa can be written as $S_1S_1S_3S_1$

baaaaabaa can be written as $S_3S_2S_1S_2$

3. In the IPv4 addressing format, the number of networks allowed under Class C addresses is
(A) 2^{14} (B) 2^7 (C) 2^{21} (D) 2^{24}

Answer: (C)

Exp:- For class C address, size of network field is 24 bits. But first 3 bits are fixed as 110; hence total number of networks possible is 2^{21}

4. Which of the following transport layer protocols is used to support electronic mail?
(A) SMTP (B) IP (C) TCP (D) UDP

Answer: (C)

Exp:- E-mail uses SMTP, application layer protocol which intern uses TCP transport layer protocol.

5. Consider a random variable X that takes values $+1$ and -1 with probability 0.5 each. The values of the cumulative distribution function $F(x)$ at $x = -1$ and $+1$ are
(A) 0 and 0.5 (B) 0 and 1
(C) 0.5 and 1 (D) 0.25 and 0.75

Answer: (C)

Exp:-The cumulative distribution function

$$F(x) = P(X \leq x)$$

$$F(-1) = P(X \leq -1) = P(X = -1) = 0.5$$

$$F(+1) = P(X \leq +1) = P(X = -1) + P(X = +1) = 0.5 + 0.5 = 1$$

6. Register renaming is done in pipelined processors
- (A) as an alternative to register allocation at compile time
 - (B) for efficient access to function parameters and local variables
 - (C) to handle certain kinds of hazards
 - (D) as part of address translation

Answer: (C)

Exp:- Register renaming is done to eliminate WAR/WAW hazards.

7. The amount of ROM needed to implement a 4 bit multiplier is
- (A) 64 bits
 - (B) 128 bits
 - (C) 1 Kbits
 - (D) 2 Kbits

Answer: (D)

Exp:- For a 4 bit multiplier there are $2^4 \times 2^4 = 2^8 = 256$ combinations.
Output will contain 8 bits.

So the amount of ROM needed is $2^8 \times 8$ bits = 2Kbits.

8. Let $W(n)$ and $A(n)$ denote respectively, the worst case and average case running time of an algorithm executed on an input of size n . Which of the following is **ALWAYS TRUE**?
- (A) $A(n) = \Omega(W(n))$
 - (B) $A(n) = \Theta(W(n))$
 - (C) $A(n) = O(W(n))$
 - (D) $A(n) = o(W(n))$

Answer: (C)

Exp:- If $B(n)$, $A(n)$ and $W(n)$ denote best case, average case and worst case time complexities of an algorithm P respectively then $B(n) = O(A(n))$, $A(n) = O(W(n))$

9. Let G be a simple undirected planar graph on 10 vertices with 15 edges. If G is a connected graph, then the number of **bounded** faces in any embedding of G on the plane is equal to
- (A) 3
 - (B) 4
 - (C) 5
 - (D) 6

Answer: (D)

Exp:- We have the relation $V - E + F = 2$, by this we will get the total number of faces, $F = 7$. Out of 7 faces one is an unbounded face, so total 6 bounded faces.

10. The recurrence relation capturing the optimal execution time of the *Towers of Hanoi* problem with n discs is
- (A) $T(n) = 2T(n-2) + n$
 - (B) $T(n) = 2T(n-1) + n$
 - (C) $T(n) = 2T(n/2) + 1$
 - (D) $T(n) = 2T(n-1) + 1$

Answer: (D)

Exp:- Let the three pegs be A,B and C, the goal is to move n pegs from A to C using peg B

The following sequence of steps are executed recursively

1.move $n-1$ discs from A to B. This leaves disc n alone on peg A --- $T(n-1)$

2.move disc n from A to C-----**1**

3.move $n-1$ discs from B to C so they sit on disc n ----- $T(n-1)$

So, $T(n) = 2T(n-1) + 1$

11. Which of the following statements are **TRUE** about an SQL query?
- P : An SQL query can contain a HAVING clause even if it does not have a GROUP BY clause
- Q : An SQL query can contain a HAVING clause only if it has GROUP BY clause
- R : All attributes used in the GROUP BY clause must appear in the SELECT clause
- S : Not all attributes used in the GROUP BY clause need to appear in the SELECT clause
- (A) P and R (B) P and S (C) Q and R (D) Q and S

Answer: (A)

Exp:- If we use a HAVING clause without a GROUP BY clause, the HAVING condition applies to all rows that satisfy the search condition. In other words, all rows that satisfy the search condition make up a single group. So, option P is true and Q is false.

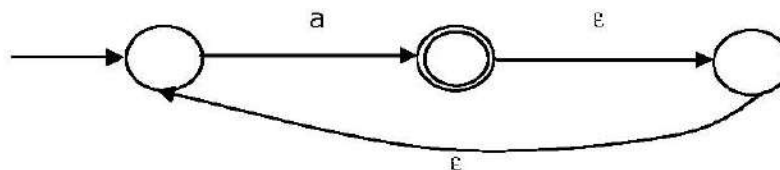
Function of GROUP BY clause is to group the result obtained using one or more attributes. If attribute name is not present in SELECT clause then GROUP BY cannot find the attribute name in the result according to which result is supposed to be grouped. So, option R is true and S is false.

12. Given the basic ER and relational models, which of the following is **INCORRECT**?
- (A) An attribute of an entity can have more than one value
- (B) An attribute of an entity can be composite
- (C) In a row of a relational table, an attribute can have more than one value
- (D) In a row of a relational table, an attribute can have exactly one value or a NULL value

Answer: (C)

Exp:- In a row of a relational table, an attribute cannot have more than one value.

13. What is the complement of the language accepted by the NFA show below? Assume $\Sigma = \{a\}$ and ϵ is the empty string.



- (A) \emptyset (B) $\{\epsilon\}$ (C) a^* (D) $\{a, \epsilon\}$ www.examrace.com

Answer: (B)

Exp:- Language accepted by NFA is a^+ , so complement of this language is $\{\epsilon\}$

14. What is the correct translation of the following statement into mathematical logic?

"Some real numbers are rational"

(A) $\exists x (\text{real}(x) \vee \text{rational}(x))$ (B) $\forall x (\text{real}(x) \rightarrow \text{rational}(x))$

(C) $\exists x (\text{real}(x) \wedge \text{rational}(x))$ (D) $\exists x (\text{rational}(x) \rightarrow \text{real}(x))$

Answer: (C)

Exp:- Option A: There exists x which is either real or rational and can be both.

Option B: All real numbers are rational

Option C: There exists a real number which is rational.

Option D: There exists some number which is not rational or which is real.

15. Let A be the 2 x 2 matrix with elements $a_{11} = a_{12} = a_{21} = +1$ and $a_{22} = -1$. Then the eigen values of the matrix A^{19} are

(A) 1024 and -1024 (B) $1024\sqrt{2}$ and $-1024\sqrt{2}$

(C) $4\sqrt{2}$ and $-4\sqrt{2}$ (D) $512\sqrt{2}$ and $-512\sqrt{2}$

Answer: (D)

Exp:- $A = \begin{bmatrix} 1 & 1 \\ 1 & -1 \end{bmatrix}$ $A^5 \cdot A^5 = \begin{bmatrix} 32 & 0 \\ 0 & 32 \end{bmatrix}$

$A^4 = \begin{bmatrix} 4 & 0 \\ 0 & 4 \end{bmatrix}$ $A^{10} \cdot A^5 = \begin{bmatrix} 128 & 128 \\ 128 & -128 \end{bmatrix}$

$A^5 = \begin{bmatrix} 4 & 4 \\ 4 & -4 \end{bmatrix}$ $A^{15} \cdot A^4 = \begin{bmatrix} 512 & 512 \\ 512 & -512 \end{bmatrix}$

$$\therefore A^{19} = \begin{bmatrix} 512 & 512 \\ 512 & -512 \end{bmatrix}$$

$$\begin{vmatrix} 512 - \lambda & 512 \\ 512 & -(512 + \lambda) \end{vmatrix} = 0$$

$$\Rightarrow -((512)^2 - \lambda^2) - (512)^2 = 0$$

$$\Rightarrow \lambda^2 = 2 \times (512)^2$$

$$\Rightarrow \lambda = \pm\sqrt{2} (512)$$

16. The protocol data unit (PDU) for the application layer in the Internet stack is

(A) Segment (B) Datagram (C) Message (D) Frame

Answer: (C)

Exp:- The PDU for Datalink layer, Network layer, Transport layer and Application layer are frame, datagram, segment and message respectively.

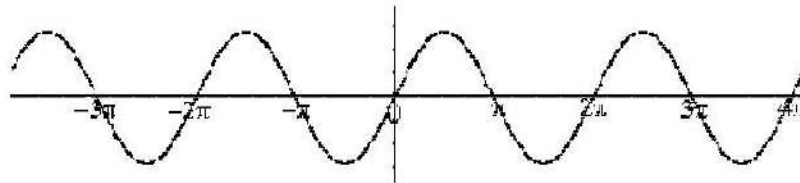
17. Consider the function $f(x) = \sin(x)$ in the interval $x \in [\pi/4, 7\pi/4]$. The number and location (s) of the local minima of this function are
- (A) One, at $\pi/2$ (B) One, at $3\pi/2$
 (C) Two, at $\pi/2$ and $3\pi/2$ (D) Two, at $\pi/4$ and $3\pi/2$

Answer: (B)

Exp:- The zeros of $f(x) = \sin x$ are at the multiples of π and at that points it crosses the x-axis

$\sin x$ has a maximum value of 1 at $\frac{\pi}{2}$, and a minimum value of -1 at $\frac{3\pi}{2}$ and at all angles conterminal with them.

The graph of $f(x) = \sin x$ is



\therefore In the interval $[\frac{\pi}{4}, \frac{7\pi}{4}]$, it has one local minimum at $x = \frac{3\pi}{2}$

18. A process executes the code
- ```
fork ();
fork ();
fork ();
```
- The total number of **child** processes created is
- (A) 3 (B) 4 (C) 7 (D) 8

Answer: (C)

Exp:- If fork is called n times, there will be total  $2^n$  running processes including the parent process. So, there will be  $2^n - 1$  child processes.

19. The decimal value 0.5 in IEEE single precision floating point representation has
- (A) fraction bits of 000...000 and exponent value of 0  
 (B) fraction bits of 000...000 and exponent value of -1  
 (C) fraction bits of 100...000 and exponent value of 0  
 (D) no exact representation

Answer: (B)

Exp:-  $(0.5)_{10} = (1.0)_2 \times 2^{-1}$

So, exponent = -1 and fraction is 000 - - - 000

20. The truth table

| X | Y | f(X,Y) |
|---|---|--------|
| 0 | 0 | 0      |
| 0 | 1 | 0      |
| 1 | 0 | 1      |
| 1 | 1 | 1      |

represents the Boolean function

- (A) X                                      (B)  $X + Y$                                       (C)  $X \oplus Y$                                       (D) Y

Answer: (A)

Exp:-  $XY' + XY = X(Y' + Y) = X \cdot 1 = X$

21. The worst case running time to search for an element in a balanced binary search tree with  $n2^n$  elements is

- (A)  $\Theta(n \log n)$                                       (B)  $\Theta(n2^n)$                                       (C)  $\Theta(n)$                                       (D)  $\Theta(\log n)$

Answer: (C)

Exp:- The worst case search time in a balanced BST on 'x' nodes is  $\log x$ . So, if  $x = n2^n$ , then  $\log(n2^n) = \log n + \log(2^n) = \log n + n = \Theta(n)$

22. Assuming  $P \neq NP$ , which of the following is **TRUE**?

- (A) NP-complete = NP                                      (B) NP-complete  $\cap$  P =  $\emptyset$   
(C) NP-hard = NP                                      (D) P = NP-complete

Answer: (B)

Exp:- If  $P \neq NP$ , then it implies that no NP-Complete problem can be solved in polynomial time which implies that the set P and the set NPC are disjoint.

23. What will be the output of the following C program segment?

```
Char inChar = 'A' ;
switch (inChar) {
case 'A' : printf ("Choice A\ n");
case 'B' :
case 'C' : print f("Choice B");
case 'D' :
case 'E' :
default : printf ("No Choice") ; }
```

- (A) No choice
- (B) Choice A
- (C) Choice A  
Choice B No choice
- (D) Program gives no output as it is erroneous

Answer: (C)

Exp:- Since there is no 'break' statement , the program executes all the subsequent case statements after printing "choice A"

24. Which of the following is **TRUE**?

- (A) Every relation is 3NF is also in BCNF
- (B) A relation R is in 3NF if every non-prime attribute of R is fully functionally dependent on every key of R
- (C) Every relation in BCNF is also in 3NF
- (D) No relation can be in both BCNF and 3NF

Answer: (C)

Exp:- Option A is false since BCNF is stricter than 3NF

Option B is false since the definition given here is of 2NF

Option C is true, since BCNF is stricter than 3NF, every relation in BCNF satisfies all the properties of 3NF.

25. Consider the following logical inferences.

$I_1$  : If it rains then the cricket match will not be played.  
The cricket match was played.

**Inference:** There was no rain.

$I_2$  : If it rains then the cricket match will not be played.  
It did not rain.

**Inference:** The cricket match was played.

Which of the following is **TRUE**?

- (A) Both  $I_1$  and  $I_2$  are correct inferences
- (B)  $I_1$  is correct but  $I_2$  is not a correct inference
- (C)  $I_1$  is not correct but  $I_2$  is a correct inference
- (D) Both  $I_1$  and  $I_2$  are not correct inferences

Answer: (B)

Exp:-

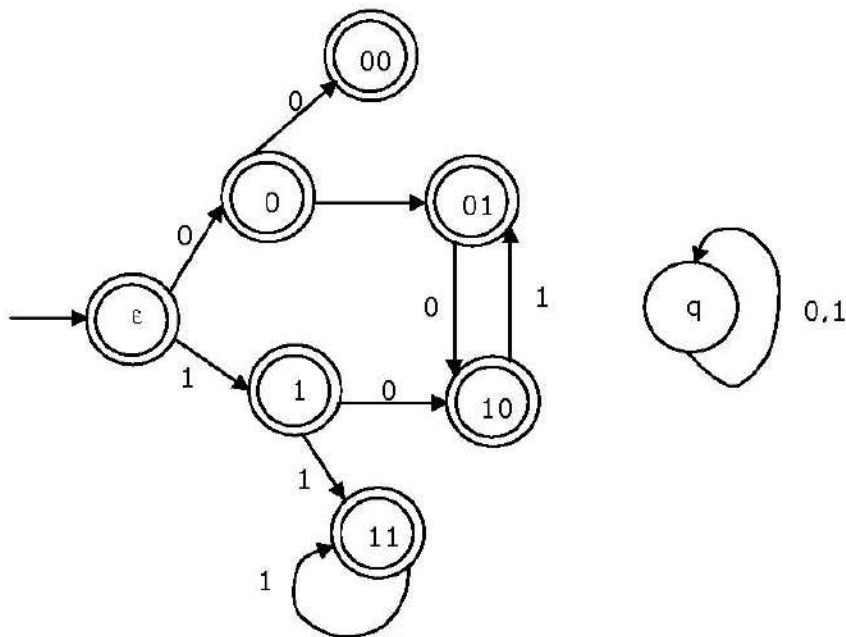
$$I_1: \quad R \rightarrow \sim C \quad \equiv \quad \frac{\sim R \vee \sim C}{\sim R} \quad (\text{there was no rain})$$

$$I_2: \quad \frac{R \rightarrow C}{\sim R} \quad \equiv \quad \frac{\sim R \vee \sim C}{\sim R \vee C}$$

( $I_1$  is correct and  $I_2$  is not correct inference)

**Q. No. 26-51 Carry Two Marks Each**

26. Consider the set of strings on  $\{0,1\}$  in which, every substring of 3 symbols has at most two zeros. For example, 001110 and 011001 are in the language, but 100010 is not. All strings of length less than 3 are also in the language. A partially completed DFA that accepts this language is shown below.



The missing arcs in the DFA are

(A)

|    | 00 | 01 | 10 | 11 | q |
|----|----|----|----|----|---|
| 00 | 1  | 0  |    |    |   |
| 01 |    |    |    | 1  |   |
| 10 | 0  |    |    |    |   |
| 11 |    |    | 0  |    |   |

(B)

|    | 00 | 01 | 10 | 11 | q |
|----|----|----|----|----|---|
| 00 |    | 0  |    |    | 1 |
| 01 |    | 1  |    |    |   |
| 10 |    |    |    | 0  |   |
| 11 |    | 0  |    |    |   |

(C)

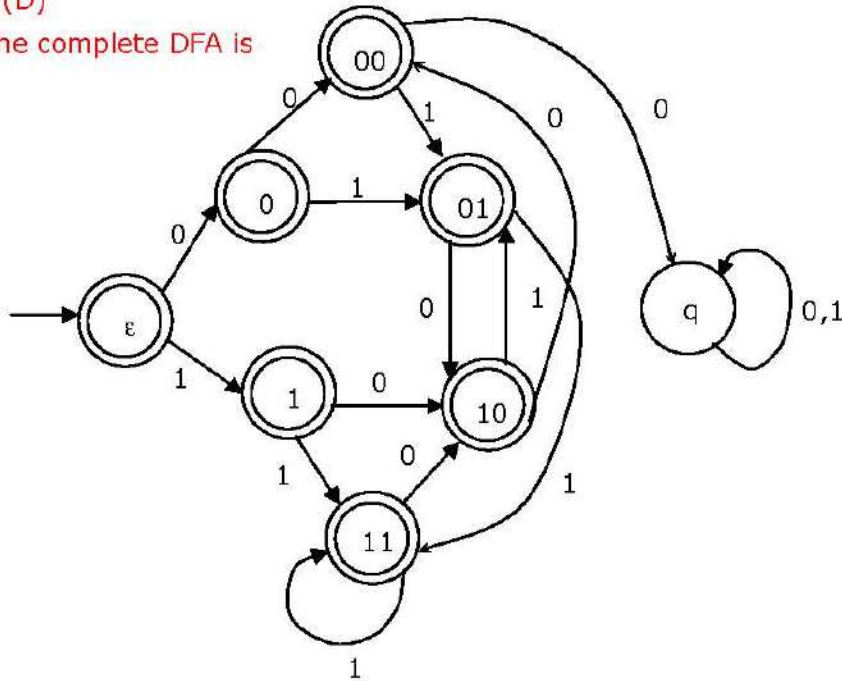
|    | 00 | 01 | 10 | 11 | q |
|----|----|----|----|----|---|
| 00 |    | 1  |    |    | 0 |
| 01 |    | 1  |    |    |   |
| 10 |    |    | 0  |    |   |
| 11 |    | 0  |    |    |   |

(D)

|    | 00 | 01 | 10 | 11 | q |
|----|----|----|----|----|---|
| 00 |    | 1  |    |    | 0 |
| 01 |    |    |    | 1  |   |
| 10 | 0  |    |    |    |   |
| 11 |    |    | 0  |    |   |

Answer: (D)

Exp:- The complete DFA is



27 The height of a tree is defined as the number of edges on the longest path in the tree. The function shown in the pseudocode below is invoked as height (root) to compute the height of a binary tree rooted at the tree pointer root.

```

int height (treeptr n)
{ if (n == NULL) return -1;
 if (n → left == NULL)
 if (n → right == NULL) return 0;
 else return [B1]; // Box 1
 else {h1 = height (n → left);
 if (n → right == NULL) return (1+h1);
 else {h2 = height (n → right);
 return [B2]; // Box 2
 }
 }
}

```

The appropriate expressions for the two boxes B1 and B2 are

(A) B1 :  $(1 + \text{height}(n \rightarrow \text{right}))$

(B) B1 :  $(\text{height}(n \rightarrow \text{right}))$

B2 :  $(1 + \max(h_1, h_2))$

B2 :  $(1 + \max(h_1, h_2))$

(C) B1 :  $\text{height}(n \rightarrow \text{right})$

B2 :  $\max(h_1, h_2)$

(D) B1 :  $(1 + \text{height}(n \rightarrow \text{right}))$

B2 :  $\max(h_1, h_2)$

Answer: (A)

Exp:-

```
int height (treeptr n)
```

```
{ if (n == null) return - 1;
 → /* If there is no node, return -1 */

 if (n→left==NULL) → /* If there is no left child for node 'n' */

 if (n → right = NULL) return 0;
 → /*If no left child & no right child for 'n', return */

 else return (1+height (n → right));
 → /* If no left child, but there is a right child, then
 compute height for right sub tree. Therefore total height is
 1+ height (n → right) */

 else { → /* If there exist left child node for node 'n' */

 h1 = height (n → left);
 → /*First Find the height of left sub tree for node 'n' */

 If (n → right = NULL) return (1+h1);
 → /* If there exist left child and no right child and no
 right child for a node 'n', then total height
 = height from (n to n → left) + left sub tree height
 =1 + height (n → left) = 1 + h1 */

 else {h2 = height (n → right);
 → /* If there exist right child also, then compute height
 of right sub tree for a node 'n' */

 return (1+ max (h1,h2));
 → /* Total height for node 'n'=
 1 + Max (Left Subtree height, Right sub tree height)
 = 1 + Max (h1, h2) */

 }

}
```

28. Consider an instance of TCP's Additive Increase Multiplicative decrease (AIMD) algorithm where the window size at the start of the slow start phase is 2 MSS and the threshold at the start of the first transmission is 8 MSS. Assume that a timeout occurs during the fifth transmission. Find the congestion window size at the end of the tenth transmission.

(A) 8MSS

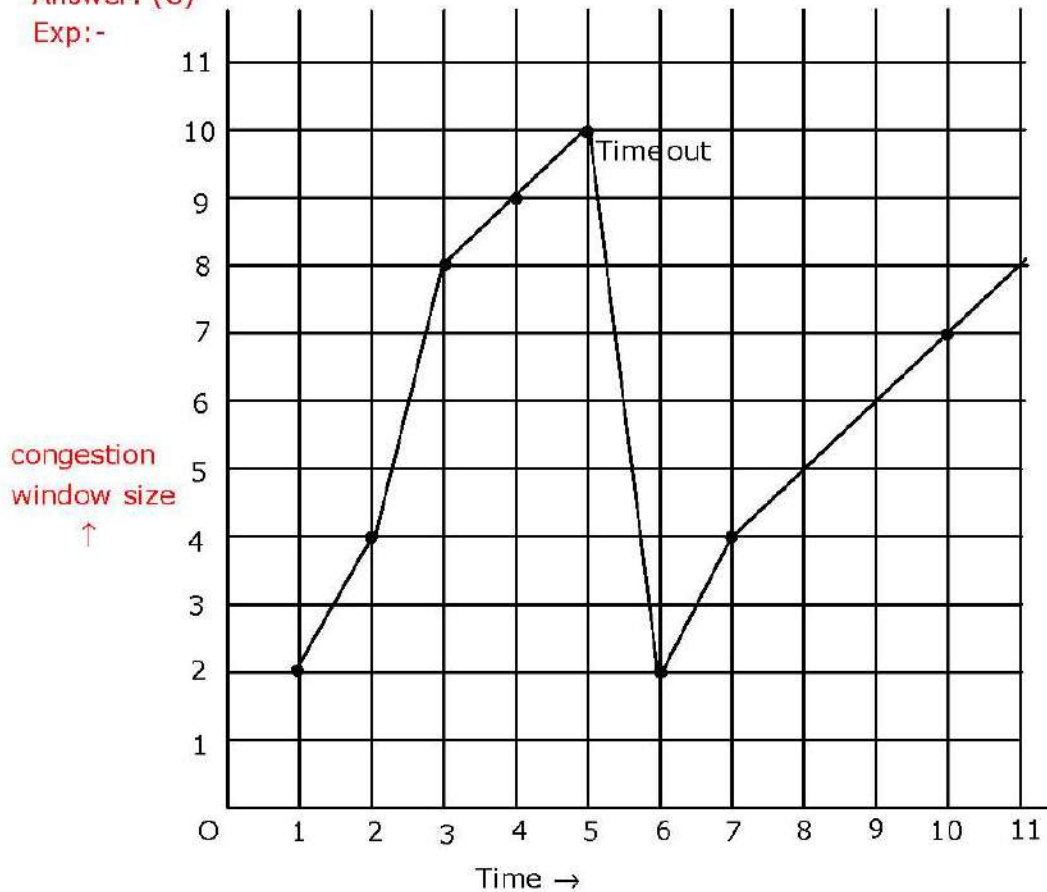
(B) 14MSS

(C) 7MSS

(D) 12MSS

Answer: (C)

Exp:-



Given, initial threshold = 8

Time = 1, during first transmission, window size = 2 (slow start phase)

Time = 2, congestion window size = 4 (double the no. of acknowledgments)

Time = 3, congestion window size = 8

Time = 4, congestion window size = 9, after threshold (increase by one Additive increase)

Time = 5, transmits 10 MSS, but time out occurs congestion window size = 10

$$\text{Hence threshold} = (\text{Congestion window size})/2 = \frac{10}{2} = 5$$

Time = 6, transmits 2

Time = 7, transmits 4

Time = 8, transmits 5 (threshold is 5)

Time = 9, transmits 6

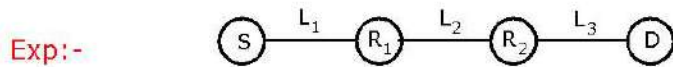
Time = 10, transmits 7

∴ During 10<sup>th</sup> transmission, it transmits 7 segments hence at the end of the tenth transmission the size of congestion window is 7 MSS.



29. Consider a source computer (S) transmitting a file of size  $10^6$  bits to a destination computer (D) over a network of two routers ( $R_1$  and  $R_2$ ) and three links ( $L_1$ ,  $L_2$ , and  $L_3$ ).  $L_1$  connects S to  $R_1$ ;  $L_2$  connects  $R_1$  to  $R_2$ ; and  $L_3$  connects  $R_2$  to D. Let each link be of length 100km. Assume signals travel over each line at a speed of  $10^8$  meters per second. Assume that the link bandwidth on each link is 1Mbps. Let the file be broken down into 1000 packets each of size 1000 bits. Find the total sum of transmission and propagation delays in transmitting the file from S to D?
- (A) 1005ms                      (B) 1010ms                      (C) 3000ms                      (D) 3003ms

Answer: (A)



Transmission delay for 1 packet from each of S,  $R_1$  and  $R_2$  will take 1ms

Propagation delay on each link  $L_1$ ,  $L_2$  and  $L_3$  for one packet is 1ms

Therefore the sum of transmission delay and propagation delay on each link for one packet is 2ms.

The first packet reaches the destination at 6<sup>th</sup>ms

The second packet reaches the destination at 7<sup>th</sup>ms

So inductively we can say that 1000<sup>th</sup> packet reaches the destination at 1005<sup>th</sup> ms

30. Suppose  $R_1$  ( $\underline{A}$ , B) and  $R_2$  ( $\underline{C}$ , D) are two relation schemas. Let  $r_1$  and  $r_2$  be the corresponding relation instances. B is a foreign key that refers to C in  $R_2$ . If data in  $r_1$  and  $r_2$  satisfy referential integrity constraints, which of the following is **ALWAYS TRUE**?

(A)  $\Pi_B(r_1) - \Pi_C(r_2) = \emptyset$

(B)  $\Pi_C(r_2) - \Pi_B(r_1) = \emptyset$

(C)  $\Pi_B(r_1) = \Pi_C(r_2)$

(D)  $\Pi_B(r_1) - \Pi_C(r_2) \neq \emptyset$

Answer: (A)

Exp:- Since B is a foreign key referring C,  $\Pi_B(r_1) \subseteq \Pi_C(r_2) \Rightarrow \Pi_B(r_1) - \Pi_C(r_2) = \emptyset$

31. Consider the virtual page reference string

1,2,3,2,4,1,3,2,4,1

on a demand paged virtual memory system running on a computer system that has main memory size of 3 page frames which are initially empty. Let LRU, FIFO and OPTIMAL denote the number of page faults under the corresponding page replacement policy. Then

(A) OPTIMAL < LRU < FIFO

(B) OPTIMAL < FIFO < LRU

(C) OPTIMAL = LRU

(D) OPTIMAL = FIFO

Answer: (B)

Exp:- FIFO

```
1 1 1 4 4 4
 2 2 2 1 1
 3 3 3 2
```

→ (6) faults

Optimal

```
1 1 1 1 1
 2 2 4 4
 3 3 2
```

→ (5) faults

LRU

```
1 1 1 4 4 4 2 2 2
 2 2 2 2 3 3 3 1
 3 3 1 1 1 4 4
```

→ (9) faults

Optimal < FIFO < LRU

32. A file system with 300 GByte disk uses a file descriptor with 8 direct block addresses, 1 indirect block address and 1 doubly indirect block address. The size of each disk block is 128 Bytes and the size of each disk block address is 8 Bytes. The maximum possible file size in this file system is
- (A) 3 KBytes  
(B) 35 KBytes  
(C) 280 KBytes  
(D) dependent on the size of the disk

Answer: (B)

Exp:- Each block size = 128 Bytes

Disk block address = 8 Bytes

∴ Each disk can contain =  $\frac{128}{8} = 16$  addresses

Size due to 8 direct block addresses:  $8 \times 128$

Size due to 1 indirect block address:  $16 \times 128$

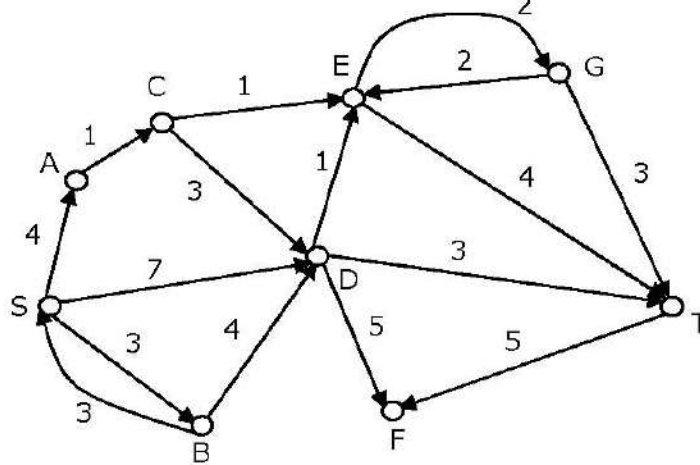
Size due to 1 doubly indirect block address:  $16 \times 16 \times 128$

Size due to 1 doubly indirect block address:  $16 \times 16 \times 128$

So, maximum possible file size:

=  $8 \times 128 + 16 \times 128 + 16 \times 16 \times 128 = 1024 + 2048 + 32768 = 35840$  Bytes = 35kBytes

33. Consider the directed graph shown in the figure below. There are multiple shortest paths between vertices S and T. Which one will be reported by Dijkstra's shortest path algorithm? Assume that, in any iteration, the shortest path to a vertex  $v$  is updated only when a strictly shorter path to  $v$  is discovered.



(A) SDT

(B) SBDT

(C) SACDT

(D) SACET

Answer: (D)

Exp:- Let  $d[v]$  represent the shortest path distance computed from 'S'

Initially  $d[S]=0, d[A] = \infty, d[B] = \infty, \dots, d[T] = \infty$

And let  $P[v]$  represent the predecessor of  $v$  in the shortest path from 'S' to ' $v$ ' and let  $P[v]=-1$  denote that currently predecessor of ' $v$ ' has not been computed

→ Let  $Q$  be the set of vertices for which shortest path distance has not been computed

→ Let  $W$  be the set of vertices for which shortest path distance has not been computed

→ So initially,  $Q = \{S, A, B, C, D, E, F, G, T\}, W = \phi$

We will use the following procedure

Repeat until  $Q$  is empty

1.  $u =$  choose a vertex from  $Q$  with minimum  $d[u]$  value
2.  $Q = Q - u$
3. update all the adjacent vertices of  $u$
4.  $W = W \cup \{u\}$

$d[S] = 0, d[A] = \infty, d[B] = \infty, \dots, d[T] = \infty$

### Iteration 1

Step 1 :  $u = S$

Step 2 :  $Q = \{A, B, C, D, E, F, G, T\}$

Step 3: final values after adjustment

$d[S] = 0, d[A] = 4, d[B] = 3, d[C] = \infty, d[D] = 7, d[E] = \infty, \dots, d[T] = \infty$

$P[A] = S, P[B] = S, P[C] = -1, P[D] = S, P[E] = -1, \dots, P[T] = -1$

Step 4 :  $W = \{S\}$

**Iteration 2:**Step 1 :  $u = B$ Step 2 :  $Q = \{A, C, D, E, F, G, T\}$ 

step 3 : final values after adjustment

$$d[S] = 0, d[A] = 4, d[B] = 3, d[C] = \infty, d[D] = 7, d[E] = \infty, \dots, d[T] = \infty$$

$$P[A] = S, P[B] = S, P[C] = -1, P[D] = S, P[E] = -1, \dots, P[T] = -1$$

Step 4 :  $W = \{S, B\}$ **Iteration 3:**Step 1 :  $u = A$ Step 2 :  $Q = \{C, D, E, F, G, T\}$ 

step 3 : final values after adjustment

$$d[S] = 0, d[A] = 4, d[B] = 3, d[C] = 5, d[D] = 7, d[E] = \infty, \dots, d[T] = \infty$$

$$P[A] = S, P[B] = S, P[C] = A, P[D] = S, P[E] = -1, \dots, P[T] = -1$$

Step 4 :  $W = \{S, B, A\}$ **Iteration 4:**Step 1 :  $u = C$ Step 2 :  $Q = \{D, E, F, G, T\}$ 

step 3 : final values after adjustment

$$d[S] = 0, d[A] = 4, d[B] = 3, d[C] = 5, d[D] = 7, d[E] = 6, \dots, d[T] = \infty$$

$$P[A] = S, P[B] = S, P[C] = A, P[D] = S, P[E] = C, \dots, P[T] = -1$$

Step 4 :  $W = \{S, B, A, C\}$ **Iteration 5:**Step 1 :  $u = E$ Step 2 :  $Q = \{D, F, G, T\}$ 

step 3 : final values after adjustment

$$d[S] = 0, d[A] = 4, d[B] = 3, d[C] = 5, d[D] = 7, d[E] = 6, d[F] = \infty, d[G] = 8, d[T] = 10$$

$$P[A] = S, P[B] = S, P[C] = A, P[D] = S, P[E] = C, P[F] = -1, P[G] = E, P[T] = E$$

Step 4 :  $W = \{S, B, A, C, E\}$ 

After Iteration 5, we can observe that  $P[T]=E$  ,  $P[E]=C$  ,  $P[C]=A$  ,  $P[A]=S$ ,  
So the shortest path from S to T Is SACET

34. A list of  $n$  strings, each of length  $n$ , is sorted into lexicographic order using the merge-sort algorithm. The worst case running time of this computation is
- (A)  $O(n \log n)$  (B)  $O(n^2 \log n)$   
(C)  $O(n^2 + \log n)$  (D)  $O(n^2)$

Answer: (B)

Exp:- The height of the recursion tree using merge sort is  $\log n$  and  $n^2$  comparisons are done at each level, where at most  $n$  pairs of strings are compared at each level

and  $n$  comparisons are required to compare any two strings, So the worst case running time is  $O(n^2 \log n)$

35. Let  $G$  be a complete undirected graph on 6 vertices. If vertices of  $G$  are labeled, then the number of distinct cycles of length 4 in  $G$  is equal to  
(A) 15                      (B) 30                      (C) 90                      (D) 360

Answer: (C)

Exp:- 4 vertices from 6 vertices can be chosen in  ${}^6C_4$  ways and number of ways in which 4 vertices can be arranged in a cycle is  $(4-1)!$ , so total number of 4 length cycles are  ${}^6C_4 \cdot 3! = 90$

36. How many onto (or surjective) functions are there from an  $n$ -element ( $n \geq 2$ ) set to a 2-element set?  
(A)  $2^n$                       (B)  $2^n - 1$                       (C)  $2^n - 2$                       (D)  $2(2^n - 2)$

Answer: (C)

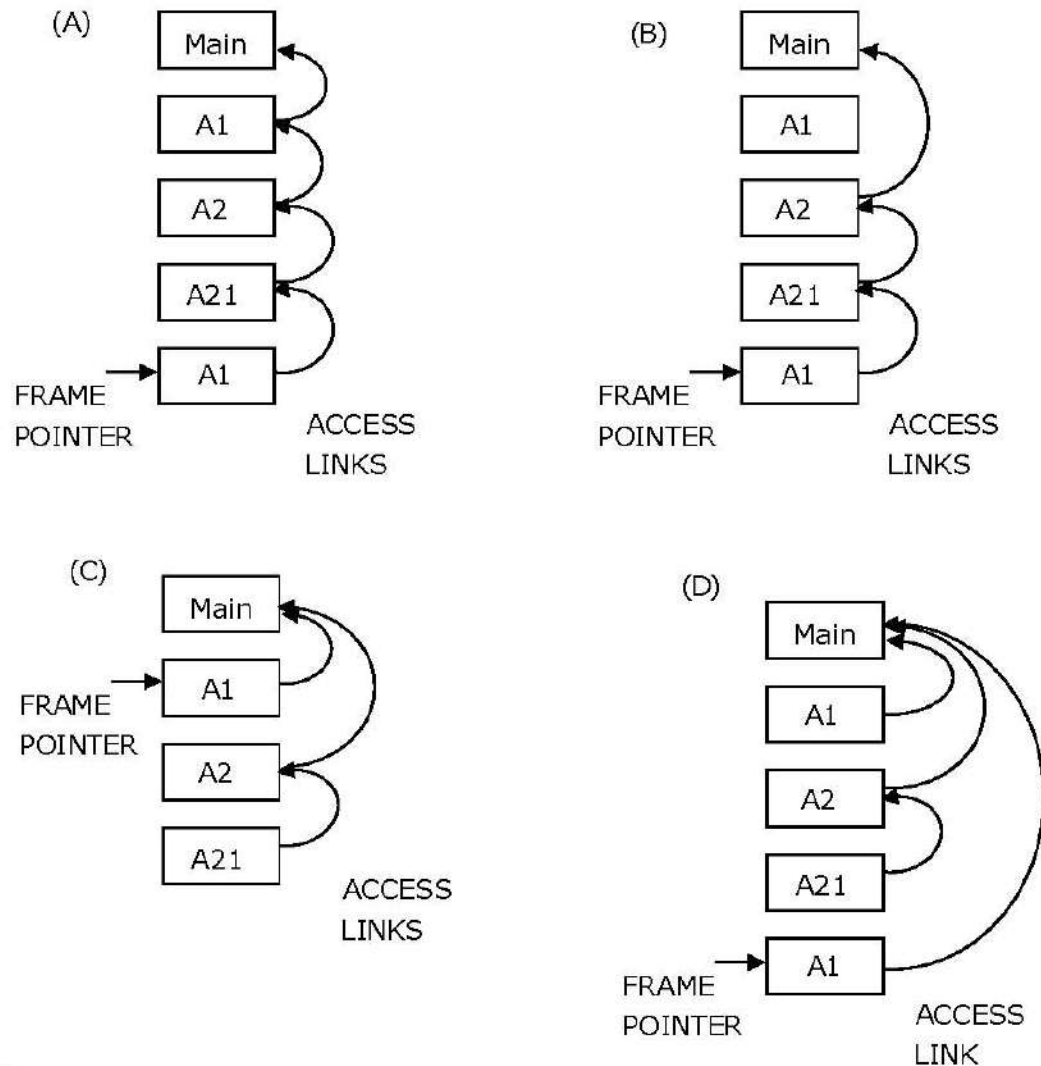
Exp:- Total number of functions is  $2^n$ , out of which there will be exactly two functions where all elements map to exactly one element, so total number of onto functions is  $2^n - 2$

37. Consider the program given below, in a block-structured pseudo-language with lexical scoping and nesting of procedures permitted.

```
Program main;
 Var . . .
 Procedure A1;
 Var
 Call A2;
 End A1
 Procedure A2;
 Var . . .
 Procedure A21;
 Var . . .
 Call A1;
 End A21
 Call A21;
 End A2
 Call A1;
End main.
```

Consider the calling chain: Main  $\rightarrow$  A1  $\rightarrow$  A2  $\rightarrow$  A21  $\rightarrow$  A1

The correct set of activation records along with their access links is given by [www.examrace.com](http://www.examrace.com)



Answer: (D)

Exp:- Access link is defined as link to activation record of closest lexically enclosing block in program text, so the closest enclosing blocks respectively for A1 ,A2 and A21 are main ,main and A2

38. Suppose a circular queue of capacity  $(n - 1)$  elements is implemented with an array of  $n$  elements. Assume that the insertion and deletion operations are carried out using REAR and FRONT as array index variables, respectively. Initially, REAR = FRONT = 0. The conditions to detect queue full and queue empty are

(A) full:  $(\text{REAR}+1) \bmod n == \text{FRONT}$       (B) full:  $(\text{REAR}+1) \bmod n == \text{FRONT}$   
 empty: REAR == FRONT      empty:  $(\text{FRONT}+1) \bmod n == \text{REAR}$

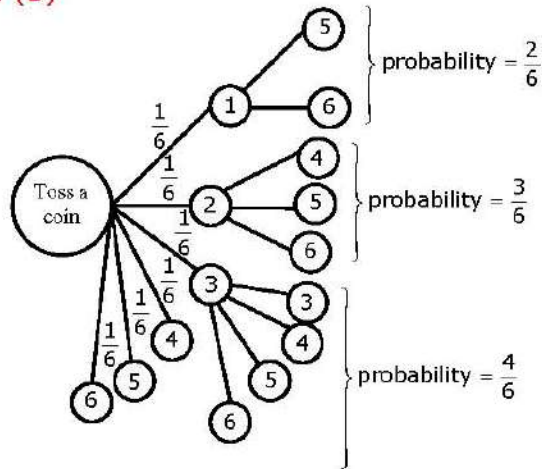
(C) full: REAR == FRONT      (D) full:  $(\text{FRONT}+1) \bmod n == \text{REAR}$   
 empty:  $(\text{REAR}+1) \bmod n == \text{FRONT}$       empty: REAR == FRONT



40. Suppose a fair six-sided die is rolled once. If the value on the die is 1, 2, or 3, the die is rolled a second time. What is the probability that the sum total of values that turn up is at least 6?
- (A) 10/21                      (B) 5/12                      (C) 2/3                      (D) 1/6

Answer: (B)

Exp:-



$$\therefore \text{Required probability} = \frac{1}{6} \times \frac{2}{6} + \frac{1}{6} \times \frac{3}{6} + \frac{1}{6} \times \frac{4}{6} + \frac{1}{6} = \frac{15}{36} = \frac{5}{12}$$

41. Fetch\_And\_Add (X, i) is an atomic Read-Modify-Write instruction that reads the value of memory location X, increments it by the value i, and returns the old value of X. It is used in the pseudocode shown below to implement a busy-wait lock. L is an unsigned integer shared variable initialized to 0. The value of 0 corresponds to lock being available, while any non-zero value corresponds to the lock being not available.

```
AcquireLock(L){
 While (Fetch_And_Add(L,1))
 L = 1;
}
Release Lock(L){
 L = 0;
}
This implementation
```

- (A) fails as L can overflow  
 (B) fails as L can take on a non-zero value when the lock is actually available  
 (C) works correctly but may starve some processes  
 (D) works correctly without starvation



Answer: (B)

Exp:-

1. Acquire lock (L) {
2. While (Fetch\_And\_Add(L, 1))
3. L = 1.
- }
4. Release Lock (L) {
5. L = 0;
6. }

Let P and Q be two concurrent processes in the system currently executing as follows

P executes 1,2,3 then Q executes 1 and 2 then P executes 4,5,6 then L=0 now Q executes 3 by which L will be set to 1 and thereafter no process can set L to zero, by which all the processes could starve.

42. Consider the 3 process, P1, P2 and P3 shown in the table.

| Process | Arrival time | Time units Required |
|---------|--------------|---------------------|
| P1      | 0            | 5                   |
| P2      | 1            | 7                   |
| P3      | 3            | 4                   |

The completion order of the 3 processes under the policies FCFS and RR2 (round robin scheduling with CPU quantum of 2 time units) are

- (A) **FCFS:** P1, P2, P3 **RR2:** P1, P2, P3  
(B) **FCFS:** P1, P3, P2 **RR2:** P1, P3, P2  
(C) **FCFS:** P1, P2, P3 **RR2:** P1, P3, P2  
(D) **FCFS:** P1, P3, P2 **RR2:** P1, P2, P3

Answer: (C)

Exp:-The completion order for round robin is given below

At time t = 2

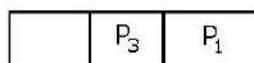
P<sub>1</sub> will move to ready queue, so status of ready queue will be:



↑ front

At time t = 3.

P<sub>3</sub> enters the system so it will be enqueued.



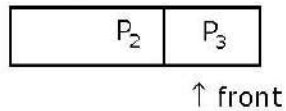
↑ front

At time t = 4,

When quantum of P2 is done.

We need to enqueue P2 into ready queue & next process to be executed which will be taken from front of Ready queue i.e, P1.

Ready queue :



So using round robin scheduling, the completion order is P1,P3,P2

43. What is the minimal form of the Karnaugh map shown below? Assume that X denotes a don't care term.

|    |    |    |    |    |    |
|----|----|----|----|----|----|
|    | ab | 00 | 01 | 11 | 10 |
| cd | 00 | 1  | X  | X  | 1  |
|    | 01 | X  |    |    | 1  |
|    | 11 |    |    |    |    |
|    | 10 | 1  |    |    | X  |

(A)  $\bar{b}\bar{d}$

(B)  $\bar{b}\bar{d} + \bar{b}\bar{c}$

(C)  $\bar{b}\bar{d} + \overline{abcd}$

(D)  $\bar{b}\bar{d} + \bar{b}\bar{c} + \bar{c}\bar{d}$

Answer: (B)

Exp:-

$a'b' + c'b'$

|    |    |    |    |    |    |
|----|----|----|----|----|----|
|    | ab | 00 | 01 | 11 | 10 |
| cd | 00 | 1  | X  | X  | 1  |
|    | 01 | X  |    |    | 1  |
|    | 11 |    |    |    |    |
|    | 10 | 1  |    |    | X  |

44. Let G be a weighted graph with edge weights greater than one and G' be the graph constructed by squaring the weights of edges in G. Let T and T' be the minimum spanning trees of G and G' respectively, with total weights t and t'. Which of the following statements is **TRUE**?

(A)  $T' = T$  with total weight  $t' = t^2$

(B)  $T' = T$  with total weight  $t' < t^2$

(C)  $T' \neq T$  but total weight  $t' = t^2$

(D) None of these

Answer: (D)



Graph G is counter example for options (B) and (C) and Graph  $G_1$  is counter example for option (A)

45. The bisection method is applied to compute a zero of the function  $f(x) = x^4 - x^3 - x^2 - 4$  in the interval  $[1,9]$ . The method converges to a solution after \_\_\_\_\_ iterations.
- (A) 1                      (B) 3                      (C) 5                      (D) 7

Answer: (B)

Exp:-

$$f(x) = x^4 - x^3 - x^2 - 4$$

$$f(1) < 0 \text{ and } f(9) > 0 \therefore x_0 = \frac{1+9}{2} = 5$$

$$f(5) > 0 \therefore \text{root lies in } [1,5]$$

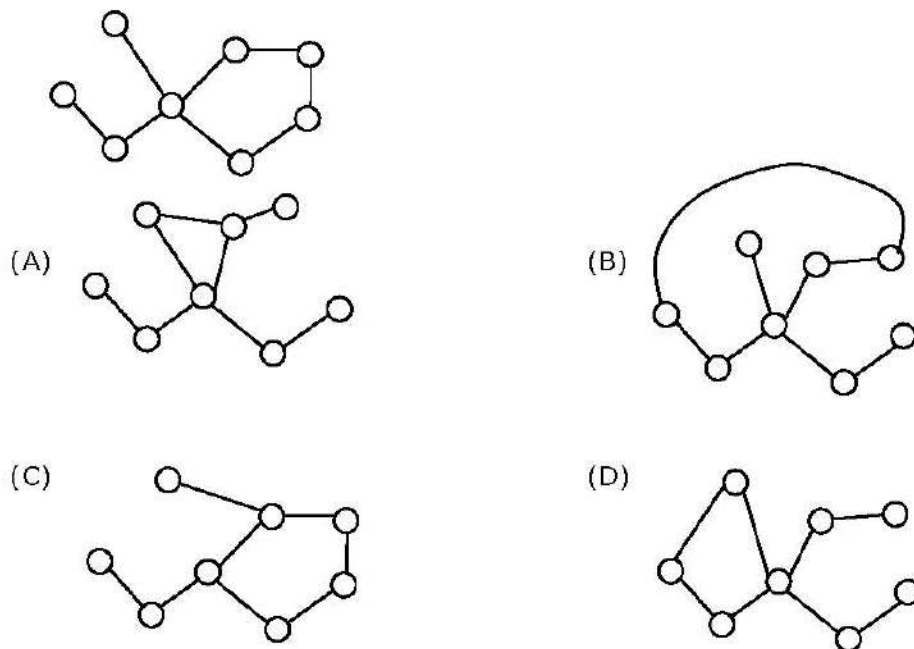
$$x_1 = \frac{1+5}{2} = 3$$

$$f(3) > 0 \therefore \text{root lies in } [1,3]$$

$$x_2 = \frac{1+3}{2} = 2$$

$$f(2) = 0 \therefore \text{root is } 2$$

46. Which of the following graph is isomorphic to



Answer: (B)

Exp:- The graph in option (A) has a 3 length cycle whereas the original graph does not have a 3 length cycle

The graph in option (C) has a vertex with degree 4 whereas the original graph does not have a vertex with degree 4

The graph in option (D) has a 4 length cycle whereas the original graph does not have a 4 length cycle

47. Consider the following transactions with data items P and Q initialized to zero:

**T<sub>1</sub>** : read (P) ;

read (Q) ;

if P = 0 then Q := Q + 1 ;

write (Q).

**T<sub>2</sub>** : read (Q) ;

read (P)

if Q = 0 then P := P + 1 ;

write (P).

Any non-serial interleaving of T1 and T2 for concurrent execution leads to

(A) a serializable schedule

(B) a schedule that is not conflict serializable

(C) a conflict serializable schedule

(D) a schedule for which precedence graph cannot be drawn

Answer: (B)

Exp:- Let S be a non-serial schedule, without loss of generality assume that T1 has started earlier than T2. The first instruction of T1 is read(P) and the last instruction of T2 is write(P), so the precedence graph for S has an edge from T1 to T2, now since S is a non-serial schedule the first instruction of T2 (read(Q)) should be executed before last instruction of T1 (write(Q)) and since read and write are conflicting operations, the precedence graph for S also contains an edge from T2 to T1, So we will have a cycle in the precedence graph which implies that any non serial schedule with T1 as the earliest transaction will not be conflict serializable.

In a similar way we can show that if T2 is the earliest transaction then also the schedule is not conflict serializable.

**Common Data Questions: 48 & 49**

Consider the following relations A, B and C:

A

| <b>Id</b> | <b>Name</b> | <b>Age</b> |
|-----------|-------------|------------|
| 12        | Arun        | 60         |
| 15        | Shreya      | 24         |
| 99        | Rohit       | 11         |

B

| <b>Id</b> | <b>Name</b> | <b>Age</b> |
|-----------|-------------|------------|
| 15        | Shreya      | 24         |
| 25        | Hari        | 40         |
| 98        | Rohit       | 20         |
| 99        | Rohit       | 11         |

C

| <b>Id</b> | <b>Phone</b> | <b>Area</b> |
|-----------|--------------|-------------|
| 10        | 220          | 02          |
| 99        | 2100         | 01          |

48. How many tuples does the result of the following SQL query contain?

**SELECT** A.Id

**FROM** A

**WHERE** A.Age > **ALL**(**SELECT** B.Age

**FROM** B

WHERE B.Name = 'Arun')

(A) 4

(B) 3

(C) 0

(D) 1

**Answer: (B)**

**Exp:-** As the result of subquery is an empty table, '>ALL' comparison is true . Therefore, all the three row Id's of A will be selected from table A.

49. How many tuples does the result of the following relational algebra expression contain? Assume that the schema of  $A \cup B$  is the same as that of A.

$(A \cup B) \bowtie_{A.Id > 40 \vee C.Id < 15} C$

(A) 7

(B) 4

(C) 5

(D) 9

Answer: (A)

Exp:- The final table is

| AUB . Id | Name   | Age | C.Id | Phone | Area |
|----------|--------|-----|------|-------|------|
| 12       | Arun   | 60  | 10   | 2200  | 02   |
| 15       | Shreya | 24  | 10   | 2200  | 02   |
| 25       | Hari   | 40  | 10   | 2200  | 02   |
| 98       | Rohit  | 20  | 10   | 2200  | 02   |
| 98       | Rohit  | 20  | 99   | 2100  | 01   |
| 99       | Rohit  | 11  | 10   | 2200  | 02   |
| 99       | Rohit  | 11  | 99   | 2100  | 01   |

### Common Data Questions: 50 & 51

Consider the following C code segment:

```
int a, b, c = 0;
```

```
void prtFun(void);
```

```
main()
```

```
{ static int a = 1; /* Line 1 */
 prtFun();
 a + = 1;
 prtFun()
 printf("\n %d %d ", a, b);
}
```

```
void prtFun(void)
```

```
{ static int a=2; /* Line 2 */
 int b=1;
 a+=++b;
 printf("\n %d %d ", a, b);
}
```

50. What output will be generated by the given code segment if:

Line 1 is replaced by **auto int a = 1;**

Line 2 is replaced by **register int a = 2;**

(A)

(B)

(C)

(D)

|   |   |   |   |   |   |   |   |
|---|---|---|---|---|---|---|---|
| 3 | 1 | 4 | 2 | 4 | 2 | 4 | 2 |
| 4 | 1 | 6 | 1 | 6 | 2 | 4 | 2 |
| 4 | 2 | 6 | 1 | 2 | 0 | 2 | 0 |

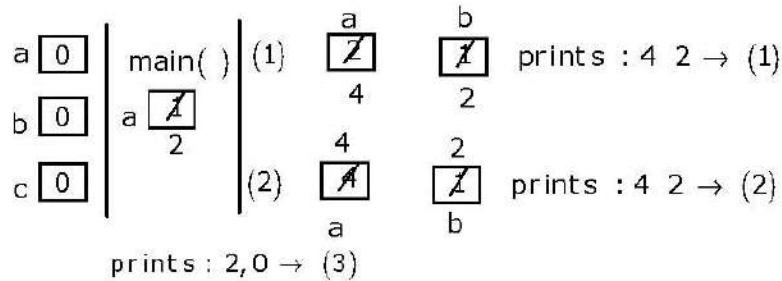
Answer: (D)

**Exp:- Static local variables:** Scope is limited to function/block but life time is entire program.

**Automatic local variables:**

Storage allocated on function entry and automatically deleted or freed when the function is exited.

**Register variables:** Same as automatic variables except that the register variables will not have addresses Hence may not take the address of a register variable.

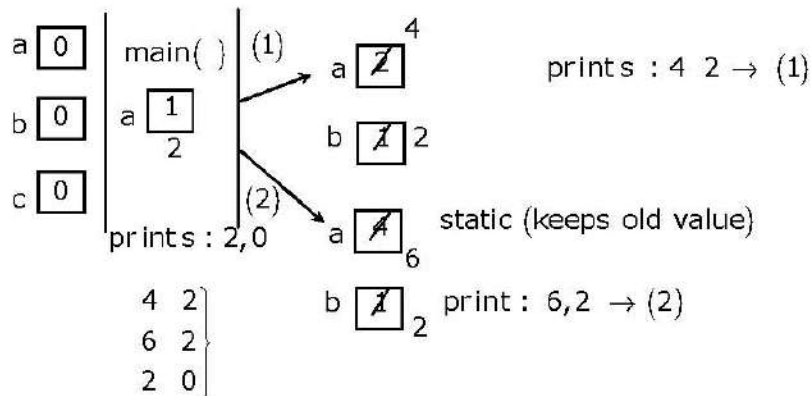


51. What output will be generated by the given code segment?

|     |     |     |     |
|-----|-----|-----|-----|
| (A) | (B) | (C) | (D) |
| 3 1 | 4 2 | 4 2 | 3 1 |
| 4 1 | 6 1 | 6 2 | 5 2 |
| 4 2 | 6 1 | 2 0 | 5 2 |

Answer: (C)

Exp:-



**Statement for Linked Answer Question: 52 & 53**

A computer has a 256 KByte, 4-way set associative, write back data cache with block size of 32 Bytes. The processor sends 32 bit addresses to the cache controller. Each cache tag directory entry contains, in addition to address tag, 2 valid bits, 1 modified bit and 1 replacement bit.

52. The number of bits in the tag field of an address is  
 (A) 11 (B) 14 (C) 16 (D) 27

Answer: (C)

Exp:- Number of blocks =  $\frac{256\text{KB}}{32\text{Bytes}} = \frac{2^{18}}{2^5} = 2^{13}$  blocks

As it is 4-way set associative, number of sets =  $\frac{2^{13}}{2^2} = 2^{11}$



53. The size of the cache tag directory is  
 (A) 160 Kbits (B) 136 Kbits (C) 40 Kbits (D) 32 Kbits

Answer: (A)

Exp:- TAG controller maintains 16 + 4 = 20 bits for every block

Hence, size of cache tag directory =  $20 \times 2^{13}$  bits = 160 Kbits

**Statement for Linked Answer Question: 54 & 55**

For the grammar below, a partial LL(1) parsing table is also presented along with the grammar. Entries that need to be filled are indicated as **E1**, **E2**, and **E3**.  $\epsilon$  is the empty string, \$ indicates end of input, and | separates alternate right hand sides of productions.

$S \rightarrow aAbB \mid bAaB \mid \epsilon$

$A \rightarrow S$

$B \rightarrow S$

|   | a                 | b                 | \$                       |
|---|-------------------|-------------------|--------------------------|
| S | <b>E1</b>         | <b>E2</b>         | $S \rightarrow \epsilon$ |
| A | $A \rightarrow S$ | $A \rightarrow S$ | error                    |
| B | $B \rightarrow S$ | $B \rightarrow S$ | <b>E3</b>                |



54. The First and Follow sets for the non-terminals A and B are

(A)  $FIRST(A) = \{a, b, \epsilon\} = FIRST(B)$

$FOLLOW(A) = \{a, b\}$

$FOLLOW(B) = \{a, b, \$\}$

(B)  $FIRST(A) = \{a, b, \$\}$

$FIRST(B) = \{a, b, \epsilon\}$

$FOLLOW(A) = \{a, b\}$

$FOLLOW(B) = \{\$\}$

(C)  $FIRST(A) = \{a, b, \epsilon\} = FIRST(B)$

$FIRST(A) = \{a, b\}$

$FOLLOW(B) = \emptyset$

(D)  $FIRST(A) = \{a, b\} = FIRST(B)$

$FIRST(A) = \{a, b\}$

$FOLLOW(B) = \{a, b\}$

Answer: (A)

Exp:-  $First(A) = First(S) = First(aAbB) \cup First(bAaB) \cup First(\epsilon)$

$= \{a\} \cup \{b\} \cup \{\epsilon\} = \{\epsilon, a, b\}$

$First(B) = First(S) = \{\epsilon, a, b\}$

$Follow(A) = First(bB) \cup First(aB) = \{a, b\}$

$Follow(B) = Follow(S) = \{\$\} \cup Follow(A) = \{\$, a, b\}$

55. The appropriate entries for E1, E2, and E3 are

(A) E1:  $S \rightarrow aAbB$ ,  $A \rightarrow S$

(B) E1:  $S \rightarrow aAbB$ ,  $S \rightarrow \epsilon$

E2:  $S \rightarrow bAaB$ ,  $B \rightarrow S$

E2:  $S \rightarrow bAaB$ ,  $S \rightarrow \epsilon$

E3:  $B \rightarrow S$

E3:  $S \rightarrow \epsilon$

(C) E1:  $S \rightarrow aAbB$ ,  $S \rightarrow \epsilon$

(D) E1:  $A \rightarrow S$ ,  $S \rightarrow \epsilon$

E2:  $S \rightarrow bAaB$ ,  $S \rightarrow \epsilon$

E2:  $B \rightarrow S$ ,  $S \rightarrow \epsilon$

E3:  $B \rightarrow S$

E3:  $B \rightarrow S$

Answer: (C)

Exp:-

$First(S) = \{\epsilon, a, b\}$ ,  $Follow(S) = \{\$, a, b\}$

|   |                          |                          |                          |
|---|--------------------------|--------------------------|--------------------------|
|   | a                        | b                        | \$                       |
| S | $S \rightarrow aAbB$     | $S \rightarrow bAaB$     | $S \rightarrow \epsilon$ |
|   | $S \rightarrow \epsilon$ | $S \rightarrow \epsilon$ |                          |

$First(B) = \{\epsilon, a, b\}$ ,  $Follow(B) = \{\$, a, b\}$

|   |                   |                   |                   |
|---|-------------------|-------------------|-------------------|
|   | a                 | b                 | \$                |
| B | $B \rightarrow S$ | $B \rightarrow S$ | $B \rightarrow S$ |

**Q. No. 56 – 60 Carry One Mark Each**

56. The cost function for a product in a firm is given by  $5q^2$ , where  $q$  is the amount of production. The firm can sell the product at a market price of Rs.50 per unit. The number of units to be produced by the firm such that the profit is maximized is
- (A) 5                      (B) 10                      (C) 15                      (D) 25

**Answer: (A)**

Exp:-  $P = 50q - 5q^2$

$$\frac{dp}{dq} = 50 - 10q; \frac{d^2p}{dq^2} < 0$$

$\therefore p$  is maximum at  $50 - 10q = 0$  or,  $q = 5$

Else check with options

57. Choose the most appropriate alternative from the options given below to complete the following sentence:

**Suresh's dog is the one \_\_\_\_\_ was hurt in the stampede.**

- (A) that                      (B) which                      (C) who                      (D) whom

**Answer: (A)**

58. Choose the grammatically **INCORRECT** sentence:

(A) They gave us the money back less the service charges of Three Hundred rupees.

(B) This country's expenditure is not less than that of Bangladesh.

(C) The committee initially asked for a funding of Fifty Lakh rupees, but later settled for a lesser sum.

(D) This country's expenditure on educational reforms is very less

**Answer: (D)**

59. Which one of the following options is the closest in meaning to the word given below?

**Mitigate**

- (A) Diminish                      (B) Divulge                      (C) Dedicate                      (D) Denote

**Answer: (A)**

60. Choose the most appropriate alternative from the options given below to complete the following sentence:

**Despite several \_\_\_\_\_ the mission succeeded in its attempt to resolve the conflict.**

- (A) attempts      (B) setbacks      (C) meetings      (D) delegations

Answer: (B)

**Q. No. 61 – 65 Carry Two Marks Each**

61. Wanted Temporary, Part-time persons for the post of Field Interviewer to conduct personal interviews to collect and collate economic data. Requirements: High School-pass, must be available for Day, Evening and Saturday work. Transportation paid, expenses reimbursed.

Which one of the following is the best inference from the above advertisement?

- (A) Gender-discriminatory      (B) Xenophobic  
(C) Not designed to make the post attractive  
(D) Not gender-discriminatory

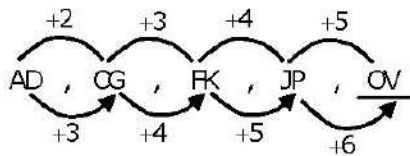
Answer: (C)

Exp:-Gender is not mentioned in the advertisement and (B) clearly eliminated

62. Given the sequence of terms, AD CG FK JP, the next term is

- (A) OV      (B) OW      (C) PV      (D) PW

Answer: (A)



63. Which of the following assertions are CORRECT?

- P: Adding 7 to each entry in a list adds 7 to the mean of the list  
Q: Adding 7 to each entry in a list adds 7 to the standard deviation of the list  
R: Doubling each entry in a list doubles the mean of the list  
S: Doubling each entry in a list leaves the standard deviation of the list unchanged

- (A) P, Q      (B) Q, R      (C) P, R      (D) R, S

Answer: (C)

Exp:- P and R always holds true

Else consider a sample set {1, 2, 3, 4} and check accordingly

64. An automobile plant contracted to buy shock absorbers from two suppliers X and Y. X supplies 60% and Y supplies 40% of the shock absorbers. All shock absorbers are subjected to a quality test. The ones that pass the quality test are considered reliable. Of X's shock absorbers, 96% are reliable. Of Y's shock absorbers, 72% are reliable.
- The probability that a randomly chosen shock absorber, which is found to be reliable, is made by Y is
- (A) 0.288                      (B) 0.334                      (C) 0.667                      (D) 0.720

Answer: (B)

Exp:-

|          | x     | y     |
|----------|-------|-------|
| Supply   | 60%   | 40%   |
| Reliable | 96%   | 72%   |
| Overall  | 0.576 | 0.288 |

$$\therefore P(x) = \frac{0.288}{0.576 + 0.288} = 0.334$$

65. A political party orders an arch for the entrance to the ground in which the annual convention is being held. The profile of the arch follows the equation  $y = 2x - 0.1x^2$  where  $y$  is the height of the arch in meters. The maximum possible height of the arch is
- (A) 8 meters                      (B) 10 meters                      (C) 12 meters                      (D) 14 meters

Answer: (B)

Exp:-  $y = 2x - 0.1x^2$

$$\frac{dy}{dx} = 2 - 0.2x$$

$$\frac{d^2y}{dx^2} < 0 \therefore y \text{ maximises at } 2 - 0.2x = 0$$

$$\Rightarrow x = 10$$

$$\therefore y = 20 - 10 = 10\text{m}$$

**GATE Previous Year  
Solved Paper  
Computer Science  
(Fully Solved)**

**GATExplore.com**

**(2013, 2015, 2016, 2017)**

**Q. No. 1 – 25 Carry One Mark Each**

1. Consider an undirected random graph of eight vertices. The probability that there is an edge between a pair of vertices is  $\frac{1}{2}$ . What is the expected number of unordered cycles of length three?
- (A)  $\frac{1}{8}$                       (B) 1                      (C) 7                      (D) 8

Ans. (C)

Exp:  $P(\text{edge}) = \frac{1}{2}$

Number of ways we can choose the vertices out of 8 is  ${}^8C_3$

(Three edges in each cycle)

Expected number of unordered cycles of length 3 =  ${}^8C_3 \times \left(\frac{1}{2}\right)^3 = 7$

2. Which of the following statements is/are **TRUE** for undirected graphs?

P: Number of odd degree vertices is even.

Q: Sum of degrees of all vertices is even.

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

Ans: (C)

Exp: Q: Sum of degrees of all vertices =  $2 \times (\text{number of edges})$

3. Function f is known at the following points:

|      |   |      |      |      |      |      |      |      |      |      |      |
|------|---|------|------|------|------|------|------|------|------|------|------|
| x    | 0 | 0.3  | 0.6  | 0.9  | 1.2  | 1.5  | 1.8  | 2.1  | 2.4  | 2.7  | 3.0  |
| f(x) | 0 | 0.09 | 0.36 | 0.81 | 1.44 | 2.25 | 3.24 | 4.41 | 5.76 | 7.29 | 9.00 |

The value of  $\int_0^3 f(x) dx$  computed using the trapezoidal rule is

- (A) 8.983                      (B) 9.003                      (C) 9.017                      (D) 9.045

Ans: (D)

Exp:  $\int_0^3 f(x) dx = \frac{h}{2} [f(x_0) + f(x_{10}) + 2(f(x_1) + f(x_2) + \dots + f(x_9))]$

$$= \frac{0.3}{2} [9.00 + 2(25.65)] = 9.045$$

4. Which one of the following functions is continuous at  $x = 3$  ?

$$(A) f(x) = \begin{cases} 2, & \text{if } x = 3 \\ x - 1, & \text{if } x > 3 \\ \frac{x+3}{3}, & \text{if } x < 3 \end{cases} \quad (B) f(x) = \begin{cases} 4, & \text{if } x = 3 \\ 8 - x, & \text{if } x \neq 3 \end{cases}$$

$$(C) f(x) = \begin{cases} x + 3, & \text{if } x \leq 3 \\ x - 4, & \text{if } x > 3 \end{cases} \quad (D) f(x) = \frac{1}{x^3 - 27}, \text{ if } x \neq 3$$

Ans: (A)

Exp:  $\lim_{x \rightarrow 3^+} f(x) = \lim_{x \rightarrow 3^+} (x - 1) = 2 = f(3)$

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

$\therefore f(x)$  is continuous at  $x = 3$

5. Which one of the following expressions does **NOT** represent exclusive NOR of  $x$  and  $y$ ?

(A)  $xy + x'y'$       (B)  $x \oplus y'$       (C)  $x' \oplus y$       (D)  $x' \oplus y'$

Ans: (D)

Exp: (A)  $x \odot y = xy + \bar{x}\bar{y}$   
 (B)  $x \oplus y = xy + \bar{x}\bar{y} = xy + \bar{x}\bar{y} = x \odot y$   
 (C)  $\bar{x} \oplus y = (\bar{x})\bar{y} + \bar{x}y = \bar{x}\bar{y} + \bar{x}y = x \odot y$   
 (D)  $\bar{x} \oplus \bar{y} = (\bar{x})y + x\bar{y} = x \oplus y$

6. In a  $k$ -way set associative cache, the cache is divided into  $v$  sets, each of which consists of  $k$  lines. The lines of a set are placed in sequence one after another. The lines in set  $s$  are sequenced before the lines in set  $(s+1)$ . The main memory blocks are numbered 0 onwards. The main memory block numbered  $j$  must be mapped to any one of the cache lines from

(A)  $(j \bmod v) * k$  to  $(j \bmod v) * k + (k - 1)$   
 (B)  $(j \bmod v)$  to  $(j \bmod v) + (k - 1)$   
 (C)  $(j \bmod k)$  to  $(j \bmod k) + (v - 1)$   
 (D)  $(j \bmod k) * v$  to  $(j \bmod k) * v + (v - 1)$

Ans: (B)

Exp: Set number in the cache = (main memory block number) MOD number of sets in the cache.

As the lines in the set are placed in sequence, we can have the lines from 0 to  $k - 1$  in the set.

Number of sets =  $v$

Main memory block number =  $j$

First line =  $(j \bmod v)$ ; last line =  $(j \bmod v) + (k - 1)$

7. What is the time complexity of Bellman-Ford single-source shortest path algorithm on a complete graph of  $n$  vertices?  
 (A)  $\Theta(n^2)$       (B)  $\Theta(n^2 \log n)$       (C)  $\Theta(n^3)$       (D)  $\Theta(n^3 \log n)$

Ans: (C)

Exp: Bellman-ford time complexity:  $\Theta(|V| \times |E|)$

$$\text{For complete graph: } |E| = \frac{n(n-1)}{2}$$

$$|V| = n$$

$$\therefore \Theta\left(n \times \frac{n(n-1)}{2}\right) = \Theta(n^3)$$

8. Which of the following statements are **TRUE**?
- (1) The problem of determining whether there exists a cycle in an undirected graph is in P.
  - (2) The problem of determining whether there exists a cycle in an undirected graph is in NP.
  - (3) If a problem A is NP-Complete, there exists a non-deterministic polynomial time algorithm to solve A.
- (A) 1,2 and 3      (B) 1 and 2 only      (C) 2 and 3 only      (D) 1 and 3 only

Ans: (A)

- Exp: 1. Cycle detection using DFS:  $O(V + E) = O(V^2)$  and it is polynomial problem  
 2. Every P-problem is NP (since  $P \subset NP$ )  
 3. NP – complete  $\in$  NP

Hence, NP-complete can be solved in non-deterministic polynomial time

9. Which of the following statements is/are **FALSE**?
- (1) For every non-deterministic Turing machine, there exists an equivalent deterministic Turing machine.
  - (2) Turing recognizable languages are closed under union and complementation.
  - (3) Turing decidable languages are closed under intersection and complementation
  - (4) Turing recognizable languages are closed under union and intersection.
- (A) 1 and 4 only      (B) 1 and 3 only      (C) 2 only      (D) 3 only

Ans: (C)

- Exp: (1)  $NTM \cong DTM$   
 (2) RELs are closed under union & but not complementation  
 (3) Turing decidable languages are recursive and recursive languages are closed under intersection and complementation  
 (4) RELs are closed under union & intersection but not under complementation



10. Three concurrent processes X, Y, and Z execute three different code segments that access and update certain shared variables. Process X executes the P operation (i.e., wait) on semaphores a, b and c; process Y executes the P operation on semaphores b, c and d; process Z executes the P operation on semaphores c, d, and a before entering the respective code segments. After completing the execution of its code segment, each process invokes the V operation (i.e., signal) on its three semaphores. All semaphores are binary semaphores initialized to one. Which one of the following represents a deadlock-free order of invoking the P operations by the processes?
- (A) X : P(a)P(b)P(c) Y : P(b)P(c)P(d) Z : P(c)P(d)P(a)  
 (B) X : P(b)P(a)P(c) Y : P(b)P(c)P(d) Z : P(a)P(c)P(d)  
 (C) X : P(b)P(a)P(c) Y : P(c)P(b)P(d) Z : P(a)P(c)P(d)  
 (D) X : P(a)P(b)P(c) Y : P(c)P(b)P(d) Z : P(c)P(d)P(a)

Ans: (B)

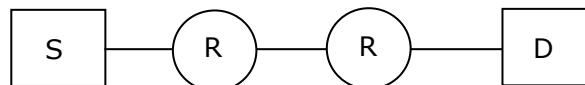
Exp: Suppose X performs P(b) and preempts, Y gets chance, but cannot do its first wait i.e., P(b), so waits for X, now Z gets the chance and performs P(a) and preempts, next X gets chance. X cannot continue as wait on 'a' is done by Z already, so X waits for Z. At this time Z can continue its operations as down on c and d. Once Z finishes, X can do its operations and so Y. In any of execution order of X, Y, Z one process can continue and finish, such that waiting is not circular. In options (A),(C) and (D) we can easily find circular wait, thus deadlock

11. An index is clustered, if
- (A) it is on a set of fields that form a candidate key.  
 (B) it is on a set of fields that include the primary key.  
 (C) the data records of the file are organized in the same order as the data entries of the index.  
 (D) the data records of the file are organized not in the same order as the data entries of the index.

Ans: (C)

Exp: Clustered index is built on ordering non key field and hence if the index is clustered then the data records of the file are organized in the same order as the data entries of the index.

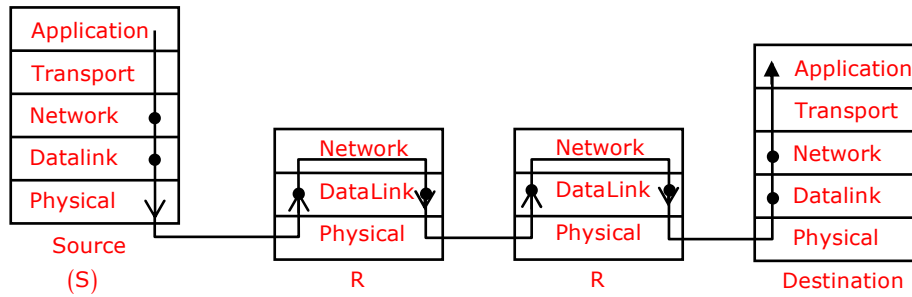
12. Assume that source S and destination D are connected through two intermediate routers labeled R. Determine how many times each packet has to visit the network layer and the data link layer during a transmission from S to D.



- (A) Network layer – 4 times and Data link layer-4 times  
 (B) Network layer – 4 times and Data link layer-3 times  
 (C) Network layer – 4 times and Data link layer-6 times  
 (D) Network layer – 2 times and Data link layer-6 times

Ans: (C)

Exp:



From above given diagram, its early visible that packet will visit network layer 4 times, once at each node [S, R, R, D] and packet will visit Data Link layer 6 times. One time at S and one time at D, then two times for each intermediate router R as data link layer is used for link to link communication.

Once at packet reaches R and goes up from physical –DL–Network and second time when packet coming out of router in order Network – DL– Physical

13. The transport layer protocols used for real time multimedia, file transfer, DNS and email, respectively are

- (A) TCP, UDP, UDP and TCP
- (B) UDP, TCP, TCP and UDP
- (C) UDP, TCP, UDP and TCP
- (D) TCP, UDP, TCP and UDP

Ans: (C)

Exp: Real time multimedia needs connectionless service, so under lying transport layer protocol used is UDP

File transfer runs over TCP protocol with port no-21

DNS runs over UDP protocol within port no-53

Email needs SMTP protocol which runs over TCP protocol within port no – 25

14. Using public key cryptography, X adds a digital signature  $\sigma$  to message M, encrypts  $\langle M, \sigma \rangle$ , and sends it to Y, where it is decrypted. Which one of the following sequences of keys is used for the operations?

- (A) Encryption: X’s private key followed by Y’s private key; Decryption: X’s public key followed by Y’s public key
- (B) Encryption: X’s private key followed by Y’s public key; Decryption: X’s public key followed by Y’s private key
- (C) Encryption: X’s public key followed by Y’s private key; Decryption: Y’s public key followed by X’s private key
- (D) Encryption: X’s private key followed by Y’s public key; Decryption: Y’s private key followed by X’s public key

Ans: (D)

Exp:



Encryption { Source has to encrypt with its private key for forming Digital signature for Authentication.  
source has to encrypt the  $\langle M, \sigma \rangle$  with Y's public key to send it confidentially

Decryption { Destination Y has to decrypt first with its private key, then decrypt using source public key

15. Match the problem domains in **Group I** with the solution technologies in **Group II**.

| Group I                                 | Group II              |
|-----------------------------------------|-----------------------|
| (p) Services oriented computing         | (1) Interoperability  |
| (q) Heterogeneous communicating systems | (2) BPMN              |
| (R) Information representation          | (3) Publish-find bind |
| (S) Process description                 | (4) XML               |

- (A) P - 1, Q - 2, R - 3, S - 4      (B) P - 3, Q - 4, R - 2, S - 1  
(C) P - 3, Q - 1, R - 4, S - 2      (D) P - 4, Q - 3, R - 2, S - 1

Ans: (C)

16. A scheduling algorithm assigns priority proportional to the waiting time of a process. Every process starts with priority zero (the lowest priority). The scheduler re-evaluates the process priorities every T time units and decides the next process to schedule. Which one of the following is TRUE if the processes have no I/O operations and all arrive at time zero?

- (A) This algorithm is equivalent to the first-come-first-serve algorithm.  
(B) This algorithm is equivalent to the round-robin algorithm.  
(C) This algorithm is equivalent to the shortest-job-first algorithm.  
(D) This algorithm is equivalent to the shortest-remaining-time-first algorithm.

Ans: (B)

Exp: The given scheduling definition takes two parameters, one is dynamically assigned process priority and the other is 'T' time unit to re-evaluate the process priorities.

This dynamically assigned priority will be deciding processes order in ready queue of round robin algorithm whose time quantum is same as 'T' time units. As all the processes are arriving at the same time, they will be given same priority but soon after first 'T' time burst remaining processes will get higher priorities

17. What is the maximum number of reduce moves that can be taken by a bottom-up parser for a grammar with no epsilon- and unit-production (i.e., of type  $A \rightarrow \epsilon$  and  $A \rightarrow a$ ) to parse a string with n tokens?

- (A)  $n/2$                       (B)  $n-1$                       (C)  $2n-1$                       (D)  $2^n$

Ans: (C)  
Exp: string = abcd

S  
 $\uparrow$  (7)  
 YD  
 $\uparrow$  (6 : Y  $\rightarrow$  XC)  
 XCD  
 $\uparrow$  (5 : X  $\rightarrow$  AB)  
 ABCD  
 $\uparrow$  (4 : D  $\rightarrow$  d)  
 ABCd  
 $\uparrow$  (3 : C  $\rightarrow$  c)  
 ABcd  
 $\uparrow$  (2 : B  $\rightarrow$  b)  
 Abcd  
 $\uparrow$  (1 : A  $\rightarrow$  a)  
 abcd

$2 \times (4) - 1 = 7$  reductions

$\Rightarrow 2n - 1$  reductions required

[Note : Unit productions is given as  $A \rightarrow a$ , it was typo]

Above reductions are not in reverse of RMD but when they are reduced in bottom up parsing we will get same number of reductions.

18. Consider the languages  $L_1 = \Phi$  and  $L_2 = \{a\}$ . Which one of the following represents  $L_1 L_2^* \cup L_1^*$  ?  
 (A)  $\{\epsilon\}$                       (B)  $\Phi$                       (C)  $a^*$                       (D)  $\{\epsilon, a\}$

Ans: (A)

EXP: Concatenation of empty language with any language will give the empty language and  $L_1^* = \Phi^* = \epsilon$ . Hence  $L_1 L_2^* \cup L_1^* = \{\epsilon\}$

19. Which one of the following is the tightest upper bound that represents the time complexity of inserting an object into a binary search tree of n nodes?  
 (A)  $O(1)$                       (B)  $O(\log n)$                       (C)  $O(n)$                       (D)  $O(n \log n)$

Ans: (C)

Exp: For skewed binary search tree on n nodes, the tightest upper bound to insert a node is  $O(n)$

20. Which one of the following is the tightest upper bound that represents the number of swaps required to sort n numbers using selection sort?  
 (A)  $O(\log n)$                       (B)  $O(n)$                       (C)  $O(n \log n)$                       (D)  $O(n^2)$

Ans: (B)

Exp: The maximum number of swaps that takes place in selection sort on n numbers is n

21. In the following truth table, V = 1 if and only if the input is valid.

| Inputs         |                |                |                | Outputs        |                |   |
|----------------|----------------|----------------|----------------|----------------|----------------|---|
| D <sub>0</sub> | D <sub>1</sub> | D <sub>2</sub> | D <sub>3</sub> | X <sub>0</sub> | X <sub>1</sub> | V |
| 0              | 0              | 0              | 0              | X              | X              | 0 |
| 1              | 0              | 0              | 0              | 0              | 0              | 1 |
| 0              | 1              | 0              | 0              |                | 1              | 1 |
| 1              | X              | 1              | 0              |                | 0              | 1 |
| X              | X              | X              | 1              | 1              | 1              | 1 |

What function does the truth table represent?

- (A) Priority encoder (B) Decoder  
(C) Multiplexer (D) Demultiplexer

Ans: (A)

Exp: 4 to 2 priority encoder.

22. The smallest integer than can be represented by an 8-bit number in 2's complement form is

- (A) -256 (B) -128 (C) -127 (D) 0

Ans: (B)

Exp:  $-2^{8-1} = -128$ . Range is  $-2^{(n-1)}$  to  $+2^{(n-1)}-1$

23. Which one of the following does **NOT** equal  $\begin{vmatrix} 1 & x & x^2 \\ 1 & y & y^2 \\ 1 & z & z^2 \end{vmatrix}$  ?

(A)  $\begin{vmatrix} 1 & x(x+1) & x+1 \\ 1 & y(y+1) & y+1 \\ 1 & z(z+1) & z+1 \end{vmatrix}$

(B)  $\begin{vmatrix} 1 & x+1 & x^2+1 \\ 1 & y+1 & y^2+1 \\ 1 & z+1 & z^2+1 \end{vmatrix}$

(C)  $\begin{vmatrix} 0 & x-y & x^2-x^2 \\ 0 & y-z & y^2-z^2 \\ 1 & z & z^2 \end{vmatrix}$

(D)  $\begin{vmatrix} 2 & x+y & x^2+y^2 \\ 2 & y+z & y^2+z^2 \\ 1 & z & z^2 \end{vmatrix}$

Ans: (A)

If matrix B is obtained from matrix A by replacing the I<sup>th</sup> row by itself plus k times the m<sup>th</sup> row, for  $l \neq m$  then  $\det(B)=\det(A)$ . With this property given matrix is equal to the matrices given in options (B),(C) and (D).

24. Suppose  $p$  is number of cars per minute passing through a certain road junction between 5 PM and 6PM, and  $p$  has a Poisson distribution with mean 3. What is the probability of observing fewer than 3 cars during any given minute in this interval?

- (A)  $8 / (2e^3)$       (B)  $9 / (2e^3)$       (C)  $17 / (2e^3)$       (D)  $26 / (2e^3)$

Ans: (C)

Exp:

$$\begin{aligned} P(p < 3) &= P(p = 0) + P(p = 1) + P(p = 2) \\ &= \frac{e^{-\mu}\mu^0}{0!} + \frac{e^{-\mu}\mu^1}{1!} + \frac{e^{-\mu}\mu^2}{2!} \quad (\text{where } \mu = 3) \\ &= e^{-3} + e^{-3} \times 3 + \frac{e^{-3} \times 9}{2} \\ &= e^{-3} \left( 1 + 3 + \frac{9}{2} \right) = \frac{17}{2e^3} \end{aligned}$$

25. A binary operation  $\oplus$  on a set of integers is defined as  $x \oplus y = x^2 + y^2$ . Which one of the following statements is **TRUE** about  $\oplus$  ?

- (A) Commutative but not associative      (B) Both commutative and associative  
(C) Associative but not commutative      (D) Neither commutative nor associative

Ans: (A)

Exp:  $x \oplus y = x^2 + y^2 = y^2 + x^2 = y \oplus x$

$\therefore$  commutative

Not associative, since, for example

$(1 \oplus 2) \oplus 3 \neq 1 \oplus (2 \oplus 3)$

**Q. No. 26 – 55 Carry Two Marks Each**

26. Which one of the following is **NOT** logically equivalent to  $\neg \exists x (\forall y (\alpha) \wedge \forall z (\beta))$ ?

- (A)  $\forall x (\exists z (\neg \beta) \rightarrow \forall y (\alpha))$       (B)  $\forall x (\forall z (\beta) \rightarrow \exists y (\neg \alpha))$   
(C)  $\forall x (\forall y (\alpha) \rightarrow \exists z (\neg \beta))$       (D)  $\forall x (\exists y (\neg \alpha) \rightarrow \exists z (\neg \beta))$

Ans: (A)

Exp:  $\neg \exists x (\forall y (\alpha) \wedge \forall z (\beta)) \equiv \forall x [\forall y (\alpha) \rightarrow \exists z (\neg \beta)]$  option "C"

$$\begin{aligned} & [\because \neg(P \wedge q) \equiv p \Rightarrow \neg q] \\ & \equiv \forall x [\forall z (\beta) \rightarrow \exists y (\neg \alpha)] \quad \text{option "B"} \\ & [\because p \Rightarrow q \equiv \neg q \Rightarrow \neg p] \\ & \equiv \forall x [\forall y (\alpha) \rightarrow \exists z (\neg \beta)] \quad \text{option "D"} \\ & [\because \neg(p \wedge q) \equiv p \Rightarrow (\neg q)] \end{aligned}$$

27. A RAM chip has a capacity of 1024 words of 8 bits each (1K × 8). The number of 2 × 4 decoders with enable line needed to construct a 16K × 16 RAM from 1K × 8 RAM is

- (A) 4                      (B) 5                      (C) 6                      (D) 7

Ans: (B)

Exp. RAM chip size = 1k × 8 [1024 words of 8 bits each]

RAM to construct = 16k × 16

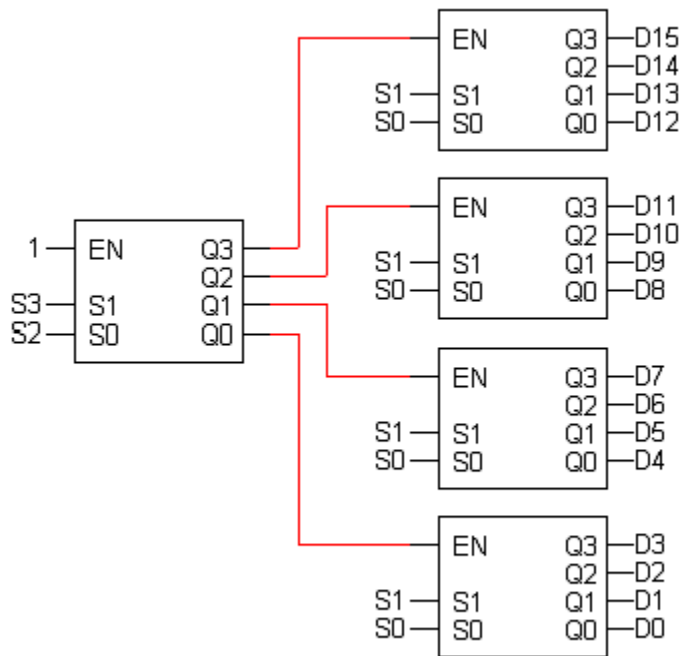
Number of chips required =  $\frac{16k \times 16}{1k \times 8} = 16 \times 2$  [16 chips vertically with each

having 2 chips horizontally]

So to select one chip out of 16 vertical chips, we need 4 × 16 decoder.

Available decoder is – 2 × 4 decoder

To be constructed is 4 × 16 decoder



So we need 5, 2 × 4 decoder in total to construct 4 × 16 decoder.

28. Consider an instruction pipeline with five stages without any branch prediction: Fetch Instruction (FI), Decode Instruction (DI), Fetch Operand (FO), Execute Instruction (EI) and Write Operand (WO). The stage delays for FI, DI, FO, EI and WO are 5 ns, 7 ns, 10 ns, 8 ns and 6 ns, respectively. There are intermediate storage buffers after each stage and the delay of each buffer is 1 ns. A program consisting of 12 instructions  $I_1, I_2, I_3, \dots, I_{12}$  is executed in this pipelined processor. Instruction  $I_4$  is the only branch instruction and its branch target is  $I_9$ . If the branch is taken during the execution of this program, the time (in ns) needed to complete the program is

- (A) 132                      (B) 165                      (C) 176                      (D) 328

Ans: (C)

Exp: Total clock slots taken are 16. Each slot will take maximum of {5, 7, 10, 8, 7} = 10.

Hence total slots for all the instructions =  $16 \times 10 + 16(\text{pipeline delay}) = 176$

29. Consider the following operation along with Enqueue and Dequeue operations on queues, where k is a global parameter

```
MultiDequeue(Q) {
 m = k
 while (Q is not empty) and (m > 0) {
 Dequeue (Q)
 m = m - 1
 }
}
```

What is the worst case time complexity of a sequence of n queue operations on an initially empty queue?

- (A)  $\Theta(n)$       (B)  $\Theta(n+k)$       (C)  $\Theta(nk)$       (D)  $\Theta(n^2)$

Ans: (C)

30. The preorder traversal sequence of a binary search tree is 30, 20, 10, 15, 25, 23, 39, 35, 42. Which one of the following is the postorder traversal sequence of the same tree?

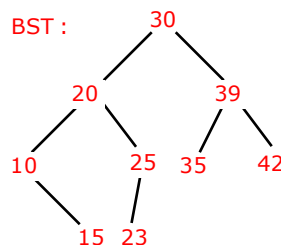
- (A) 10, 20, 15, 23, 25, 35, 42, 39, 30      (B) 15, 10, 25, 23, 20, 42, 35, 39, 30  
(C) 15, 20, 10, 23, 25, 42, 35, 39, 30      (D) 15, 10, 23, 25, 20, 35, 42, 39, 30

Ans: (D)

Exp:

Pre order : 30, 20, 10, 15, 25, 23, 39, 35, 42

Inorder : 10, 15, 20, 23, 25, 30, 35, 39, 42





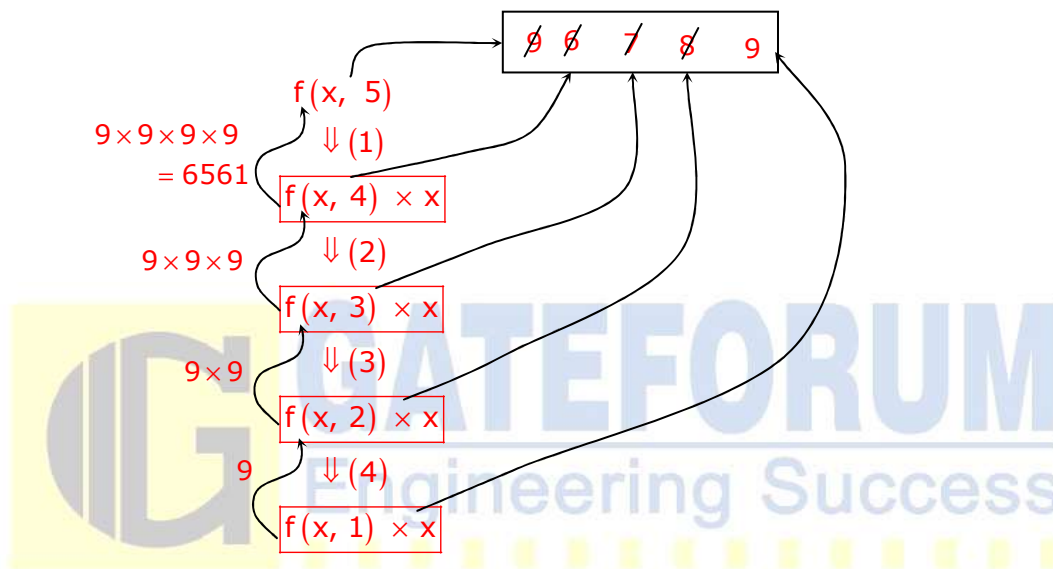
31. What is the return value of  $f(p,p)$  if the value of  $p$  is initialized to 5 before the call? Note that the first parameter is passed by reference, whereas the second parameter is passed by value.

```
int f (int & x, int c) {
 c = c - 1;
 if(c == 0) return 1;
 x = x + 1;
 return f(x,c) * x;
}
```

- (A) 3024                      (B) 6561                      (C) 55440                      (D) 161051

Ans: (B)

Exp:



32. Which of the following is/are undecidable?

1.  $G$  is a CFG. Is  $L(G) = \Phi$ ?
2.  $G$  is a CFG. IS  $L(G) = \Sigma^*$ ?
3.  $M$  is a Turing machine. Is  $L(M)$  regular?
4.  $A$  is a DFA and  $N$  is a NFA. Is  $L(A) = L(N)$ ?

- (A) 3 only                      (B) 3 and 4 only                      (C) 1, 2 and 3 only                      (D) 2 and 3 only

Ans: (D)

Exp: There is an algorithm to check whether the given CFG is empty, finite or infinite and also to convert NFA to DFA hence 1 and 4 are decidable.

33. Consider the following two sets of LR(1) items of an LR(1) grammar

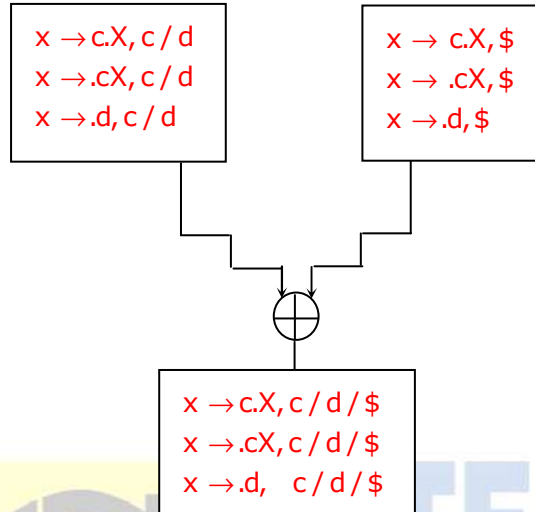
|                          |                         |
|--------------------------|-------------------------|
| $X \rightarrow cX, c/d$  | $X \rightarrow cX, \$$  |
| $X \rightarrow .cX, c/d$ | $X \rightarrow .cX, \$$ |
| $X \rightarrow .d, c/d$  | $X \rightarrow .d, \$$  |

Which of the following statements related to merging of the two sets in the corresponding LALR parser is/are **FALSE**?

1. Cannot be merged since look aheads are different
  2. Can be merged but will result in S-R conflict
  3. Can be merged but will result in R-R conflict
  4. Cannot be merged since goto on c will lead to two different sets
- (A) 1 only            (B) 2 only            (C) 1 and 4 only    (D) 1, 2, 3 and 4

Ans: (D)

Exp:



1. Merging of two states depends on core part (production rule with dot operator), not on look aheads.
  2. The two states are not containing Reduce item ,So after merging, the merged state can not contain any S-R conflict
  3. As there is no Reduce item in any of the state, so can't have R-R conflict.
  4. Merging of stats does not depend on further goto on any terminal.
- So all statements are false.

34. A certain computation generates two arrays a and b such that  $a[i] = f(i)$  for  $0 \leq i < n$  and  $b[i] = g(a[i])$  for  $0 \leq i < n$ . Suppose this computation is decomposed into two concurrent processes X and Y such that X computes the array a and Y computes the array b. The processes employ two binary semaphores R and S, both initialized to zero. The array a is shared by the two processes. The structures of the processes are shown below.

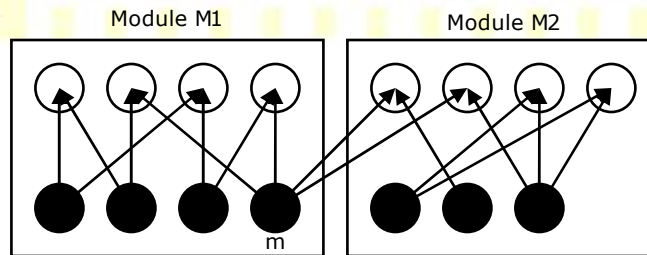
|                                                                                                                    |                                                                                                                        |
|--------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------|
| <pre> Process X; private i; for(i = 0; i &lt; n; i++) {     a[i] = f(i);     ExitX(R, S); }                 </pre> | <pre> Process Y; private i; for(i = 0; i &lt; n; i++) {     EntryY(R, S);     b[i] = g(a[i]); }                 </pre> |
|--------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------|

Which one of the following represents the **CORRECT** implementations of ExitX and EntryY?

- |                                                                                         |                                                                                         |
|-----------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------|
| <pre>(A) ExitX(R, S) {     P(R);     V(S); } EntryY(R, S) {     P(S);     V(R); }</pre> | <pre>(B) ExitX(R, S) {     V(R);     V(S); } EntryY(R, S) {     P(R);     P(S); }</pre> |
| <pre>(C) ExitX(R, S) {     P(S);     V(R); } EntryY(R, S) {     V(S);     P(R); }</pre> | <pre>(D) ExitX(R, S) {     V(R);     P(S); } EntryY(R, S) {     V(S);     P(R); }</pre> |

Ans: (B)

35. The following figure represents access graphs of two modules M1 and M2. The filled circles represent methods and the unfilled circles represent attributes. IF method m is moved to module M2 keeping the attributes where they are, what can we say about the average cohesion and coupling between modules in the system of two modules?



- (A) There is no change.  
 (B) Average cohesion goes up but coupling is reduced  
 (C) Average cohesion goes down and coupling also reduces  
 (D) Average cohesion and coupling increase

Ans: (B)

36. In an IPv4 datagram, the M bit is 0, the value of HLEN is 10, the value of total length is 400 and the fragment offset value is 300. The position of the datagram, the sequence numbers of the first and the last bytes of the payload, respectively are
- (A) Last fragment, 2400 and 2789      (B) First fragment, 2400 and 2759  
 (C) Last fragment, 2400 and 2759      (D) Middle fragment, 300 and 689

Ans: (C)

Exp: M= 0 – Means there is no fragment after this, i.e. Last fragment

HLEN=10 - So header length is  $4 \times 10 = 40$ , as 4 is constant scale factor

Total Length =  $400(40 \text{ Byte Header} + 360 \text{ Byte Payload})$

Fragment Offset = 300, that means  $300 \times 8 \text{ Byte} = 2400 \text{ bytes}$  are before this last fragment

So the position of datagram is last fragment

Sequence number of First Byte of Payload = 2400 (as 0 to 2399 Sequence no are used)

Sequence number of Last Byte of Payload =  $2400 + 360 - 1 = 2759$

37. Determine the maximum length of cable (in km) for transmitting data at a rate of 500 Mbps in an Ethernet LAN with frames of size 10,000 bits. Assume the signal speed in the cable to be 2,00,000 km/s

(A) 1

(B) 2

(C) 2.5

(D) 5

Ans: (B)

Exp:

$500 \times 10^6 \text{ bits} \text{ ----- } 1 \text{ sec}$

$\therefore 10^4 \text{ bits} \text{ ----- } \frac{5 \times 10^8}{10^4} = \frac{10^4}{5 \times 10^8} \text{ sec} = \frac{1}{5 \times 10^4} \text{ sec}$

$1 \text{ sec} \text{ ----- } 2 \times 10^5 \text{ km}$

$\therefore \frac{1}{5 \times 10^4} \text{ sec} \text{ ----- } \frac{2 \times 10^5}{5 \times 10^4} = 4 \text{ km}$

$\therefore \text{Maximum length of cable} = \frac{4}{2} = 2 \text{ km}$

38. Consider the following relational schema.

Students(rollno: integer, sname: string)

Courses(courseno: integer, cname: string)

Registration(rollno: integer, courseno: integer, percent: real)

Which of the following queries are equivalent to this query in English?

"Find the distinct names of all students who score more than 90% in the course numbered 107"

(I) SELECT DISTINCT S.sname

FROM Students as S, Registration as R

WHERE R.rollno=S.rollno AND R.Course=107 AND R.percent>90

(II)  $\Pi_{\text{sname}} (\sigma_{\text{course}=107} \wedge \text{percent} > 90 (\text{Registration} \text{ Students}))$

(III)  $\{T \mid \exists S \in \text{Students}, \exists R \in \text{Registration} (S.\text{rollno} = R.\text{rollno} \wedge R.\text{course} = 107 \wedge R.\text{percent} > 90 \wedge T.\text{sname} = S.\text{sname})\}$

(IV)  $\{ \langle S_N \rangle \mid \exists S_R \exists R_p (\langle S_R, S_N \rangle \in \text{Students} \wedge \langle S_R, 107, R_p \rangle \in \text{Registration} \wedge R_p > 90) \}$

(A) I, II, III and IV

(B) I, II and III only

(C) I, II and IV only

(D) II, III and IV only

Ans: (A)

Exp: Four queries given in SQL, RA, TRC and DRC in four statements respectively retrieve the required information.

39. A shared variable  $x$ , initialized to zero, is operated on by four concurrent processes  $W, X, Y, Z$  as follows. Each of the processes  $W$  and  $X$  reads  $x$  from memory, increments by one, stores it to memory, and then terminates. Each of the processes  $Y$  and  $Z$  reads  $x$  from memory, decrements by two, stores it to memory, and then terminates. Each process before reading  $x$  invokes the  $P$  operation (i.e., wait) on a counting semaphore  $S$  and invokes the  $V$  operation (i.e., signal) on the semaphore  $S$  after storing  $x$  to memory. Semaphore  $S$  is initialized to two. What is the maximum possible value of  $x$  after all processes complete execution?

- (A) -2                      (B) -1                      (C) 1                      (D) 2

Ans: (D)

Exp:

|   | W    | X    | Y      | Z      |
|---|------|------|--------|--------|
| 1 | R(x) | R(x) | R(x)   | R(x)   |
| 2 | x++  | x++  | x=x-2; | x=x-2; |
| 3 | w(x) | w(x) | w(x)   | w(x)   |

R(x) is to read  $x$  from memory, w(x) is to store  $x$  in memory

(I)  $w_1 (x \boxed{0})$  [W is Preempted]

(II)  $Y_1, Y_2, Y_3 (x \boxed{-2})$  [Y is completed]

(III)  $Z_1, Z_2, Z_3 (x \boxed{-4})$  [Z is completed]

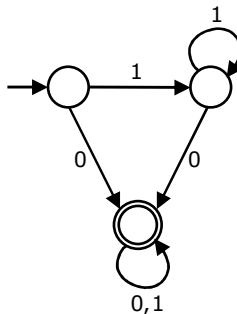
(IV)

$w_2, w_3 (x \boxed{1})$  [It increments local copy of  $x$  and stores & W is completed]

(V)  $X_1, X_2, X_3 (x \boxed{2})$  [X is completed]

Maximum value of  $x = 2$

40. Consider the DFA given below.

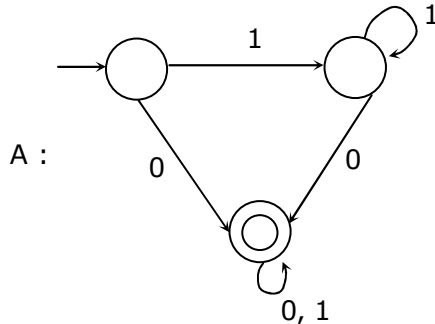


Which of the following are FALSE?

1. Complement of  $L(A)$  is context-free
  2.  $L(A) = L((11^*0 + 0)(0 + 1)^*0^*1^*)$
  3. For the language accepted by  $A$ ,  $A$  is the minimal DFA
  4.  $A$  accepts all strings over  $\{0, 1\}$  of length at least 2
- (A) 1 and 3 only    (B) 2 and 4 only    (C) 2 and 3 only    (D) 3 and 4 only

Ans: (D)

Exp:



- (1)  $L(A)$  is regular, its complement is also regular and if it is regular it is also context free.
- (2)  $L(A) = (11^*0 + 0)(0 + 1)^*0^*1^* = 1^*0(0 + 1)^*$   
Language has all strings where each string contains '0'.
- (3)  $A$  is not minimal, it can be constructed with 2 states
- (4) Language has all strings, where each string contains '0'. (atleast length one)

41. Consider the following languages

$$L_1 = \{0^p 1^q 0^r \mid p, q, r \geq 0\}$$

$$L_2 = \{0^p 1^q 0^r \mid p, q, r \geq 0, p \neq r\}$$

Which one of the following statements is FALSE?

- (A)  $L_2$  is context-free
- (B)  $L_1 \cap L_2$  is context-free
- (C) Complement of  $L_2$  is recursive
- (D) Complement of  $L_1$  is context-free but not regular

Ans: (D)

Exp:  $L_1 = \{0^p 1^q 0^r \mid p, q, r \geq 0\}$  is regular

$$L_2 = \{0^p 1^q 0^r \mid p, q, r \geq 0, p \neq r\} \text{ is CFL}$$

- (A)  $L_2$  is CFL (True)
- (B)  $L_1 \cap L_2 = \text{CFL}$  (True)
- (C)  $L_2$  complement is recursive (True)
- (D)  $L_1$  complement is CFL but not regular (False) as  $L_1$  is regular  $\bar{L}_1$  is regular

42. Consider the following function

```
int unknown(int n){
 int i, j, k = 0;
 for (i = n / 2; i <= n; i++)
 for (j = 2; j <= n; j = j * 2)
 k = k + n / 2;
 return (k);
}
```

- (A)  $\Theta(n^2)$             (B)  $\Theta(n^2 \log n)$             (C)  $\Theta(n^3)$             (D)  $\Theta(n^3 \log n)$

Ans: (B)

Exp:  $i = \left(\frac{n}{2}, \frac{n}{2} + 1, \frac{n}{2} + 2, \dots, n\right)$

Repeats  $\frac{n}{2}$  to  $n = \left(\frac{n}{2} + 1\right)$  times  $\left\{ \begin{array}{l} J = (2, 2^2, 2^3, 2^4, \dots, n) \\ k = k + \frac{n}{2} \end{array} \right\} k = \Theta(n \log n)$

$k = \frac{n}{2} + \frac{n}{2} + \dots + \log n \text{ times} = \frac{n}{2} \log n$

$= \frac{n}{2} \log n + \frac{n}{2} \log n + \frac{n}{2} \log n \dots \left(\frac{n}{2} + 1\right) \text{ times}$   
 $= \left(\frac{n}{2} + 1\right) \cdot \frac{n}{2} \log n$   
 $= \Theta(n^2 \log n)$

43. The number of elements that can be sorted in  $\Theta(\log n)$  time using heap sort is

- (A)  $\Theta(1)$             (B)  $\Theta(\sqrt{\log n})$             (C)  $\Theta\left(\frac{\log n}{\log \log n}\right)$             (D)  $\Theta(\log n)$

Ans: (A)

Exp: After constructing a max-heap in the heap sort, the time to extract maximum element and then heapifying the heap takes  $\Theta(\log n)$  time by which we could say that  $\Theta(\log n)$  time is required to correctly place an element in sorted array. If  $\Theta(\log n)$  time is taken to sort using heap sort, then number of elements that can be sorted is constant which is  $\Theta(1)$

44. Consider a hard disk with 16 recording surfaces (0 – 15) having 16384 cylinders (0 – 16383) and each cylinder contains 64 sectors (0 – 63). Data storage capacity in each sector is 512 bytes. Data are organized cylinder-wise and the addressing format is <cylinder no., sector no.>. A file of size 42797 KB is stored in the disk and the starting disk location of the file is <1200, 9, 40>. What is the cylinder number of the last sector of the file, if it is stored in a contiguous manner?

- (A) 1281            (B) 1282            (C) 1283            (D) 1284

Ans: (D)

$$42797 \text{ KB} \equiv \frac{42797 \times 1024}{512} = 85594 \text{ sectors}$$

Starting is  $\langle 1200, 9, 40 \rangle$  contains total  $24 + (6 \times 64) = 408$  sectors

Next, 1201, -----, 1283 cylinders contains total  $1024 \times 83 = 84992$  sectors

( $\therefore$  each cylinder contains  $16 \times 64 = 1024$  sectors)

$\therefore$  Total =  $408 + 84992 = 85400$  sectors

$\therefore$  The required cylinder number is  $\langle 1284 \rangle$  which will contain the last sector of the file

45. Consider the following sequence of micro-operations

MBR  $\leftarrow$  PC

MAR  $\leftarrow$  X

PC  $\leftarrow$  Y

Memory  $\leftarrow$  MBR

Which one of the following is a possible operation performed by this sequence?

(A) Instruction fetch

(B) Operand fetch

(C) Conditional branch

(D) Initiation of interrupt service

Ans: (D)

Exp: PC content is stored in memory via MBR and PC gets new address from Y. It represents a function call (routine), which is matching with interrupt service initiation

46. The line graph  $L(G)$  of a simple graph  $G$  is defined as follows:

- There is exactly one vertex  $v(e)$  in  $L(G)$  for each edge  $e$  in  $G$ .
- For any two edges  $e$  and  $e'$  in  $G$ ,  $L(G)$  has an edge between  $v(e)$  and  $v(e')$ , if and only if  $e$  and  $e'$  are incident with the same vertex in  $G$ .

Which of the following statements is/are **TRUE**?

(P) The line graph of a cycle is a cycle.

(Q) The line graph of a clique is a clique.

(R) The line graph of a planar graph is planar.

(S) The line graph of a tree is a tree.

(A) P only

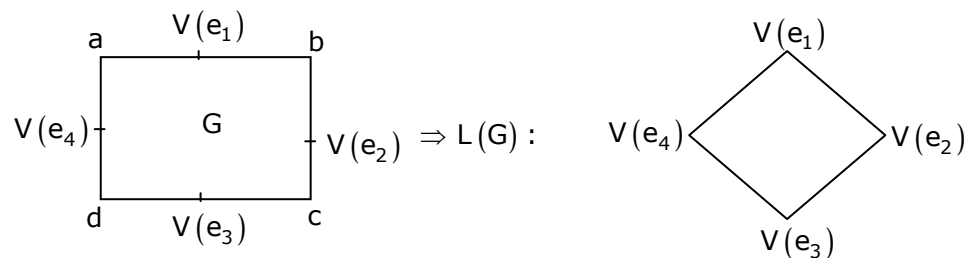
(B) P and R only

(C) R only

(D) P, Q and S only

Ans: (B)

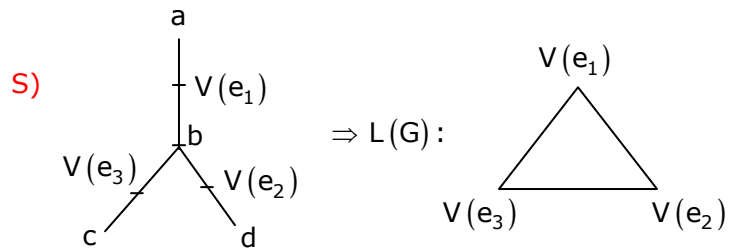
Exp: P) The line graph of a cycle is a cycle



is also cycle graph



R) Line graph of planar graph is planar



The line graph of a tree need not be tree.

47. What is the logical translation of the following statement?

“None of my friends are perfect.”

(A)  $\exists x(F(x) \wedge \neg P(x))$

(B)  $\exists x(\neg F(x) \wedge P(x))$

(C)  $\exists x(\neg F(x) \wedge \neg P(x))$

(D)  $\neg \exists x(F(x) \wedge P(x))$

Ans: (D)

Exp: “None of my friends are perfect”

=  $\forall x(F(x) \rightarrow \neg P(x))$

=  $\forall x(\neg F(x) \vee \neg P(x))$

=  $\neg \exists x(F(x) \wedge P(x))$

### Common Data Questions: 48 & 49

The procedure given below is required to find and replace certain characters inside an input character string supplied in array A. The characters to be replaced are supplied in array oldc, while their respective replacement characters are supplied in array newc. Array A has a fixed length of five characters, while arrays oldc and newc contain three characters each. However, the procedure is flawed

```
void find_and_replace (char * A, char * oldc, char * newc) {
 for (int i = 0; i < 5; i++)
 for (int j = 0; j < 3; j++)
 if (A[i] == oldc[j]) A[i] = newc[j];
}
```

The procedure is tested with the following four test cases

(1) oldc = "abc", newc = "dab"

(2) oldc = "cde", newc = "bcd"

(3) oldc = "bca", newc = "cda"

(4) oldc = "abc", newc = "bac"

48. The tester now tests the program on all input strings of length five consisting of characters 'a', 'b', 'c', 'd' and 'e' with duplicates allowed. If the tester carries out this testing with the four test cases given above, how many test cases will be able to capture the flaw?

(A) Only one

(B) Only two

(C) Only three

(D) All four

Ans: (B)

Exp: Flaw in this given procedure is that one character of Array 'A' can be replaced by more than one character of newc array, which should not be so. Test case (3) and (4) identifies this flaw as they are containing 'oldc' and 'newc' array characters arranged in specific manner. Following string can reflect flaw, if tested by test case (3).

**initially i = j = 0**

|            |              |              |
|------------|--------------|--------------|
| A = "bcda" | oldc = "bca" | newc = "cda" |
| ↑          | ↑            | ↑            |
| i = 0      | j = 0        | j = 0        |

b = b so replaced by c

**Next i = 0 & j = 1**

|            |              |              |
|------------|--------------|--------------|
| A = "ccda" | oldc = "bca" | newc = "cda" |
| ↑          | ↑            | ↑            |
| i = 0      | j = 1        | j = 1        |

c = c so replaced by d

Likewise single character 'b' in A is replaced by 'c' and then by 'd'.

Same way test case (4) can also catch the flaw.

49. If array A is made to hold the string "abcde", which of the above four test cases will be successful in exposing the flaw in this procedure?

(A) None                      (B) 2 only                      (C) 3 and 4 only                      (D) 4 only

Ans: (C)

Exp: Now for string "abcde" in array A, both test case (3) and (4) will be successful in finding the flaw, as explained in above question.

### Common Data Questions: 50 & 51

The following code segment is executed on a processor which allows only register operands in its instructions. Each instruction can have almost two source operands and one destination operand. Assume that all variables are dead after this code segment

```

c = a + b;
d = c * a;
e = c + a;
x = c * c;
if (x > a) {
 y = a * a;
}
else {
 d = d * d;
 e = e * e;
}

```

50. Suppose the instruction set architecture of the processor has only two registers. The only allowed compiler optimization is code motion, which moves statements from one place to another while preserving correctness. What is the minimum number of spills to memory in the compiled code?

- (A) 0                      (B) 1                      (C) 2                      (D) 3

Ans: (C)

Exp:

|                                                |                                                                                                                                          |
|------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------|
| $c = a + b;$                                   | $R_2 \leftarrow R_1 + R_2$                                                                                                               |
| $d = c * a;$                                   | $[spill] \leftarrow R_2 * R_1$                                                                                                           |
| $e = c + a;$                                   | $[spill_2] \leftarrow R_2 + R_1$                                                                                                         |
| $x = c * c;$                                   | $R_2 \leftarrow R_2 * R_2$                                                                                                               |
| if ( $x > a$ )                                 | CMP $R_2$ $R_1$<br>JNG xxx (Jump if not greater)                                                                                         |
| { $y = a * a;$ }                               | $R_1 \leftarrow R_1 * R_1$<br>goto yyy                                                                                                   |
| else<br>{<br>$d = d * d;$<br>$e = e * e;$<br>} | xxx : $R_1 \leftarrow [spill_1]$<br>$R_2 \leftarrow [spill_2]$<br>$R_1 \leftarrow R_1 * R_1$<br>$R_2 \leftarrow R_2 * R_2$<br>yyy : Exit |

In the above code total number of spills to memory is 2

51. What is the minimum number of registers needed in the instruction set architecture of the processor to compile this code segment without any spill to memory? Do not apply any optimization other than optimizing register allocation

- (A) 3                      (B) 4                      (C) 5                      (D) 6

Ans: (B)

Exp:

|              |                            |
|--------------|----------------------------|
| $c = a + b;$ | $R_2 \leftarrow R_1 + R_2$ |
| $d = c * a;$ | $R_3 \leftarrow R_2 * R_1$ |
| $e = c + a;$ | $R_4 \leftarrow R_2 + R_1$ |
| $x = c * c;$ | $R_2 \leftarrow R_2 * R_2$ |

|                                            |                                                                                                                          |
|--------------------------------------------|--------------------------------------------------------------------------------------------------------------------------|
| if (x > a)                                 | CMP R <sub>2</sub> R <sub>1</sub><br>JNG xxx (Jump if not greater)                                                       |
| {y = a * a;}                               | R <sub>1</sub> ← R <sub>1</sub> * R <sub>1</sub><br>goto yyy                                                             |
| else<br>{<br>d = d * d;<br>e = e * e;<br>} | xxx : R <sub>3</sub> ← R <sub>3</sub> * R <sub>3</sub><br>R <sub>4</sub> ← R <sub>4</sub> * R <sub>4</sub><br>yyy : Exit |

In the above code minimum number of registers are used = 4

**Linked Answer Questions: Q.52 to Q.55 Carry Two Marks Each**

**Statement for Linked Answer Questions: 52 & 53**

Relation R has eight attributes ABCDEFGH. Fields of R contain only atomic values.

$F = \{CH \rightarrow G, A \rightarrow BC, B \rightarrow CFH, E \rightarrow A, F \rightarrow EG\}$  is a set of functional dependencies (FDs) so that  $F^+$  is exactly the set of FDs that hold for R

52. How many candidate keys does the relation R have?

- (A) 3                      (B) 4                      (C) 5                      (D) 6

Ans: (B)

Exp: Candidate keys are AD, BD, ED and FD

53. The relation R is

- (A) in 1NF, but not in 2NF                      (B) in 2NF, but not in 3NF  
(C) in 3NF, but not in BCNF                      (D) in BCNF

Ans: (A)

Exp:  $A \rightarrow BC, B \rightarrow CFH$  and  $F \rightarrow EG$  are partial dependencies. Hence it is in 1NF but not in 2NF

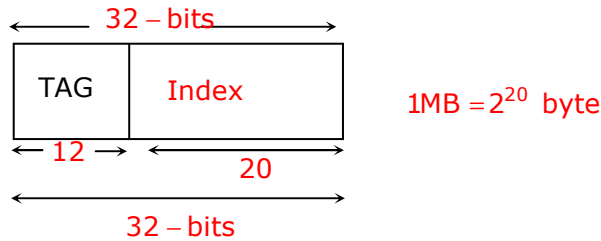
**Statement for Linked Answer Questions: 54 & 55**

A computer uses 46-bit virtual address, 32-bit physical address, and a three-level paged page table organization. The page table base register stores the base address of the first-level table ( $T_1$ ), which occupies exactly one page. Each entry of  $T_1$  stores the base address of a page of the second-level table ( $T_2$ ). Each entry of  $T_2$  stores the base address of a page of the third-level table ( $T_3$ ). Each entry of  $T_3$  stores a page table entry (PTE). The PTE is 32 bits in size. The processor used in the computer has a 1 MB 16 way set associative virtually indexed physically tagged cache. The cache block size is 64 bytes.

54. What is the size of a page in KB in this computer?  
 (A) 2 (B) 4 (C) 8 (D) 16

Ans: (B)

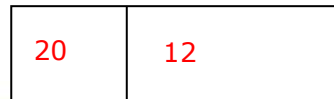
Exp: As it is virtually indexed



$$\text{Set size} = 16 \times 64 \text{ Bytes} = 2^{10}$$

$$\text{number of sets} = \frac{2^{20}}{2^{10}} = 2^{10}$$

Index of cache bits will be used as frame bits.



F.No      offset

$$\text{Frame size} = 2^{12} = 4K \text{ bytes}$$

55. What is the minimum number of page colours needed to guarantee that no two synonyms map to different sets in the processor cache of this computer?  
 (A) 2 (B) 4 (C) 8 (D) 16

Ans:

**Q. No. 56 – 60 Carry One Mark Each**

56. Complete the sentence:  
 Universalism is to particularism as diffuseness is to \_\_\_\_\_  
 (A) specificity (B) neutrality (C) generality (D) adaptation

Ans: (A)

The relation is that of antonyms

57. Were you a bird, you \_\_\_\_\_ in the sky.  
 (A) would fly (B) shall fly  
 (C) should fly (D) shall have flown

Ans: (A)

58. Which one of the following options is the closest in meaning to the word given below?

**Nadir**

- (A) Highest (B) Lowest (C) Medium (D) Integration

Ans: (B)  
Nadir in the lowest point on a curve

59. Choose the grammatically INCORRECT sentence:  
 (A) He is of Asian origin  
 (B) They belonged to Africa  
 (C) She is an European  
 (D) They migrated from India to Australia

Ans: (C)

60. What will be the maximum sum of 44, 42, 40, ... ?  
 (A) 502 (B) 504 (C) 506 (D) 500

Ans: (C)  
 The maximum sum is the sum of 44, 42, - - - -2.  
 The sum of 'n' terms of an AP

$$= \frac{n}{2} [2a + (n-1)d]$$

In this case,  $n = 22$ ,  $a = 44$  and  $d = -2$

$$\therefore \text{Sum} = 11[44 + 21 \times (-2)] = 11 \times 46 = 506$$

**Q. No. 61 – 65 Carry Two Marks Each**

61. Out of all the 2-digit integers between 1 and 100, a 2-digit number has to be selected at random. What is the probability that the selected number is not divisible by 7?  
 (A) 13/90 (B) 12/90 (C) 78/90 (D) 77/90

Ans: (D)  
 The number of 2 digit multiples of 7 = 13  
 $\therefore$  Probability of choosing a number

$$\text{Not divisible by 7} = \frac{90 - 13}{90} = \frac{77}{90}$$

62. A tourist covers half of his journey by train at 60 km/h, half of the remainder by bus at 30 km/h and the rest by cycle at 10 km/h. The average of the tourist in km/h during his entire journey is  
 (A) 36 (B) 30 (C) 24 (D) 18

Ans: (C)  
 Let the total distance covered be 'D'

$$\text{Now, average speed} = \frac{D}{\text{Total time taken}}$$

$$= \frac{D}{\left(\frac{D}{60} + \frac{D}{30} + \frac{D}{40}\right)} = \frac{1}{\frac{1}{60} + \frac{1}{30} + \frac{1}{40}} = \frac{120}{5} = 24 \text{ km/hr}$$

63. Find the sum of the expression

$$\frac{1}{\sqrt{1} + \sqrt{2}} + \frac{1}{\sqrt{2} + \sqrt{3}} + \frac{1}{\sqrt{3} + \sqrt{4}} + \dots + \frac{1}{\sqrt{80} + \sqrt{81}}$$

- (A) 7 (B) 8 (C) 9 (D) 10

Ans: (B)

The expression can be written as

$$\begin{aligned} & \frac{(\sqrt{2})^2 - (\sqrt{1})^2}{\sqrt{1} + \sqrt{2}} + \frac{(\sqrt{3})^2 - (\sqrt{2})^2}{\sqrt{2} + \sqrt{3}} + \dots + \frac{(\sqrt{81})^2 - (\sqrt{80})^2}{\sqrt{80} + \sqrt{81}} \\ &= \frac{(\sqrt{2} - \sqrt{1})(\sqrt{1} + \sqrt{2})}{(\sqrt{1} + \sqrt{2})} + \dots + \frac{(\sqrt{81} - \sqrt{80})(\sqrt{81} + \sqrt{80})}{\sqrt{80} + \sqrt{81}} \end{aligned}$$

64. The current erection cost of a structure is Rs. 13,200. If the labour wages per day increase by 1/5 of the current wages and the working hours decrease by 1/24 of the current period, then the new cost of erection in Rs. is

- (A) 16,500 (B) 15,180 (C) 11,000 (D) 10,120

Ans: (B)

Let 'W' be the labour wages, and 'T' be the working hours.

Now, total cost is a function of  $W \times T$

Increase in wages = 20%

∴ Revised wages = 1.2 W

Decrease in labour time =  $\left(\frac{100}{24}\right)\%$

∴ Revised time =  $\left(1 - \frac{1}{24}\right)T = \frac{23}{24}T$

∴ Revised Total cost =  $1.2 \times \frac{23}{24} WT = 1.15 WT$   
 $= 1.15 \times 13200 = 15180$

65. After several defeats in wars, Robert Bruce went in exile and wanted to commit suicide. Just before committing suicide, he came across a spider attempting tirelessly to have its net. Time and again, the spider failed but that did not deter it to refrain from making attempts. Such attempts by the spider made Bruce curious. Thus, Bruce started observing the near-impossible goal of the spider to have the net. Ultimately, the spider succeeded in having its net despite several failures. Such act of the spider encouraged Bruce not to commit suicide. And then, Bruce went back again and won many a battle, and the rest is history.

Which one of the following assertions is best supported by the above information?

- (A) Failure is the pillar of success  
 (B) Honesty is the best policy  
 (C) Life begins and ends with adventures  
 (D) No adversity justifies giving up hope

Ans: (D)

**GATE 2015 – A Brief Analysis**  
**(Based on student test experiences in the stream of CS on 8th**  
**February, 2015 – (Morning Session))**

**Section wise analysis of the paper**

| <b>Section Classification</b> | <b>1 Mark</b> | <b>2 Marks</b> | <b>Total Number of Questions</b> |
|-------------------------------|---------------|----------------|----------------------------------|
| Engineering Mathematics       | 2             | 3              | 5                                |
| Discrete Mathematics          | 3             | 2              | 5                                |
| Digital Logic                 | 1             | 2              | 3                                |
| Computer Organization         | 2             | 2              | 4                                |
| Theory of Computation         | 1             | 3              | 4                                |
| Data Structures & Algorithms  | 9             | 5              | 14                               |
| Compiler Design               | 1             | 3              | 4                                |
| Operating Systems             | 2             | 2              | 4                                |
| DBMS                          | 1             | 3              | 4                                |
| Computer Networks             | 2             | 2              | 4                                |
| SEWT                          | 1             | 3              | 4                                |
| Verbal Ability                | 2             | 3              | 5                                |
| Numerical Ability             | 3             | 2              | 5                                |
|                               | <b>30</b>     | <b>35</b>      | <b>65</b>                        |

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**Questions from the Paper**

**GATE 2015**

**8<sup>th</sup> February 9:00 to 12:00**

1. Let  $f(x)$  be a linear function such that  $f(-2) = 29$  and  $f(3) = 39$ . Find the value of  $f(5)$ .
2. What is the value of the postfix operation?
3. Consider a program code which was fed with 100 artificial errors. On analyzing the errors, 159 errors were reported of which 75 were the artificial errors that were initially seeded. What is the closest approximation of the number of errors in the program?
4. Question on `<base href=" " >`
5. Consider a power set  $U$  of a set  $S = \{1, 2, 3, 4, 5, 6\}$ . Let  $T \in U$  such that  $T'$  denotes the complement of the set and  $|T|$  denote the number of elements in  $T$ . Let  $T/R$  denote the set of elements which are  $T$  but not in  $R$ . Which of the following is true?
  - (A)  $\forall X \in U (|X| = |X'|)$
  - (B)  $\exists X \exists Y \in U (|X| = 5, |Y| = 5, X \cap Y = \phi)$
  - (C)  $\forall X \forall Y \in U (|X| = 2, |Y| = 3, X/Y = \phi)$
  - (D)  $\forall X \forall Y \in U (X/Y = Y'/X')$
6. The maximum number of processes that can be in READY state on a processor with  $n$  CPUs is?
  - (A)  $n$
  - (B)  $n - 1$
  - (C)  $2^n$
  - (D) Independent of  $n$

**Key:** (D)

**Exp:** Number of processes which are in running processes will be atmost  $n$  as there are  $n$  processors. Maximum no. of processes that will be in ready state in independent of no. of processors.
7. Consider the following statements. Which of them is true?
 

S1: TCP allows full duplex communication

S2: TCP has no option for selective acknowledgments

S3: TCP work as a message stream.

  - (A) Only S1
  - (B) Only S2
  - (C) S1, S2, S3
  - (D) S1 and S3, but not S2

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8. Consider a hash table with 25 slots and 200 entries. What is the load factor  $\alpha$  of the hash table?
9. Consider the following relation table:  
table(theatre, address capacity)  
What should be written at the end of this query  
Select P1.address  
From table P1  
Such that it returns the theatre with maximum capacity?  
(A) Where capacity  $\geq$  ALL( select P2.capacity from table p2)  
(B) Where capacity  $\geq$  ANY( select P2.capacity from table p2)  
(C) Where capacity  $>$  ALL( select P2.capacity from table p2)  
(D) Where capacity  $>$  ANY( select P2.capacity from table p2)

**Key:** (A)

**Exp:** Inner query collects capacities of all the theatres and in outer query we are filterin the tuples with the condition "capaicty $\geq$ All". So the theatres which are having maximum capacity will be satisfy the conductivity and they will.

10. How many 4-digit numbers can be formed such that the digits are in non-decreasing order (from left to right) using only digits {1, 2, 3}?
11. Question on critical section where two processes  $P_1$  and  $P_2$ . It asks about mutual exclusion and deadlock.
12. Consider the equation  $\sum i^3 = X$ . Also consider the following:  
i.  $\theta(n^4)$   
ii.  $\theta(n^3)$   
iii.  $O(n^5)$   
iv.  $\Omega(n^5)$

Which of the above can correctly replace X?

- (A) Only I                      (B) I and II                      (C) I, III and IV                      (D)

**Key:** (C)

**Exp:**  $X = \text{sum of the cubes of } n \text{ natural numbers} = \frac{n^2(n+1)^2}{4}$  which is  $\theta(n^4)$ ,  $O(n^5)$  &  $\Omega(n^3)$ .

13. Consider the following C code:

```
#include<stdio.h>
main(){
char s1[7] = "1234", *p;
```

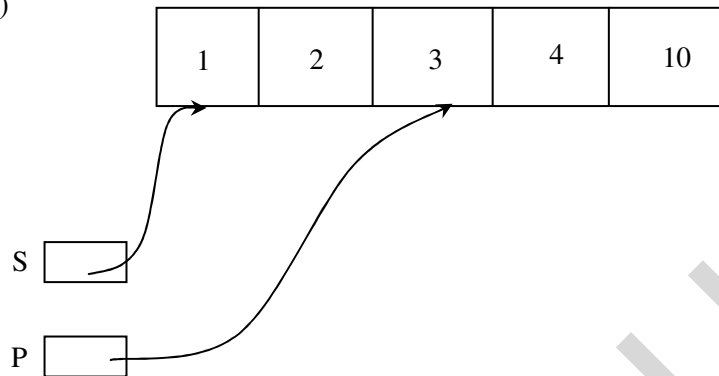
Disclaimer – This paper analysis and questions have been collated based on the memory of some students who appeared in the paper and should be considered only as guidelines. GATEFORUM does not take any responsibility for the correctness of the same.

```
p = s1+2;
*p = '0';
Printf("%s", s1);
}
```

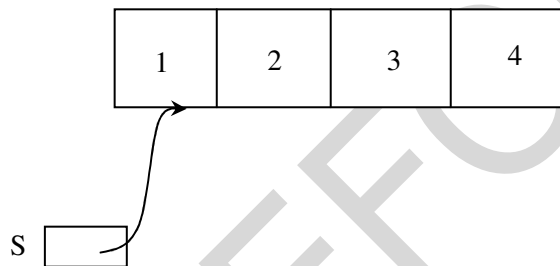
- (A) 12                      (B) 120400                      (C) 1204                      (D)

**Key:** (1204)

**Exp:**



After \*P = '0'.

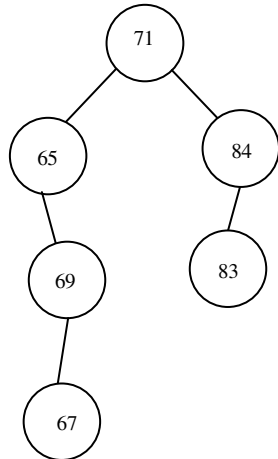


and we are pointing strife s which is 1204.

14. Let # be a binary operator such that:  
 $X\# = X' + Y'$   
 Consider the following two statements:  
 S1:  $(P\#Q)\#R = P\#(Q\#R)$   
 S2:  $Q\#R = R\#Q$   
 Which of them is correct?
15. Consider the language  $L = \Sigma^*0011\Sigma^*$  where  $\Sigma = \{0,1\}$ . What is the minimum number of states in the DFA of compliment of L i.e. L'?
16. The elements 71, 65, 84, 69, 67, 83 are inserted in a binary search tree. The element in the lowest level is?

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**Exp:**



17. Consider the following elements:  
< 85,19,50,17,11,12,15,8,9,6,5,2,100 >

The minimum number of interchanges required to convert this into a max-heap is?

**Exp:** 1<sup>st</sup> snap is between 100 & 12  
2<sup>nd</sup> snap is between 100 & 50  
3<sup>rd</sup> snap is between 100 & 85.

18. The limit evaluates to:

$$\lim_{x \rightarrow \infty} (1 + x^2)e^{-x}$$

- (A) 1                      (B)  $\frac{1}{2}$                       (C) -1                      (D)  $\infty$

19. Given a relation (PQRTUV) and the following two functional dependencies:  
PQ -> RS.

Which of the following is a trivial FD which can be implied from F+ over F?

20. CSMA/CD question to find speed of signal:

$$\text{Ans: } \frac{1250 * 8}{10^8} \geq 2 * \frac{1}{x}$$

**Exp:** Given L=1250 Bytes

B= 100 mbps

d= 1km

V=?

$$\text{In CSMA/CD, } L = 2 \times \frac{d}{v} \times B$$

$$\Rightarrow V = \frac{2dB}{L} = \frac{2 \times 10^3 \times 10^{84}}{10^4}$$

$$\Rightarrow V = 20,000 \text{ KM/sec}$$

(or)

$$V = 0.2 \times \omega^8 \text{ m/s}$$

21. Consider a binary tree with 200 leaf nodes. What is the number of nodes having exactly two children?

**Key:** 399

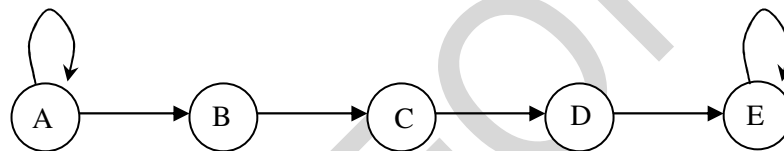
**Exp:**  $p = \frac{n+1}{2}$

$$p = 200$$

$$200 = \frac{n+1}{2}$$

$$2(200) = n + 1$$

$$n = 400 - 1 = 399$$



|      |      |     |
|------|------|-----|
| A    | AB   | A   |
| B    | C    | -   |
| C    | -    | D   |
| D    | -    | E   |
| E    | E    | E   |
| AB   | ABC  | A   |
| ABC  | ABC  | AD  |
| AD   | AB   | AE  |
| AE   | ABE  | AE  |
| ABE  | ABCE | AE  |
| ABCE | ABCE | ADE |
| ADE  | ABE  | AE  |

22. Consider a  $2^{20}$  byte addressable main memory and block size of 16 bytes with a direct mapped cache of  $2^{12}$  cache lines. Two bytes are consecutively stored in the memory addresses  $(E201F)_{16}$  and  $(E2020)_{16}$ . What is the tag and cache line address of address  $(E201F)_{16}$ ?

(A) E, 201                      (B) E, E201                      (C) F, 201                      (D) ..

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23. There are types of people. Type 1 always tells the truth and Type 2 always tell the lie. A coin is tossed by one person whose type is unknown. He does not tell the result of coin toss till asked. Upon asking, he replies:  
 “The coin toss has resulted in heads if and only if I tell the truth”  
 Which of the following is true?  
 (A) Result is head  
 (B) Result is tail  
 (C) If person is Type 1, then result is tail  
 (D) If person is Type 2, then result is tail

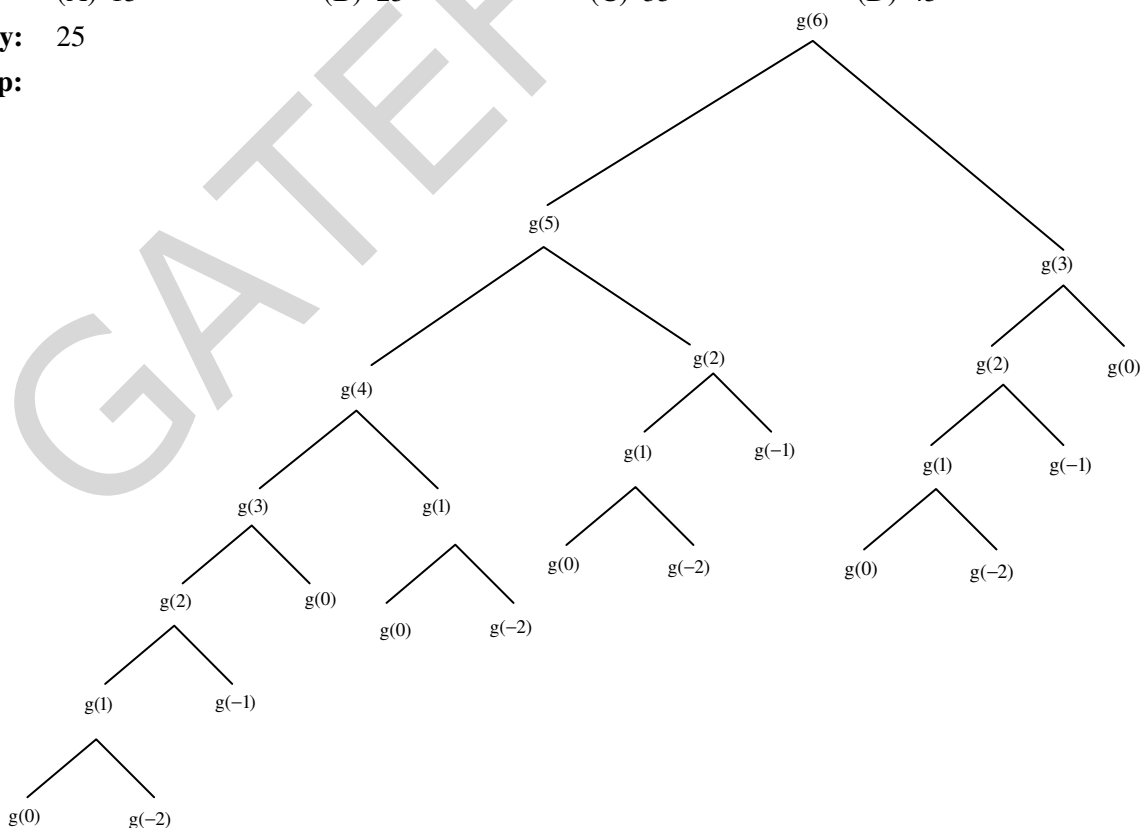
24. Consider the following C code:

```
get int (n)
{
 if (n < 1) return;
 get (n - 1);
 get (n - 3)
 printf ("%d", n);
}
```

If the above function is called from main() with get(6), then the number of times the get() recursive call is made?

- (A) 15                      (B) 25                      (C) 35                      (D) 45

**Key:** 25  
**Exp:**



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25. Question about GoBackN and minimum number of bits in sequence number.  $W \geq 1+2a$
26. A language  $L_1$  is polynomial time reducible to  $L_2$ . A language  $L_3$  is also polynomial time reducible to  $L_2$ , which in turn is polynomial time reducible to  $L_4$ . Which of the following statements are true?
- If  $L_4 \in P$ , then  $L_2 \in P$
  - 
  - 
  - If  $L_4 \in P$ , then  $L_1 \in P$  and  $L_3 \in P$

**Key:** (C)

**Exp:**  $L_2 \leq pL_4$

$$L_1 \leq pL_2$$

If  $L_4 \in P$  then  $L_2 \in P$  hence  $L_1 \in P$  hence option C.

27. Mergesort algorithm takes about 30 seconds on an input of 64 elements. What is the correct approximation for the number of elements that can be sorted in 6 minutes using mergesort?

**Key:** 256

**Exp:** Time complexity =  $O(n \log n)$

$$O(n \log n) = 30s.$$

$$n = 64$$

$$\theta(64 \times \log 64) = 30$$

hence will set factor of 12.8.

for 3 min.

$$= 3 \times 60$$

$$O(256109256) \Rightarrow 180$$

will get factor of 11.37

for 512 will get 25.6.

for 1024 will get 56.8

for 2048 will get 125.155

hence 256 is near to answer.

28. Consider a network 200.10.11.144/27. What is the value of the last octet (in decimal) of the last host in this network?

**Key:**

**Exp:** Given IP address 200.10.11.144/27

To find out the last address in a block, we have to set (32-4) no. of right most bits to 1.

$$n=27$$

$$32 - n = 32 - 27 = 5$$

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200.10.11.10011111

200.10.11.159

$\therefore$  CDR Address range is 200.10.11.128/27-200.10.11.159/27

But w.r.t the question, the volume of the last octet of last host in this n/w is

200.10.11.158.

29. Consider two functions:

$$f(n) = n$$

$$g(n) = n^{(1+\sin n)}$$

Then which is correct

$$f(n) = O(g(n))$$

$$g(n) = O(f(n))$$

**Exp:** As  $-1 \leq \sin x \leq 1$ , neither of them is true

30. Consider a relation R on ordered pair of integers such that  $((p,q),(r,s)) \in R$  If  $p - s = q - r$ .

Which of the following is true about the relation R?

- (A) Reflexive and Symmetric
- (B) Not reflexive but symmetric
- (C) Reflexive but not symmetric
- (D) Not reflexive nor symmetric

**Key:** (B)

**Exp:** R is reflexive if  $(p,q) R (p,q) \forall p,q \in \mathbb{Z}$

$(p,q) R (p,q)$  if  $p - q = q - p$  which is false

$\therefore$  R is not reflexive

R is symmetric is  $(p,q) R (r,s)$  then  $(r,s) R (p,q)$

If  $(p,q) R (r,s)$  then  $p - s = q - r$

If  $(r,s) R (p,q)$  then  $r - q = s - p$  which is true when  $p - s = q - r$

$\therefore$  R is symmetric

31. A graph consists of 100 vertices and 300 edges. The minimum spanning tree of the graph has a weight of 500. The weight of each edge is then increased by 5. The weight of the new MST is \_\_\_\_.

**Key:** 995

**Exp:** 100 vertices and weight 500

So there 99 edges with weight 500.



Consider one instances  
 where 98 edges have weight 5  
 and one edge having weight 10  
 now we have to increase weight by 5.  
 Hence,  $98 \times 10 + 15 = 995$

32. McCabe cyclomatic complexity of two modules A and B, and their combined cyclomatic complexity: Answer: 4,4,7
33. Two hosts communicate using packet switched. The hosts are connected via a switch over  $10^7$  bit per second links. The propagation delay on both links is 20 microseconds. The hosts send a total of 10000 bits in two packets of 5000 bits each. The switch waits for 35 microseconds between sending a frame and receiving a frame. What is the total delay (in microseconds) between sending the last bit and receiving the first bit?

34. The function  $af(x) + bf\left(\frac{1}{x}\right) = \frac{1}{x} - 25$ . What is the value of  $\int_1^2 f(x) dx$ ?

(A)  $\frac{1}{a^z - b^z} \left\{ a(\ln 2 - 25) + \frac{47b}{2} \right\}$

35. The maximum number of possible solutions to the equation  $(43)_x = (y3)_8$  are:

**Key:** (5)

**Exp:**  $(43)_x = (y3)_8$

$$\Rightarrow 3 + 4x = 3 + 8y \Rightarrow 4x = 8y$$

$$\Rightarrow x = 2y$$

$$\Rightarrow x \geq 5 \text{ and } y \leq 7$$

$\therefore$  5 solutions are possible which are (14,7), (12,6), (10,5), (8,4) and (6,3)

36. Consider the following code fragment:

```
#include <stdio.h >
```

```
int x = 10
```

```
int f1();
```

```
int f2();
```

```
int f3();
```

```

main () {
int x = 1;
x + f1() + f2() + f3() + f2()
printf ("%d,x);
return 0;
}

int f1() {int x = 25; x ++; return x;}
int f2() {static int 50; x ++; return x;}
int f3() {x* = 10; return x;}

```

What is the output?

- (A) i only                      (B) ii only                      (C) I & iii                      (D) I & ii

**Key:**

**Exp:**  $a^m b^n a^n b^m \Rightarrow$  This one is CFL

$a^m b^n a^m b^n \Rightarrow$  by pumping lemma this one is not CFL.

$\{a^m b^n \mid m = 2n + 1\}$  This is CFL.

37. An array  $C = \langle c_0, c_1, \dots, c_{k-1} \rangle$  has elements from either 0 or 1. Consider the following code:

```

DoSomething(c,a,n)
{
 z < -1
 For i = 0 to k - 1
 do
 z < -z2 mod n
 if c[i] = 1
 z < -a * z mod n
 end
 return z;
}

```

If  $k = 4$ ,  $c = \langle 1, 0, 1, 1 \rangle$ ,  $a = 2$ , and  $n = 8$ , what is the value returned?

**Key:** (0)

**Exp:** C 

|   |   |   |   |
|---|---|---|---|
| i | 0 | 1 | 1 |
|---|---|---|---|

$2 = 0$

20something

|                         |          |          |          |          |
|-------------------------|----------|----------|----------|----------|
| {z = 1                  | k = 0    |          |          |          |
| for i = 0 + 0.3         | z = 1    |          |          |          |
| do                      |          |          |          |          |
| z < -2 <sup>2</sup> mod | z = 1    | z = 4    | z = 0    | z = 0    |
| if c[i] = 1             | c[0] = 1 | c[1] = 0 | c[1] = 1 | c[1] = 1 |
| z < -2 × 2 mod 8        | z = 2    |          | z = 0    | z = 0    |
| end                     |          |          |          |          |
| return 2}               |          |          |          |          |

Ans: z=0

38. Which of the following is a context free language?

- i.  $\{a^m b^n a^n b^m\}$
- ii.  $\{a^m b^n a^m b^n\}$
- iii.  $\{a^m b^n \mid 2m = n + 1\}$

39. Consider a binary function  $F = P' + QR$  such that  $P' = !P$ . Which of the following is correct for F?

- i.  $F = \Sigma(4, 5, 6)$
- ii.  $F = \Sigma(0, 1, 2, 3, 7)$
- iii.  $F = \Pi(4, 5, 6)$
- iv.  $F = \pi(0, 1, 2, 3, 7)$

(A) only A      (B) only B      (C) Both B & C      (D) Both A & C

**Key:**

**Exp:**  $F = P' + QR$

|   |   |    |    |    |    |    |
|---|---|----|----|----|----|----|
|   |   | QR | 00 | 01 | 11 | 10 |
| P | 0 |    | 1  | 1  | 1  | 1  |
|   | 1 |    | 0  | 0  | 1  | 0  |

hence  $\Sigma(0, 1, 2, 3, 7)$

$\pi(4, 5, 6)$

41. A B+ tree has a search value field of 12 Bytes, a record pointer of ..bytes, and a block pointer of 8 bytes with block size 1024. What is the maximum number of keys that can be accommodated in a non-leaf node?

**Key:** 50

**Exp:** Suppose that 'k' is order of the non-leaf node

$$k(8)+(k-1)12 \leq 1024$$

$$20k \leq 1036$$

$$k \leq \left\lfloor \frac{1036}{20} \right\rfloor \Rightarrow k \leq 51$$

As the order is 51, maximum we can store 50 keys

42. Consider the following C Code:

```
#include <stdio.h >
void main()
{
int a{10,20,30,40,50};
int* p[] = {a, a + 3, a + 4, a + 1, a + 2}
int**ptr;
ptr = &p;

ptr ++;
printf ("%d%d", ptr - p, **ptr);
}
```

What is the output?

43. CO question about data dependence in pipeline:

OP OP  $r_1, r_2, r_3$  implies  $r_1 < -r_2$  OP  $r_3$

There are five instructions to be executed. ....

44. X is a two dimensional matrix such that X is initialized as  $X[I, j] = i + j$ , and Y is a one dimensional matrix with all zero's. Two code fragments are given.

In one:  $y[i] += x[0][i]$  and in another  $y[i] += x[i][0]$

45. Question about Simpson's 1/3<sup>rd</sup> rule

46. Question about computing Function point after providing all the parameter values

47. Question about smallest turnaround time in OS after providing four processes:

---

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| Process        | Arrival Time | Duration |
|----------------|--------------|----------|
| P <sub>0</sub> | 0            | 4        |
| P <sub>2</sub> | 1            | 6        |
| P <sub>3</sub> | 5            | 4        |
| P <sub>4</sub> | 6            | 2        |

(Values may be inaccurate)

**Exp:** Given snapshot

| Process        | AT | BT |
|----------------|----|----|
| P <sub>0</sub> | 0  | 4  |
| P <sub>1</sub> | 1  | 6  |
| P <sub>2</sub> | 4  | 3  |
| P <sub>3</sub> | 6  | 2  |

(A) Gantt chart:

|                | AT | BT | LT | TAT    |
|----------------|----|----|----|--------|
| P <sub>0</sub> | 0  | 4  | 4  | 4      |
| P <sub>1</sub> | 1  | 6  | 10 | 9      |
| P <sub>2</sub> | 4  | 3  | 13 | 9      |
| P <sub>3</sub> | 6  | 2  | 15 | 9      |
|                |    |    | 31 |        |
|                |    |    | 4  | = 7.75 |

| P <sub>0</sub> | P <sub>1</sub> | P <sub>2</sub> | P <sub>3</sub> |
|----------------|----------------|----------------|----------------|
| 0              | 4              | 10             | 13             |
|                |                |                | 15             |

(B) SJF(Non-preemption)

|                | AT | BT | LT | TAT |
|----------------|----|----|----|-----|
| P <sub>0</sub> | 0  | 4  | 4  | 4   |
| P <sub>1</sub> | 1  | 6  | 15 | 14  |
| P <sub>2</sub> | 4  | 3  | 7  | 3   |
| P <sub>3</sub> | 6  | 2  | 9  | 3   |
|                |    |    | 24 | = 6 |
|                |    |    | 4  |     |

Gantt Chart

| P <sub>0</sub> | P <sub>2</sub>    | P <sub>3</sub>    | P <sub>1</sub>    |
|----------------|-------------------|-------------------|-------------------|
| 0              | 4                 | 7                 | 9                 |
|                |                   |                   | 15                |
|                | p <sub>1</sub> -6 | p <sub>1</sub> -6 | p <sub>1</sub> -6 |
|                | p <sub>2</sub> -3 | p <sub>3</sub> -2 |                   |

(C) SRTF

|                | AT | BT | LT | TAT |
|----------------|----|----|----|-----|
| P <sub>0</sub> | 0  | 4  | 4  | 4   |
| P <sub>1</sub> | 1  | 6  | 15 | 14  |
| P <sub>2</sub> | 4  | 3  | 7  | 3   |
| P <sub>3</sub> | 6  | 2  | 9  | 3   |
|                |    |    | 24 | = 6 |

Gantt Chart

|                |                |                |                |
|----------------|----------------|----------------|----------------|
| P <sub>0</sub> | P <sub>2</sub> | P <sub>3</sub> | P <sub>1</sub> |
| 0              | 4              | 7              | 9              |
|                |                |                | 15             |

|                |                   |                   |                   |                   |                   |
|----------------|-------------------|-------------------|-------------------|-------------------|-------------------|
| P <sub>0</sub> | P <sub>0</sub>    | P <sub>2</sub>    | P <sub>2</sub>    | P <sub>3</sub>    | P <sub>1</sub>    |
| 0              | 1                 | 4                 | 6                 | 7                 | 9                 |
|                |                   |                   |                   |                   | 15                |
|                | p <sub>0</sub> -3 | p <sub>1</sub> -6 | p <sub>1</sub> -6 | p <sub>1</sub> -6 | p <sub>1</sub> -6 |
|                | p <sub>1</sub> -6 | p <sub>2</sub> -3 | p <sub>2</sub> -1 | p <sub>3</sub> -2 |                   |
|                |                   |                   | p <sub>3</sub> -2 |                   |                   |

(D) R.R

(T.Q=2)

|                | AT | BT | LT | TAT                                                                                         |
|----------------|----|----|----|---------------------------------------------------------------------------------------------|
| P <sub>0</sub> | 0  | 4  | 6  | 6                                                                                           |
| P <sub>1</sub> | 1  | 6  | 15 | 14                                                                                          |
| P <sub>2</sub> | 4  | 3  | 13 | 9                                                                                           |
| P <sub>3</sub> | 6  | 2  | 12 | 6                                                                                           |
|                |    |    | 35 | = 8.7 ⇒ R.Q: P <sub>0</sub> /P <sub>1</sub> /P <sub>2</sub> /P <sub>3</sub> /P <sub>1</sub> |
|                |    |    | 4  |                                                                                             |

Gantt Chart

|                |                |                |                |                |                |                |                |
|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|
| P <sub>0</sub> | P <sub>1</sub> | P <sub>0</sub> | P <sub>2</sub> | P <sub>1</sub> | P <sub>3</sub> | P <sub>2</sub> | P <sub>1</sub> |
| 0              | 2              | 4              | 6              | 8              | 10             | 12             | 13             |
|                |                |                |                |                |                |                | 15             |

49. Consider the following system of equation with a non-trivial solution

$$px + qy + rz = 0$$

$$qx + ry + pz = 0$$

$$rx + py + qz = 0$$

50. Consider two transactions:

|                                          |                                                                                                      |
|------------------------------------------|------------------------------------------------------------------------------------------------------|
| <p>T1</p> <p>Read(A)</p> <p>Write(A)</p> | <p>T2</p> <p>Read(C)</p> <p>Write(C)</p> <p>Read(B)</p> <p>Write(B)</p> <p>Read(A)</p> <p>Commit</p> |
|------------------------------------------|------------------------------------------------------------------------------------------------------|

Read(B)

If the transaction T1 fails after the execution of Read(B), then which is true?

- (A) Recoverable
- (B) Non-recoverable

**Key:** (B)

**Exp:** T<sub>2</sub> is reading the value written by T<sub>1</sub> and getting committed before T<sub>1</sub> commits. So it is non-recoverable schedule

51. Consider three random variables  $X_i$  with  $i = \{1, 2, 3\}$ .  $X_i$  is either 0 or 1 for  $i = \{1, 2, 3\}$

Consider another variable  $Y = X_1 \cdot X_2 \oplus X_3$ . What is the probability of  $P[Y = 0 | X_3 = 0]$ ?

52. A graph was given and asked about correct equation:

**Exp:**  $x = -(y - |y|)$

53. A code fragment was provided with case statement and asked how many times printf statement will be printed.

**General Aptitude****Q. 1 – Q. 5 carry one mark each**

1. Out of the following four sentences, select the most suitable sentence with respect to grammar and usage.
- (A) I will not leave the place until the minister does not meet me.  
(B) I will not leave the place until the minister doesn't meet me.  
(C) I will not leave the place until the minister meet me.  
(D) I will not leave the place until the minister meets me.

**Key: (D)**

2. A rewording of something written or spoken is a \_\_\_\_\_.
- (A) paraphrase      (B) paradox      (C) paradigm      (D) paraffin

**Key: (A)**

3. Archimedes said, "Give me a lever long enough and a fulcrum on which to place it, and I will move the world."  
The sentence above is an example of a \_\_\_\_\_ statement.
- (A) figurative      (B) collateral      (C) literal      (D) figurine

**Key: (A)**

4. 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

**Key: (C)**

5. 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

**Key: (D)**

**Exp:** Four blocks are needed for each direction (totally 3 directions) to build a bigger cube containing 64 blocks. So area of one side of the bigger cube =  $4 \times 4 = 16$  units

There are 6 faces so total area =  $6 \times 16 = 96$  units

When cubes at the corners are removed they introduce new surfaces equal to exposed surfaces so the area of the bigger cube does not change from 96



**Q. No. 6 – 10 Carry Two Marks Each**

6. 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 piece. The table below shows the numbers of each razor sold in each quarter of a year.

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

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

- (A) Elegance            (B) Executive            (C) Smooth            (D) Soft

Key: (B)

Exp: Total income from Elegance =  $48(27300+25222+28976+21012) = 4920480$

Total income from Smooth =  $63(20009+19392+22429+18229) = 5043717$

Total income from Soft =  $78(17602+18445+19544+16595) = 5630508$

Total income from Executive =  $173(9999+8942+10234+10109) = 6796132$

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

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

- (A) India is a country of exactly seventeen languages.  
 (B) Linguistic pluralism is the only indicator of a nation's diversity.  
 (C) Indian currency notes have sufficient space for all the Indian languages.  
 (D) Linguistic pluralism is strong evidence of India's diversity.

Key: (D)

8. 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)

**Key:** (D)

9. 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)  $(x+1)$

**Key:** (B)

**Exp:** from the option (b) substitute  $x=1$  in

$$2x^7 + 3x - 5 = 0$$

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

$$5 - 5 = 0$$

So  $(x-1)$  is a factor of  $f(x)$

10. 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

**Key:** (B)

**Exp:** From the data given we assume

$$\text{load} = \frac{\text{exponent}}{\log(\text{cycles})}$$

$$80 = \frac{x}{\log(10000)} \Rightarrow x = 160$$

$$40 = \frac{x}{\log(10000)} \Rightarrow x = 160$$

$$\text{load} = \frac{160}{\log 5000} = 43.25$$

**Computer Science Engineering**

**Q. No. 1 – 25 Carry One Mark Each**

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

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

q: x is a composite number

r: x is a perfect square

s: x is a prime number

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

**Key:** (11)

**Exp:**  $\sim((p \Rightarrow q) \wedge (\sim r \vee \sim s)) = \sim(P \Rightarrow q) \vee \sim(\sim r \wedge \sim s)$

$$\begin{aligned}
 &= \sim(p \Rightarrow q) \vee \sim(r \wedge s) \\
 &= \sim(p \Rightarrow q) \vee (r \wedge s) \\
 &= \sim(\sim p \vee q) \wedge (r \wedge s) \\
 &= (p \wedge \sim q) \wedge (r \wedge s)
 \end{aligned}$$

For x=11 only the above compound proposition is true.

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

(A)  $a_n = a_{n-1} + 2a_{n-2}$

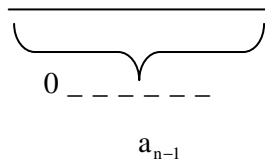
(B)  $a_n = a_{n-1} + 2a_{n-2}$

(C)  $a_n = a_{n-1} + 2a_{n-2}$

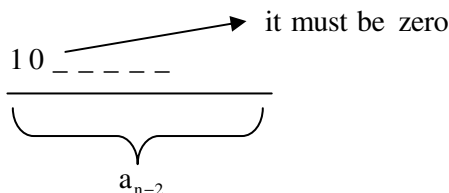
(D)  $a_n = a_{n-1} + 2a_{n-2}$

**Key:** (B)

**Exp:** Case I First bit is '0'



Case II First bit is '1'



$\therefore a_n = a_{n-1} + a_{n-2}$

3.  $\lim_{x \rightarrow 4} \frac{\sin(x-4)}{x-4} = \underline{\hspace{2cm}}$ .

Key: (1)

Exp:

$$\begin{aligned} & \lim_{x \rightarrow 4} \frac{\sin(x-4)}{x-4} \\ &= \lim_{x \rightarrow 4} \frac{\sin(x-4)}{x-4} \\ &= \lim_{y \rightarrow 0} \frac{\sin y}{y} \quad (\text{By taking } y = x - 4) \\ &= 1 \end{aligned}$$

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

Key: (0.5)

Exp: Given  $f(x) = \frac{1}{x^2} \quad x \in [a, 1]$   
 $= 0$  other wise

We know that  $\int_a^1 f(x) dx = 1$

$$\Rightarrow \int_a^1 \frac{1}{x^2} dx = 1 \Rightarrow \left( \frac{-1}{x} \right)_a^1 = 1$$

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

$$\Rightarrow a = 0.5$$

5. Two eigen values of a  $3 \times 3$  real matrix  $P$  are  $(2 + \sqrt{-1})$  and  $3$ . The determinant of  $P$  is \_\_\_\_\_.

Key: (15)

Exp: Given that  $2 + \sqrt{-1}$  and  $3$  are two Eigen values of  $3 \times 3$  real matrix is,  $2 + i$  and  $3$  are Eigen values.

But  $2 - i$  also Eigen values ( $\because$  complex roots occurs in pair only)

det = Product of Eigen values

$$= (2 + i) \times (2 - i) \times 3 = 5 \times 3 = 15$$

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

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

- (A)  $x\bar{y} + \bar{x}y$                       (B)  $x\bar{y} + \bar{x}\bar{y}$                       (C)  $\bar{x}y + xy$                       (D)  $xy + \bar{x}\bar{y}$

Key: (A)

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

Key: (-11)

Exp:

1111 1111 1111 0101

2's complement 0000 0000 0000 1011

11 and 1st bit is 1.

So result is -11

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

Key: (4)

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

Key: (31)

Exp: Memory size=4GB= $2^{32}$ bytes

Word size=2 bytes

$$\therefore \text{No. of Address bits} = \frac{\text{Memory size}}{\text{Word size}} = \frac{2^{32} \text{ bytes}}{2 \text{ bytes}} = 2^{31} \Rightarrow 31 \text{ bits}$$

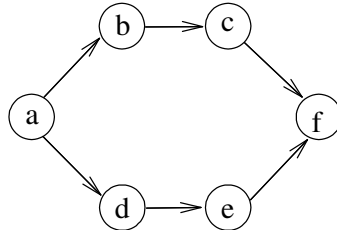
10. A queue is implemented using an array such that ENQUEUE and DEQUEUE operations are performed efficiently. Which one of the following statements is **CORRECT** (n refers to the number of items in the queue)?

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

- (C) The worst case time complexity for both operations will be  $\Omega(n)$
- (D) Worst case time complexity for both operations will be  $\Omega(\log n)$

Key: (A)

11. Consider the following directed graph:



The number of different topological orderings of the vertices of the graph is \_\_\_\_\_.

Key: (6)

Exp:

abcdef  
 adefbcf  
 abdcfe  
 adbcef  
 abdecf  
 adbcef

12. Consider the following C program.

```

void f(int, short);

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

```

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

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

Key: (D)

Exp: Here function f takes two arguments one is int and the other is short and its return type is void. So, in main function 'P' is a pointer to short and when we call f(i,\*p) there won't be any type checking error.

13. The worst case running times of Insertion sort, Merge sort and Quick sort, respectively, are:  
 (A)  $\Theta(n \log n)$ ,  $\Theta(n \log n)$ , and  $\Theta(n^2)$   
 (B)  $\Theta(n^2)$ ,  $\Theta(n^2)$ , and  $\Theta(n \log n)$   
 (C)  $\Theta(n^2)$ ,  $\Theta(n \log n)$ , and  $\Theta(n \log n)$   
 (D)  $\Theta(n^2)$ ,  $\Theta(n \log n)$ , and  $\Theta(n^2)$

Key: (D)

Exp: Merge sort  $\theta(n \log n)$  in all the cases

Quick sort  $\theta(n \log n)$  best case and  $\theta(n^2)$  worst cases

Insertion sort  $\theta(n)$  best case  $\theta(n^2)$  worst case

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

P: Minimum spanning tree of G does not change

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

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

Key: (A)

15. Consider the following C program.

```
#include<stdio.h>

void mystery(int *ptrA, int *ptrB) {
 int *temp;
 temp = ptrB;
 ptrB = ptrA;
 ptrA = temp;
}
```

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

The output of the program is \_\_\_\_\_.

**Key:** (2016)

**Exp:** Output is not affected by the function mystery () as it is just taking the address of a&b into ptr a & ptr b and contents of ptr a & ptr b are swapped leaving a&b as it is.

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

$S \rightarrow aS|bS|\epsilon$

- (A)  $\{a^n b^m \mid n, m \geq 0\}$
- (B)  $\{w \in \{a, b\}^* \mid w \text{ has equal number of } a\text{'s and } b\text{'s}\}$
- (C)  $\{a^n \mid n \geq 0\} \cup \{b^n \mid n \geq 0\} \cup \{a^n b^n \mid n \geq 0\}$
- (D)  $\{a, b\}^*$

**Key:** (D)

**Exp:** Given grammar generates all strings of a's and b's including null string

$$\therefore L = (a + b)^*$$

17. Which of the following decision problems are undecidable?

- I. Given NFAs  $N_1$  and  $N_2$ , is  $L(N_1) \cap L(N_2) = \Phi$ ?
- II. Given a CFG  $G = (N, \Sigma, P, S)$  and a string  $x \in \Sigma^*$ , does  $x \in L(G)$ ?
- III. Given CFGs  $G_1$  and  $G_2$ , is  $L(G_1) = L(G_2)$ ?
- IV. Given a TM  $M$ , is  $L(M) = \Phi$ ?
- (A) I and IV only      (B) II and III only
- (C) III and IV only      (D) II and IV only



Key: (C)

Exp: There is no known algorithm to check whether the language accepted by TM is empty. Similarly there is no algorithm to check whether language CFG's are equivalent.

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

- (A)  $(0 + 1)^*0011(0 + 1)^* + (0 + 1)^*1100(0 + 1)^*$
- (B)  $(0 + 1)^*(00(0 + 1)^*11 + 11(0 + 1)^*00)(0 + 1)^*$
- (C)  $(0 + 1)^*00(0 + 1)^* + (0 + 1)^*11(0 + 1)^*$
- (D)  $00(0 + 1)^*11 + 11(0 + 1)^*00$

Key: (B)

Exp: (a) contains 00 & 11 consecutively which is not the required condition.

(c) Doesn't guaranty that both 00 & 11 will be present in the string.

(d) Says string should start with 11 & ends with 00 or vice versa.

19. Consider the following code segment.

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

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

Key: (7)

20. Consider an arbitrary set of CPU-bound processes with unequal CPU burst lengths submitted at the same time to a computer system. Which one of the following process scheduling algorithms would 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

Key: (A)

Exp: SRTF is pre-emptive SJF which produces less average waiting time.

21. Which of the following is NOT a super key in a relational schema with attributes V , W , X , Y , Z and primary key V Y ?
- (A) V X Y Z                      (B) V W X Z                      (C) V W X Y                      (D) V W X Y Z

**Key:** (B)

**Exp:** Any superset of VY is a super key.

22. Which one of the following is NOT a part of the ACID properties of database transactions?
- (A) Atomicity                      (B) Consistency                      (C) Isolation                      (D) Deadlock-freedom

**Key:** (D)

**Exp:** 'D' means durability not deadlock freedom.

23. A database of research articles in a journal uses the following schema. (VOLUME, NUMBER, STARTPAGE, ENDPAGE, TITLE, YEAR, PRICE)
- The primary key is (VOLUME, NUMBER, STARTPAGE, ENDPAGE) and the following functional dependencies exist in the schema.

(VOLUME, NUMBER, STARTPAGE, ENDPAGE) → TITLE

(VOLUME, NUMBER → YEAR

(VOLUME, NUMBER, STARTPAGE, ENDPAGE) → PRICE

The database is redesigned to use the following schemas.

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

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

- (A) 1NF                      (B) 2NF                      (C) 3NF                      (D) BCNF

**Key:** (A)

**Exp:** candidate key is (volume, number, start page, end page)

(Volume number) → year is a partial dependency. So original table is in 1NF but not in 2NF

24. Which one of the following protocols is NOT used to resolve one form of address to another one?
- (A) DNS                      (B) ARP                      (C) DHCP                      (D) RARP

**Key:** (C)

Exp: Except DHCP, remaining all the protocols are used to resolve one form of address to another one.

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

- (i) HTTP                      (ii) FTP                      (iii) TCP                      (iv) POP3

(A) (i) and (ii) only

(B) (ii) and (iii) only

(C) (ii) and (iv) only

(D) (iv) only

Key: (C)

Exp: FTP and POP 3 are stateful application layer protocols

**Q. No. 26 – 55 Carry Two Marks Each**

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

Key: (10)

Exp:  $(x^3 + x^4 + x^5 + x^6 + \dots)^3$

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

$$= x^9 ((1-x)^{-1})^3$$

$$= x^9 (1-x)^{-3}$$

$$= x^9 \sum_{n=0}^{\infty} \frac{(n+1)(n+2)}{2} x^n$$

For coefficient of  $x^{12}$  put  $n=3 = \frac{4 \times 5}{2} = 10$

27. 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 \_\_\_\_\_.

Key: (198)

Exp: The recurrence relation can be written as  $a_n - a_{n-1} = 6n^2 + 2n \dots(i)$

Characteristic equation is  $m-1=0, m=1$

Complementary solution  $= a_n^{(1)} = C_1(1)^n = C_1$

Let the particular solution be  $a_n^{(b)} = (An^2 + Bn + c)n \dots(2)$

(∵ RHS is second degree polynomial and 1 is root)

By substituting  $a_n = (An^2 + Bn + C)n$  in (1) and solving  $A=2, B=4, C=2$

General solution is  $a_n = a_n^{(c)} + a_n^{(b)} = C_1 + (2n^2 + 4n + 2)n$

given  $a_1 = B \Rightarrow B = C_1 + B \Rightarrow C_1 = 0$

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

$$\Rightarrow [2(99)^2 + 4(99) + 2]99 = 2[(100-1)^2 + 2(100-1) + (100-1)] = 10^4(198) = K \times 10^4$$

$K=198$

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

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

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

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

Key: (2)

Exp: Given  $f(n) = f\left(\frac{n}{2}\right)$  if  $n$  is even

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

We can observe that  $f(1) = f(2) = f(3) = f(4) = f(6) = f(7) = \dots$

and  $f(5) = f(10) = f(15) = \dots$

Clearly, the range of  $f(x)$  will contain two distinct elements only.

29. 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) \_\_\_\_\_.

Key: (0.33)

Exp: From the given steps we can observe that probabilities of y are

$$\frac{1}{4}, \left(\frac{1}{4}\right)\left(\frac{1}{4}\right), \left(\frac{1}{4}\right)^2 \frac{1}{4}, \dots$$

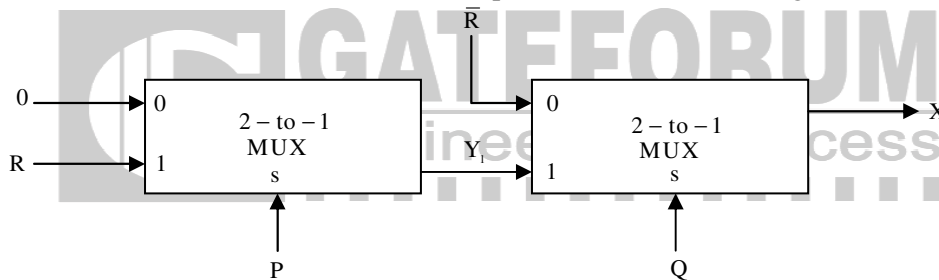
Required probability

$$= \frac{1}{4} + \left(\frac{1}{4} \times \frac{1}{4}\right) + \left(\left(\frac{1}{4}\right)^2 \times \frac{1}{4}\right) + \dots$$

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

$$= \frac{1}{4} \left(1 + \frac{1}{4} + \left(\frac{1}{4}\right)^2 + \dots\right) = \frac{1}{4} \left(\frac{1}{1 - \frac{1}{4}}\right) = \frac{1}{4} \times \frac{4}{3} = \frac{1}{3} = 0.33$$

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



The minimal sum of products form of the output X is

- (A)  $\bar{P}\bar{Q} + PQR$       (B)  $\bar{P}Q + QR$       (C)  $PQ + \bar{P}\bar{Q}R$       (D)  $\bar{Q}\bar{R} + PQR$

Key: (D)

Exp: Output of first multiplexer is  $Y_1 = \bar{P}0 + PR = PR$

Output of second multiplexer is  $X = \bar{Q}\bar{R} + QY_1 = \bar{Q}\bar{R} + QPR \Rightarrow \bar{Q}\bar{R} + PQR$

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

Key: (456)

Exp: DMA controller needs  $\Rightarrow \frac{29154\text{kB}}{2^{16}\text{ byte}} \Rightarrow 455.53125 = 456$

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

Key: (33.33)

Exp:

Old design  $t_p = 800$

New design  $t_p = 600$

Throughput =  $\frac{800 - 600}{600} \times 100\% = 33.33\%$

33. 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)  $\Theta(\sqrt{n})$                       (D)  $\Theta(n)$

Key: (B)

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

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

The missing loop condition is

- (A)  $a \neq n$                       (B)  $b \neq 0$                       (C)  $b > (a + 1)$                       (D)  $b \neq a$

Key: (D)

Exp: When a=b then P[a] will have the maximum value of the array

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

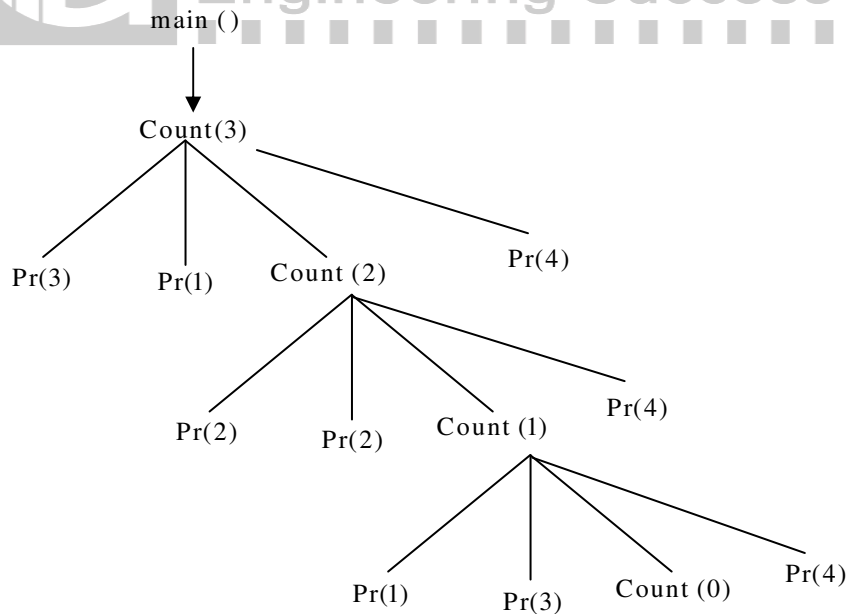
```
void count(int n){
 static int d=1;
 printf("%d ", n); printf("%d ", d); d++;
 if(n>1) count(n-1);
 printf("%d ", d);
}

void main(){
 count(3);
}
```

- (A) 3 1 2 2 1 3 4 4 4    (B) 3 1 2 1 1 1 2 2 2    (C) 3 1 2 2 1 3 4    (D) 3 1 2 1 1 1 2

Key: (A)

Exp:



Output is 31 22 13 4 4 4

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

```
a=3;
```

```
void n(x) {x = x * a; print(x);}

void m(y) {a = 1; a = y - a; n(a); print(a);}

void main() {m(a);}
```

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

**Key:** (D)

**Exp:** Dynamic scoping looks for the definition of free variable in the reverse order of calling sequence.

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

- (A) O(1)                                              (B) O(d) but not O(1)  
(C) O(2d) but not O(d)                      (D) O(d 2d) but not O(2d)

**Key:** (B)

**Exp:** Time complexity of heapification is O (height) =O(d)

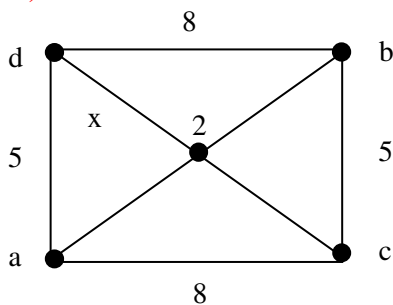
38. Consider the weighted undirected graph with 4 vertices, where the weight of edge {i, j} is given by the entry  $W_{ij}$  in the matrix W.

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

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

**Key:** (12)

**Exp:**



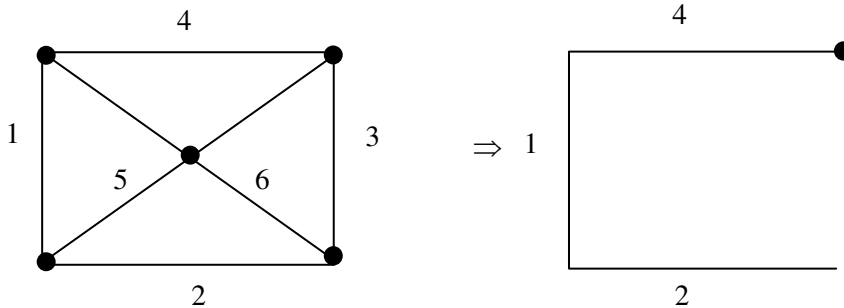
If  $x=12$  then the shortest path between d & c will contain edge with lable 'x'.



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

Key: (7)

Exp:



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

- I. If  $e$  is the lightest edge of some cycle in  $G$ , then every MST of  $G$  includes  $e$
  - II. If  $e$  is the heaviest edge of some cycle in  $G$ , then every MST of  $G$  excludes  $e$
- (A) I only      (B) II only      (C) both I and II      (D) neither I nor II

Key: (B)

41. Let  $Q$  denote a queue containing sixteen numbers and  $S$  be an empty stack.  $\text{Head}(Q)$  returns the element at the head of the queue  $Q$  without removing it from  $Q$ . Similarly  $\text{Top}(S)$  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
end

```

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

**Key:** (256)

**Exp.** Maximum number of iterations will be  $n^2 = 256$  [∵  $n = 16$ ]

42. Consider the following context-free grammars:

G1:  $S \rightarrow aSb, B \rightarrow bB$

G2:  $S \rightarrow aAb, A \rightarrow aAb \mid \epsilon, B \rightarrow bB \mid \epsilon$

Which one of the following pairs of languages is generated by G1 and G2, respectively?

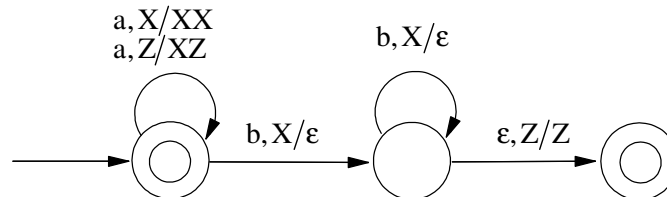
- (A)  $\{a^m b^n \mid m > 0 \text{ or } n > 0\}$  and  $\{a^m b^n \mid m > 0 \text{ and } n > 0\}$
- (B)  $\{a^m b^n \mid m > 0 \text{ and } n > 0\}$  and  $\{a^m b^n \mid m > 0 \text{ or } n \leq 0\}$
- (C)  $\{a^m b^n \mid m \geq 0 \text{ or } n > 0\}$  and  $\{a^m b^n \mid m > 0 \text{ and } n > 0\}$
- (D)  $\{a^m b^n \mid m \geq 0 \text{ or } n > 0\}$  and  $\{a^m b^n \mid m > 0 \text{ or } n > 0\}$

**Key:** (D)

**Exp:** Lagrange's generated by  $G_1 = a^* b^+$

Lagrange's generated by  $G_2 = a^+ b^* \setminus b^+$

43. Consider the transition diagram of a PDA given below with input alphabet  $\Sigma = \{a, b\}$  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)  $L = \{a^n b^n \mid n \geq 0\}$  and is not accepted by any finite automata
- (B)  $L = \{a^n \mid n \geq 0\} \cup \{a^n b^n \mid n \geq 0\}$  and is not accepted by any deterministic PDA
- (C) L is not accepted by any Turing machine that halts on every input
- (D)  $L = \{a^n \mid n \geq 0\} \cup \{a^n b^n \mid n \geq 0\}$  and is deterministic context-free

**Key:** (D)

44. Let X be a recursive language and Y be a recursively enumerable but not recursive language.

Let W and Z be two languages such that Y reduces to W, and Z reduces to X (reduction means the standard many-one reduction). Which one of the following statements is TRUE?

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

- (B) W can be recursive and Z is recursively enumerable.
- (C) W is not recursively enumerable and Z is recursive.
- (D) W is not recursively enumerable and Z is not recursive.

**Key:** (C)

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

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

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

**Key:** (9)

**Exp:**

$$\begin{aligned}
 &2 - 5 + 1 - 7 * 3 \\
 &2 - (5 + 1) - 7 * 3 \\
 &2 - 6 - 7 * 3 \\
 &2 - (6 - 7) * 3 \\
 &2 - (-1) * 3 \\
 &(2 + 1) * 3 \\
 &3 * 3 = 9
 \end{aligned}$$

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

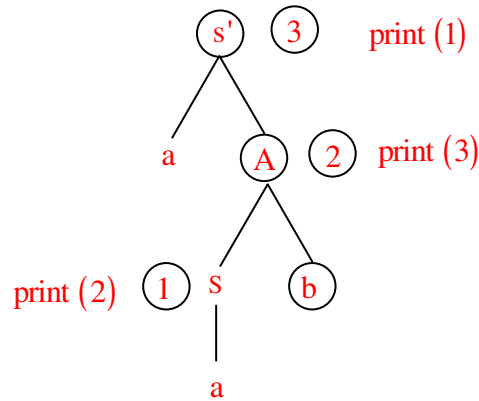
$$\begin{aligned}
 S &\rightarrow aA \{ \text{print 1} \} \\
 S &\rightarrow a \{ \text{print 2} \} \\
 A &\rightarrow Sb \{ \text{print 3} \}
 \end{aligned}$$

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

**Key:** (C)

**Exp:**



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

Key: (384)

Exp: Given LA = 40 bit = LAS =  $2^{40}$

Pagesize = 16KB

Page table Entry size (e) = 48 bits (or) 6 bytes

Page table size = ?

Size of the page table =  $n \times e$

$$\therefore \text{No. of pages (n)} = \frac{\text{LAS}}{\text{PS}} = \frac{2^{40}}{2^{14}} = 2^{26} = 64\text{M}$$

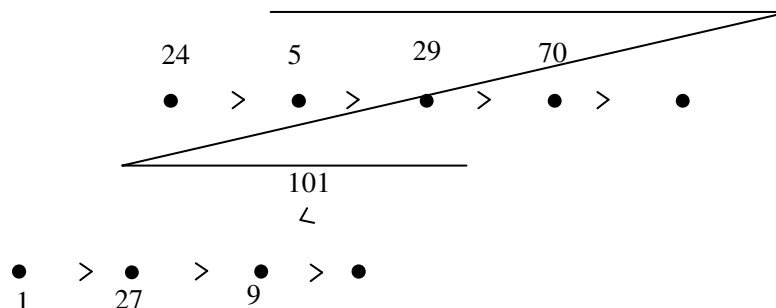
$$\therefore \text{Page table size} = 64 \times 6\text{B} = 384\text{MB}$$

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

Key: (346)

Exp: C-Look disc Scheduling

0 10 11 38 47 63 87 92 121 191 199



$$\therefore \text{Total Head movements} = 24 + 5 + 29 + 70 + 181 + 1 + 27 + 9 = 346$$

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

Key: (1)

Exp:  $a_1 a_2 \dots a_{20} a_1 a_2 \dots a_{20}$

|      |   |                           |
|------|---|---------------------------|
| LIFO | 0 | a <sub>1</sub>            |
|      | 1 | a <sub>2</sub>            |
|      | 2 | a <sub>3</sub>            |
|      | 3 | a <sub>4</sub>            |
|      | 4 | a <sub>5</sub>            |
|      | 5 | a <sub>6</sub>            |
|      | 6 | a <sub>7</sub>            |
|      | 7 | a <sub>8</sub>            |
|      | 8 | a <sub>9</sub>            |
|      | 9 | <del>a<sub>10</sub></del> |

~~a<sub>11</sub>~~ ~~a<sub>12</sub>~~ ~~a<sub>13</sub>~~ ~~a<sub>14</sub>~~ ~~a<sub>15</sub>~~ ~~a<sub>16</sub>~~ ~~a<sub>17</sub>~~ ~~a<sub>18</sub>~~ ~~a<sub>19</sub>~~ a<sub>20</sub>

For first  $a_1$  to  $a_{20}$  20 page fault

Now  $a_1$  to  $a_9$  Hit

again  $a_{10}$  to  $a_{20}$  replace only 9<sup>th</sup> position, so 11 page fault.

So total 31 page fault

|         |   |                           |
|---------|---|---------------------------|
| Optimal | 0 | a <sub>1</sub>            |
|         | 1 | a <sub>2</sub>            |
|         | 2 | a <sub>3</sub>            |
|         | 3 | a <sub>4</sub>            |
|         | 4 | a <sub>5</sub>            |
|         | 5 | a <sub>6</sub>            |
|         | 6 | a <sub>7</sub>            |
|         | 7 | a <sub>8</sub>            |
|         | 8 | a <sub>9</sub>            |
|         | 9 | <del>a<sub>10</sub></del> |

~~a<sub>11</sub>~~ ~~a<sub>12</sub>~~ ~~a<sub>13</sub>~~ ~~a<sub>14</sub>~~ ~~a<sub>15</sub>~~ ~~a<sub>16</sub>~~ ~~a<sub>17</sub>~~ ~~a<sub>18</sub>~~ ~~a<sub>19</sub>~~ a<sub>20</sub>

For first  $a_1$  to  $a_{20}$  20 fault

Next  $a_1$  to  $a_9$  Hit

again  $a_{10}$  to  $a_{19}$  replace any location from 0 to 9 for  $a_{20}$  Hit.

So total 30 page fault

Difference = 31 – 30 = 1

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

Code for  $P_i$ :

```
do {
 c[i]=1; t[i] = pmax(t[0],..,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

**Key:** (A)

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

Step 1.  $T$  acquires exclusive locks to  $O_1, \dots, O_k$  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 serializability

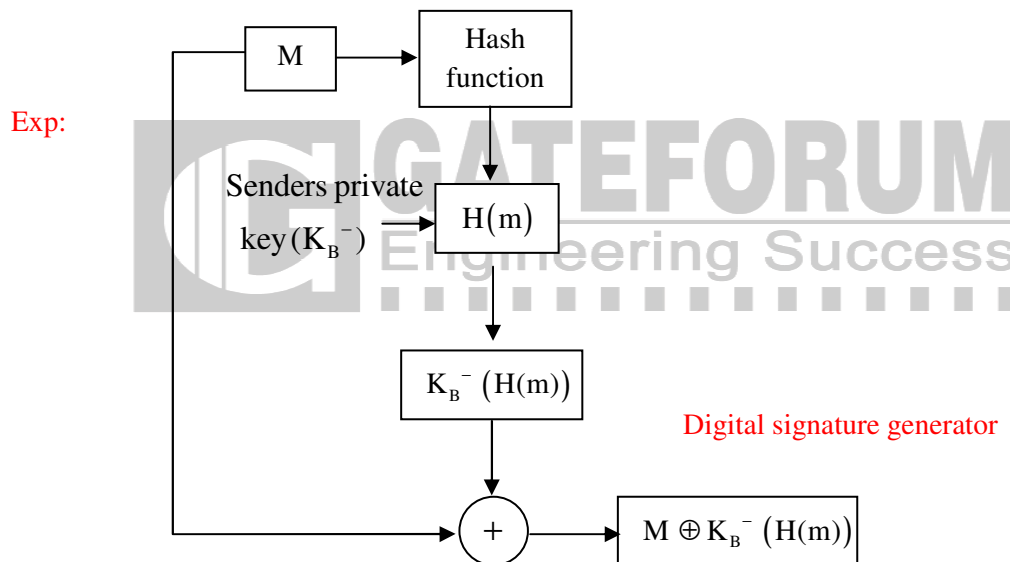
Key: (A)

Exp: 2PL ensures serializability and here as we are following linear order in acquiring the locks there will not be any deadlock.

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

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

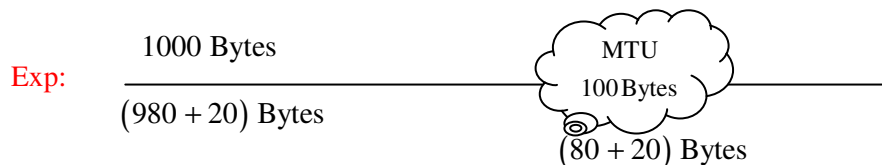
Key: (B)



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

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

Key: (13)



So, no. of fragments that are transferred in this scenario is 13.

54. 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. Tokens arrive at a rate to sustain output at a rate of 10 megabytes per second. The token bucket is currently full and the machine needs to send 12 megabytes of data. The minimum time required to transmit the data is \_\_\_\_\_ seconds.

Key: (1.2)

Exp: Given

$$C = 1\text{Mb}$$

$$\text{Max Output rate} = 20\text{Mbps}$$

$$\text{Arrival rate} = 10\text{Mbps}$$

$$\therefore \text{The minimum time required to transmit the data is } S = \frac{c}{m - \rho}$$

$$S = \frac{1\text{ Mb}}{20 - 10\text{Mbps}} = \frac{1}{10} = 0.1\text{ sec}$$

For 12Mb of data, S value becomes 1.2seconds

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

Key: (2500)

Exp: Frame size (L) = 1000bytes

$$\text{Sender side bandwidth (B}_S\text{)} = 80\text{kbps}$$

$$\text{Acknowledgement (L}_A\text{)} = 100\text{bytes}$$

$$\text{Receiver side bandwidth (B}_R\text{)} = 8\text{kbps}$$

$$T_p = 100\text{ms}$$

$$n = \frac{T_x}{T_x + T_{\text{ack}} + 2T_p}$$

$$(\text{msg}) T_x = \frac{L}{B_S} = \frac{1000\text{ Bytes}}{10 \times 10^3 \text{ BPS}} = 100\text{ms}$$

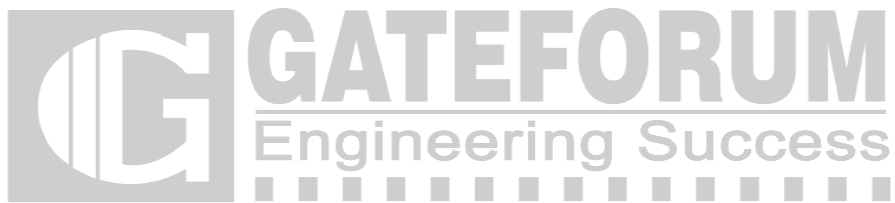
$$(\text{Ack}) T_A = \frac{L_A}{B_R} = \frac{100 \text{ Bytes}}{1 \times 10^3 \text{ BPS}} = 100\text{ms}$$

$$T_p = 100\text{ms}$$



$$\therefore \text{Channel Utilization} = \frac{T_n}{T_n + T_{\text{ack}} + 2T_p} = \frac{100\text{ms}}{100\text{ms} + 100\text{ms} + 200\text{ms}} = \frac{1}{4}$$

$$\therefore \text{Throughput} = \eta \times B = \frac{1}{4} \times 10 \times 10^3 = 2.5 \text{ Kbps (or 2500 Bps)}$$



**General Aptitude**

**Q. No. 1 – 5 Carry One Mark Each**

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

**Key:** (B)

2. 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 phase in the above sentence.
- (A) put up with                      (B) put in with                      (C) put down to                      (D) put up against

**Key:** (A)

3. Find the odd one in the following group of words.  
Mock, deride, praise, jeer
- (A) mock                      (B) deride                      (C) praise                      (D) jeer

**Key:** (C)

4. Pick the odd one from the following options.
- (A) CADBE                      (B) JHKIL                      (C) XVYWZ                      (D) ONPMQ

**Key:** (D)

5. In a quadratic function, the value of the product of the roots  $(\alpha, \beta)$  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)  $4^{n-1}$

**Key:** (B)

**Exp:** Given  $\alpha\beta = 4$

$$\begin{aligned} \frac{\alpha^n + \beta^n}{\alpha^{-n} + \beta^{-n}} &= \frac{\alpha^n + \beta^n}{\frac{1}{\alpha^n} + \frac{1}{\beta^n}} \\ &= \frac{(\alpha^n + \beta^n) \alpha^n \beta^n}{(\alpha^n + \beta^n)} \\ &= (\alpha\beta)^n = 4^n \end{aligned}$$

**Q. No. 6 – 10 Carry Two Marks Each**

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

**Key:** (A)

**Exp:** F → Facebook, W → WhatsApp, E → Total faculties

given

$$n(E) = 150, n(\overline{F \cup W}) = 30$$

$$n(F \cup W) = n(E) - n(\overline{F \cup W}) = 150 - 30$$

$$n(F \cup W) = 120$$

$$n(f \cup w) = n(f) + [n(w) - n(F \cap w)]$$

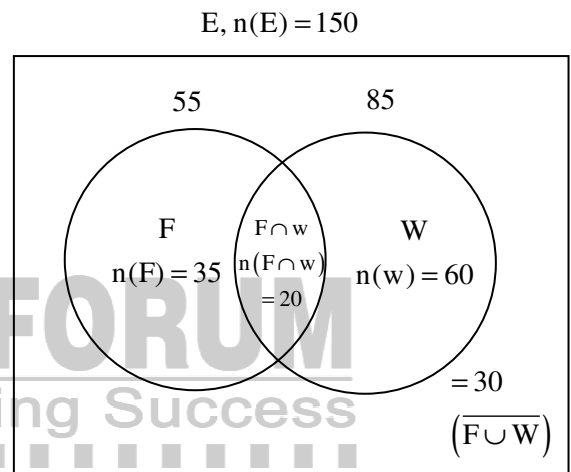
$$120 = n(F) + 85$$

$$n(F) = 120 - 85 = 35$$

$$55 = n(F) + n(F \cap W)$$

$$n(F \cap w) = 55 - n(F) = 55 - 35 = 20$$

$$n(w) = 85 - 20 = 65$$



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

**Key:** (D)

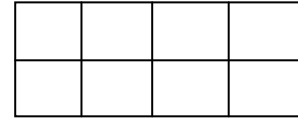
8. All hill-stations have a lake. Ooty has two lakes.
- Which of the statement(s) below is/are logically valid and can be inferred from the above sentences?
- (i) Ooty is not a hill-station

- (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)

Key: (D)

9. In a  $2 \times 4$  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



Key: (C)

Exp: 1: (AEOK)

2: (AEJF), (FJOK)

4: (ABLK), (BCML), (CDNM), (DEON)

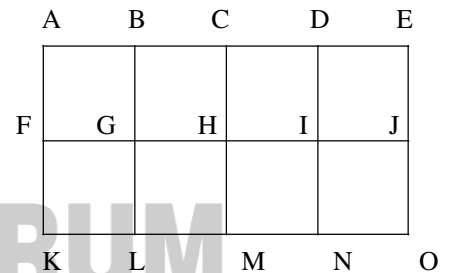
2: ACMK, ADNK | 2: ECMD, EBLO | 2: ACHF, ADIF

2: ECHJ, EBGJ | 2: FHMK, FINK | 2: JHMD, JGLO

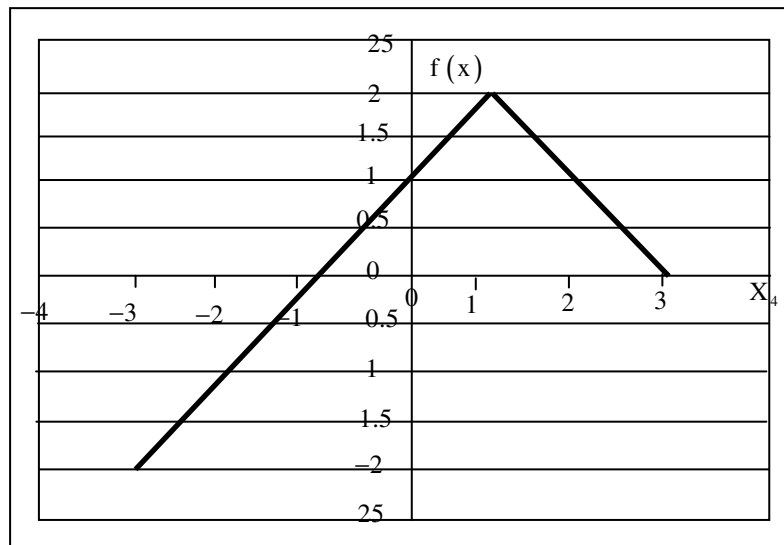
1: BDNL | 2: BDIG, GINL

8: ABGF, BCHJ, CDIH, EDI, FGLK, GHML, HINM

Total = 1+2+4+2+2+2+2+2+2+1+2+8=30



- 10.



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

Key: (C)

Exp: Substituting the coordinates of the straight lines and checking all the four options given, we get the correct option as C which is  $f(x) = 2 - |x - 1|$

## Computer Science Engineering

## Q. No. 1 – 25 Carry One Mark Each

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 \_\_\_\_\_.

Key: (4)

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 \_\_\_\_\_.

Key: (9)

Exp: If  $f(x)$  is polynomial of degree  $n$ ,  
then  $g(x) = f'(x)$  is polynomial of degree  $n$ ,

$\Rightarrow f(x) + f(-x)$  is polynomial of degree  $n$ ,

But given  $f(x) + f(-x)$  is polynomial of degree 10.

$\therefore n = 10$ .

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

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

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

Key: (4)

Exp: Any planar graph is four-colourable.

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

Key: (C)

Exp: I is not correct

$$x+y+z=1$$

$$x+y+z=0$$

Has no solution, when no of equations is less than no of variables.

II is not correct

Eg:

$$x - 2y = 2$$

$$2x + 8y = 16$$

$$x + y = 5$$

Has a solution (x=4, y=1).

III is correct

Eg:

$$x+y = 4,$$

$$x+2y=0$$

Has solutions (x=6, y=-2)



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 \_\_\_\_\_.

Key: (0.55)

Exp:  $E_1$  –event of selecting type-I bulb

$E_2$ -event of selecting type-II bulb

A- Event of selecting a bulb lasts more than 100 hours

$$\text{Given } P(E_1) = 0.5, P(E_2) = 0.5$$

$$P(A / E_1) = 0.7, P(A / E_2) = 0.4$$

Required probability,

$$P(A) = P(E_1)P(A / E_1) + P(E_2)P(A / E_2)$$

$$= 0.5 \times 0.7 + 0.5 \times 0.4$$

$$= 0.55$$

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

Key: (0.125)

Exp: Given that 1,2,4 are eigen values of A>

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

$$\text{Now, } |(A^{-1})^+| = |A^{-1}|^T = |A^{-1}| = \frac{1}{8} = 0.125$$

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 \_\_\_\_\_.

Key: (-1)

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

Key: (C)

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 \_\_\_\_\_.

Key: (1)

Exp:

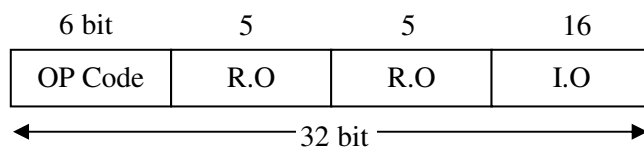
$$X = -2^{16-1} \text{ to } +2^{16-1} - 1$$

$$Y = -2^{16-1} - 1 \text{ to } +2^{16-1} - 1$$

$$\text{So } [X - Y = 1]$$

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 \_\_\_\_\_.

Key: (16)

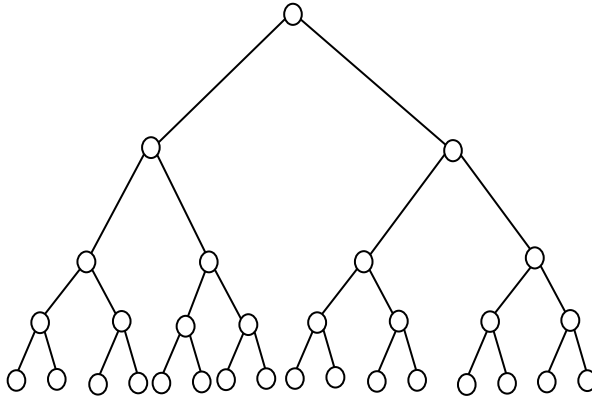


So 16 bit for immediate operand field

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 \_\_\_\_\_.

**Key:** (31)

**Exp:**



→ Required vertex is 31<sup>st</sup> vertex.

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);
}
```

**Key:** (30)

**Exp:**  $i$ 's address and  $j$ 's value are passed to the function of  $f$ .  $f$  modifies  $i$  value to 20.  $j$  value remains same (as its value is passed not the reference).

∴  $i + j = 30$  will be printed

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. 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

**Key:** (D)

**Exp:** As input is already sorted quick sort runs in  $\theta(n^2)$  & insertion sort runs in  $\theta(n)$ .

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

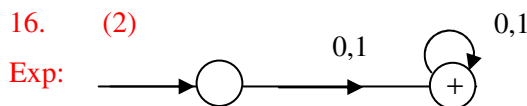
**Key:** (C)

**Exp:** Floyd - warshall algorithm follows dynamic programming paradigm.

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)  $\Theta(N^2 \log N)$

**Key:** (C)

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



17. Language  $L_1$  is defined by the grammar:  $S_1 \rightarrow aS_1b \mid \epsilon$   
 Language  $L_2$  is defined by the grammar:  $S_2 \rightarrow abS_2 \mid \epsilon$   
 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

**Key:** (C)

**Exp:**  $L_1 = \{a^n b^n / n \geq 1\}$  CFL but not regular

$L_2 = (ab)^+$  regular

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

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

III.  $L_1^* \cap L_2$  is context-free

IV.  $L_1 \cup \bar{L}_2$  is context-free

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

**Key:** (D)

**Exp:**  $L_1 \cup \bar{L}_2$  is recursive but not CFL as CFL's are not closed under complementation.

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 |

**Key:** (B)

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)

Key: (D)

Exp: If page fault rate increases even when the number of allocated frames increases, then that situation is called “Belady’s Anomaly”. It was happening with only FIFO among the given options.

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. (A)

Exp: In both B& B+ trees all the leaf nodes will be at same level will be at same level.

22. Suppose a database schedule  $S$  involves transactions  $T_1, \dots, T_n$ . 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

Key: (A)

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

Key: (A)

Exp: In digital signature generation process using senders private key we can encrypt the message and in verification process using senders public key we can decrypt the message.

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.

Key: (D)

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

**Key:** (C)

**Exp:** When a browser requests a webpage from a remote server then that requests (URL address) will be mapped to IP address using DNS, then TCP synchronization takes place after that HTTP verify whether it is existed in the web server or not.

**Q. No. 26 – 55 Carry Two Marks Each**

26. 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

**Key:** (B)

**Exp:** 26. It is reflexive as every ordered pair is related to itself

$(a,b) R (a,b)$  since  $a \leq a$  or  $b \leq b$

It is not transitive as  $(2,4)R(3,2)$  &  $(3,2) R(1,3)$  but  $(2,4) R (1,3)$

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

**Key:** (D)

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

Key: (B)

Exp: We can solve the given problems by taking an undirected graph with 23 vertices and 9 of these with degree 3.

Assume that if two compounds react with each other, then there exists an edge between the vertices.

Given that 9 vertices of degree 3 (odd)

By degree theorem atleast one of the remaining vertices must have odd degree ( $\because$  No. of vertices of odd degree is always even).

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

Key: (4)

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.

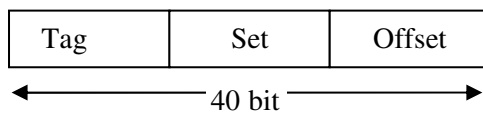
Key: (28)

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 \_\_\_\_\_.

Key: (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.

Key: (24)

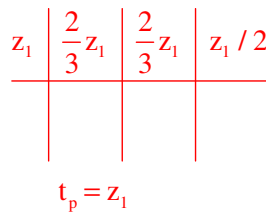
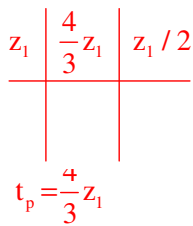


Tag bits =  $40 - (19 - 3) = 24$  bits

33. Consider a 3 GHz (gigahertz) processor with a three-stage pipeline and stage latencies  $\tau_1$ ,  $\tau_2$ , and  $\tau_3$  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.

Key: (4)

Exp: Pipeline New Pipeline



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 \_\_\_\_\_.

Key: (8)

Exp:  $n^{\text{th}}$  smallest element will be present within 'n' levels of min heap

35. The following function computes XY 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)  $XY = ab$  (B)  $(res * a)Y = (res * X)b$
- (C)  $XY = res * ab$  (D)  $XY = (res * a)b$

Key: (C)

36. Consider the following New-order strategy for traversing a binary tree:

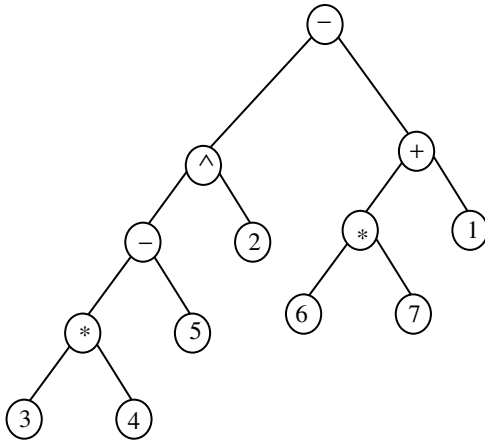
- Visit the root;
- Visit the right subtree using New-order;
- Visit the left subtree using New-order;

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)  $1\ 7\ 6\ *\ +\ 2\ 5\ 4\ 3\ *\ -\ ^\ -$

**Key:** (C)

**Exp:** Given is the post fix expression the expression tree given below.



New-order of above expression tree is

$- + 1 * 7 6 \wedge 2 - 5 * 4 3$

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.

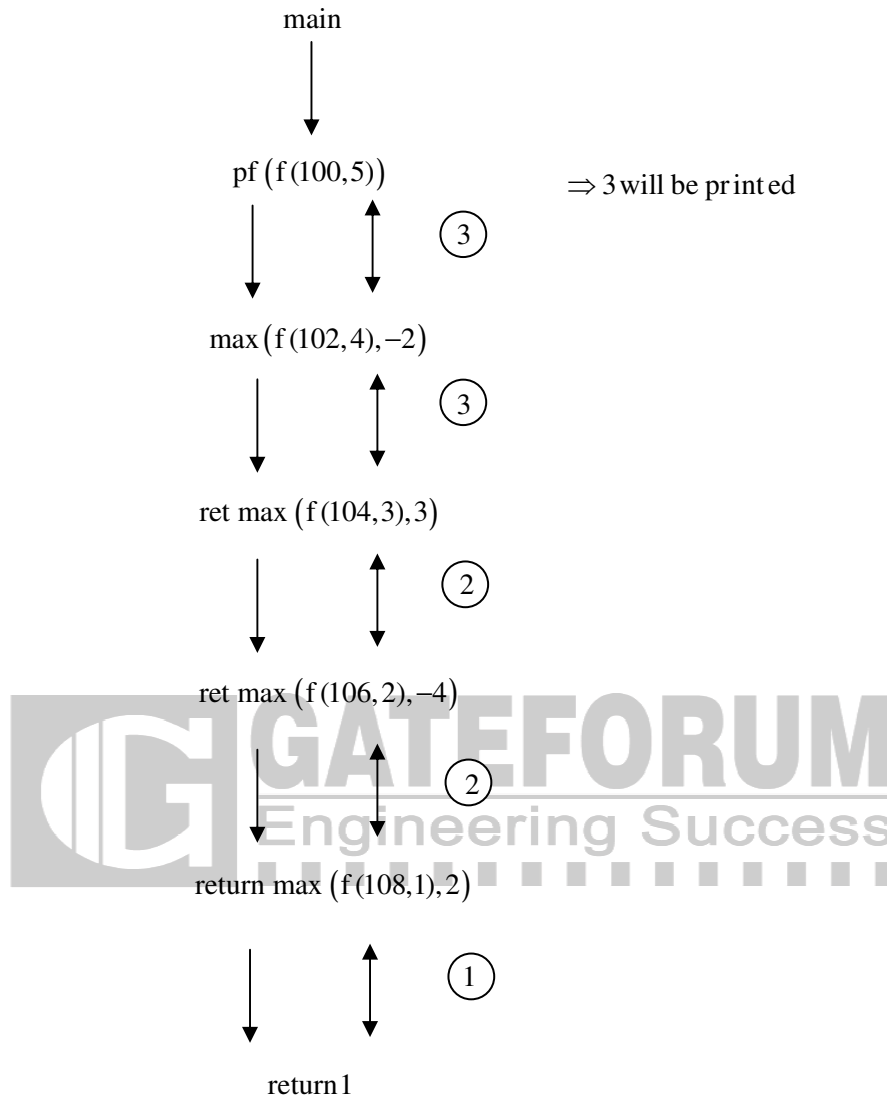
The value printed by this program is \_\_\_\_\_.

**Key:** (3)

**Exp:** Assume base address of array a is 100.

|   |   |   |   |   |
|---|---|---|---|---|
| 3 | 5 | 2 | 6 | 4 |
|---|---|---|---|---|

100      102      104      106      108



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  $10 \times 5,$  respectively. The minimum number of scalar multiplications required to find the product  $A_1 A_2 A_3 A_4$  using the basic matrix multiplication method is \_\_\_\_\_.

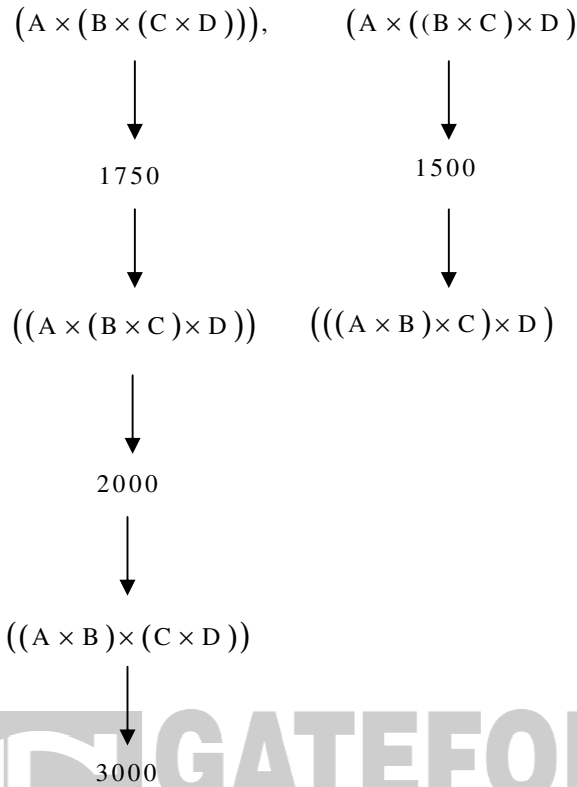
**Key:** (1500)

**Exp:** No. of ways of multiplying the chain of matrices =  $\frac{2^m C_m}{m+1}$

Where  $m =$  no. of multiplications (not matrices)

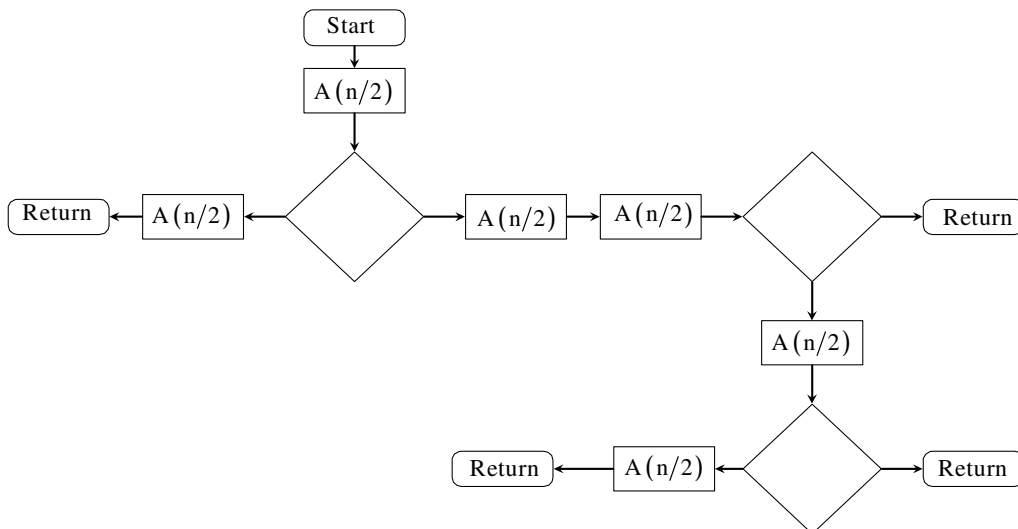
$$\Rightarrow \frac{{}^6 C_3}{3+1} = 5$$





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<sup>α</sup>), then the least possible value (accurate up to two decimal positions) of α is \_\_\_\_\_.

Flowchart for Recursive Function A(n)



Key: (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.

Key: (64)

Exp:  $64, 2^6 = 64$

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)  $\Theta(n^4)$

Key: (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  $\Sigma^*$ .

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

Key: (B)

Exp: II is false, if all the states of DFA are accepting states then  $L = \Sigma^*$

II is true because we can have regular language  $A = [ ]$  [Empty language] which satisfies the condition.

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.

Key: (B)

Exp:  $L_1 \rightarrow$  we can push a's & b's and for each c we can pop one item from stack, one c's are over stack should be empty.

$\therefore L_1 = CFL$

For  $L_2$ , we can't build PDA [a's & b's should be equal & C' should be double of that count]

44. Consider the following languages.

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

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

$L_3 = \{ \langle M \rangle \mid M \text{ accepts } \epsilon \}$ ,

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

Key: (C)

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

- |                                                                           |                                                                                                               |
|---------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------|
| (A) $S \rightarrow AB$<br>$A \rightarrow Aa \mid b$<br>$B \rightarrow c$  | (B) $S \rightarrow Ab \mid Bb \mid c$<br>$A \rightarrow Bd \mid \epsilon$<br>$B \rightarrow e$                |
| (C) $S \rightarrow Aa \mid B$<br>$A \rightarrow Bb \mid Sc \mid \epsilon$ | (D) $S \rightarrow Aa \mid Bb \mid c$<br>$A \rightarrow Bd \mid \epsilon$<br>$B \rightarrow Ae \mid \epsilon$ |

Key: (B)

Exp (C) & (D) are having indirect left recursion.

46. A student wrote two context-free grammars  $G_1$  and  $G_2$  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 $G_1$                  | Grammar $G_2$                  |
| $D \rightarrow \text{int } L;$ | $D \rightarrow \text{int } L;$ |
| $L \rightarrow \text{id } [E$  | $L \rightarrow \text{id } E$   |
| $E \rightarrow \text{num}]$    | $E \rightarrow E [\text{num}]$ |
| $E \rightarrow \text{num}] [E$ | $E \rightarrow [\text{num}]$   |

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

Key: (A)

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 <sub>1</sub> | 0            | 10         |
| P <sub>2</sub> | 3            | 6          |
| P <sub>3</sub> | 7            | 1          |
| P <sub>4</sub> | 8            | 3          |

The average turnaround time of these processes is \_\_\_\_\_ milliseconds.

Key: (8.25)

Exp:

| Process        | Arrival Time | Burst Time | CT | TAT  |
|----------------|--------------|------------|----|------|
| P <sub>1</sub> | 0            | 10         | 20 | 20   |
| P <sub>2</sub> | 3            | 6          | 10 | 7    |
| P <sub>3</sub> | 7            | 1          | 8  | 1    |
| P <sub>4</sub> | 8            | 3          | 13 | 5    |
| Total          |              |            |    | 8.25 |

Gant chart

| P <sub>1</sub> | P <sub>2</sub>     | P <sub>3</sub>     | P <sub>4</sub>     | P <sub>4</sub>     | P <sub>1</sub> |    |
|----------------|--------------------|--------------------|--------------------|--------------------|----------------|----|
| 0              | 3                  | 7                  | 8                  | 10                 | 13             | 20 |
|                | P <sub>1</sub> - 7 | P <sub>1</sub> - 7 | P <sub>1</sub> - 7 | P <sub>1</sub> - 7 |                |    |
|                | P <sub>2</sub> - 6 | P <sub>2</sub> - 2 | P <sub>2</sub> - 2 | P <sub>4</sub> - 3 |                |    |
|                |                    | P <sub>3</sub> - 1 | P <sub>4</sub> - 3 |                    |                |    |

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.

Key: (C)

Exp: The given solution for two process synchronization using “Turn” variable, satisfies the only mutual exclusion and bounded waiting but progress is violated.

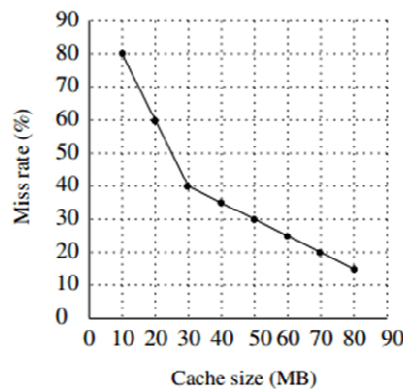
49. Consider a non-negative counting semaphore S. The operation P(S) decrements S, and V(S) increments S. During an execution, 20 P(S) operations and 12 V(S) operations are issued in some order. The largest initial value of S for which at least one P(S) operation will remain blocked is \_\_\_\_\_.

Key: (7)

Exp:  $S = -20 + 12 = -8$

∴ The largest initial value of S for which atleast one P(S) operation remains blocked is 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 1ms and to read a block from the disk is 10ms. 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.

Key: (30)

51. Consider the following database schedule with two transactions, T1 and T2.

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

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

**Key:** (C)

**Exp:** No transaction is reading the data item written by some other transaction. So the given schedule is cascadeless.

52. Consider the following database table named water\_schemes:

| Water_schemes |               |          |
|---------------|---------------|----------|
| Scheme_no     | District_name | Capacity |
| 1             | Ajmeer        | 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

```

**Key:** (2)

**Exp:** Two names Bikaner & churu will be selected.

53. A network has a data transmission bandwidth of  $20 \times 10^6$  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.

**Key:** (200)

**Exp:**  $B = 2 \times 10^6$  bps

$T_p = 40 \mu s$

$$L = ?$$

$$L = 2 \times T_p \times B \Rightarrow L = 2 \times 40 \times 10^{-6} \times 20 \times 10^6 \\ = 1600 \text{ bits (or) } 200 \text{ bytes}$$

$$L = 200 \text{ bytes}$$

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

Key: (B)

Exp: In collision avoidance, we use RTS-CTS mechanism but not in collision detection, only statement II is false.

55. Consider a  $128 \times 10^3$  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 \_\_\_\_\_.

Key: (4)

Exp:  $B = 128 \text{ kbps}$

$$T_p = 150 \text{ ms}$$

$$L = 1 \text{ KB}$$

$$\eta = 100\% \Rightarrow 1 = \frac{w}{1 + 2a}$$

$$T_x = \frac{L}{B} = \frac{8 \times 10^3}{128 \times 10^3} = 62.5 \text{ ms}$$

$$a = \frac{T_p}{T_x} = \frac{150 \text{ ms}}{62.5 \text{ ms}} = 2.4$$

$$\Rightarrow w = 1 + 2a \Rightarrow \frac{2^n}{2} = 1 + 2(2.4) \Rightarrow \frac{2^n}{2} = 5.8 \Rightarrow 2^n = 11.65$$

$$\Rightarrow 2^n = 11.6 \approx 12 \approx 2^4$$

$$n = 4$$

**Computer Science Engineering**

**Q. No. 1 – 25 Carry One Mark Each**

1. Let  $X$  be a Gaussian random variable mean 0 and variance  $\sigma^2$ . Let  $Y = \max(X, 0)$  where  $\max(a, b)$  is the maximum of  $a$  and  $b$ . The median of  $Y$  is \_\_\_\_\_.

**Key: (0)**

**Exp:** 'X' is Gaussian random variable

$$\Rightarrow X \sim N(0, \sigma^2) \text{ for } -\infty < x < \infty$$

$$\text{Given } y = \max(x, 0)$$

$$= \begin{cases} 0 & \text{if } -\infty < x \leq 0 \\ x & \text{if } 0 < x < \infty, \text{ is a random variable} \end{cases}$$

Since median is positional average

Therefore, median of  $Y$  is '0'.

2. Consider the Karnaugh map given below, where  $x$  represents "don't care" and blank represents 0.

|    |    |    |    |    |    |
|----|----|----|----|----|----|
|    | ba | 00 | 01 | 11 | 10 |
| dc |    |    |    |    |    |
|    | 00 |    | x  | x  |    |
|    | 01 | 1  |    |    | x  |
|    | 11 | 1  |    |    | 1  |
|    | 10 |    | x  | x  |    |

Assume for all inputs  $(a, b, c, d)$  the respective complements  $(\bar{a}, \bar{b}, \bar{c}, \bar{d})$  are also available. The above logic is implemented 2-input NOR gates only. The minimum number of gates required is \_\_\_\_\_.

**Key: (1)**

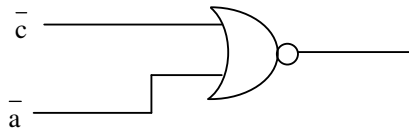
**Exp:**

|    |    |    |    |    |    |
|----|----|----|----|----|----|
|    | ba | 00 | 01 | 11 | 10 |
| dc |    |    |    |    |    |
|    | 00 |    | x  | x  |    |
|    | 01 | 1  |    |    | x  |
|    | 11 | 1  |    |    | 1  |
|    | 10 |    | x  | x  |    |



$$F(a,b,c,d) = \overline{a}c \Rightarrow \overline{a}c = a + c \quad (\overline{x+y} = \overline{x} \cdot \overline{y})$$

$$= \overline{a+c}$$



Only 1 NOR gate required

3. The statement  $(\neg p) \Rightarrow (\neg q)$  is logically equivalent to which of the statements below?

I.  $p \Rightarrow q$

II.  $q \Rightarrow p$

III.  $(\neg q) \vee p$

IV.  $(\neg p) \vee q$

(A) I only

(B) I and IV only

(C) II only

(D) II and III only

**Key:** (D)

**Exp:** By rule of contrapositive,

$$\neg p \rightarrow \neg q \Leftrightarrow q \rightarrow p$$

$$q \rightarrow p \Leftrightarrow \neg q \vee p$$



4. Consider the following table:

| Algorithms |                | Design Paradigms |                     |
|------------|----------------|------------------|---------------------|
| P.         | Kruskal        | i.               | Divide and Conquer  |
| Q.         | Quicksort      | ii.              | Greedy              |
| R.         | Floyd-Warshall | iii.             | Dynamic Programming |

Match the algorithms to the design paradigms they are based on.

(A) P-(ii), Q-(iii), R-(i)

(B) P-(iii), Q-(i), R-(ii)

(C) P-(ii), Q-(i), R-(iii)

(D) P-(i), Q-(ii), R-(iii)

**Key:** (C)

**Exp:** Kruskal's algorithm follows greedy approach in order to find MST of a connected graph. Quick sort follows divide and conquer strategy. Floyd Warshal algorithm is used to find the shortest path between every pair of vertices and it follows dynamic programming strategy.

5. A sender S sends a message m to receiver R, which is digitally signed by S with its private key. In this scenario, one or more of the following security violations can take place.

I. S can launch a birthday attack to replace m with a fraudulent message.

II. A third party attacker can launch a birthday attack to replace m with a fraudulent message.

III. R can launch a birthday attack to replace m with a fraudulent message.

Which of the following are possible security violations?

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

**Key:** (B)

**Exp:** Sender can launch a Birthday Attack to replace with fraudulent message, because he has the signature and he can decrypt the signature by his own public key and gets the hash value. With that same hash value, he can create another message and can be sent instead of original. Hence option(B) is correct.

6. Consider the following grammar.

|                            |
|----------------------------|
| $P \rightarrow xQRS$       |
| $Q \rightarrow yz z$       |
| $R \rightarrow w \epsilon$ |
| $S \rightarrow y$          |

What is FOLLOW (Q) ?

- (A) {R}      (B) {w}      (C) {w, y}      (D) {w, \$}

**Key:** (C)

**Exp:** FOLLOW(Q) is FIRST(R) hence

$FIRST(R) = \{w, \epsilon\}$

We add 'w' in FOLLOW(Q) and for  $\epsilon$  we calculate FIRST(S)

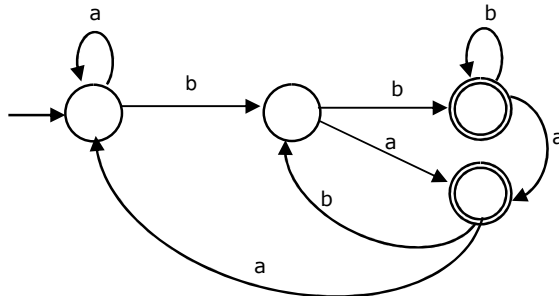
$FIRST(S) = \{y\}$

FOLLOW(Q) is {w ,y}

7. Consider the language L given by the regular expression  $(a + b)^* b(a+b)$  over the alphabet {a, b}. The smallest number of states needed in a deterministic finite-state automation (DFA) accepting L is \_\_\_\_\_.

**Key:** (4)

**Exp:** The regular expression can be described as "All strings over {a, b} ending with "ba" or "bb". The minimal DFA accepting L is having 4 states:



8. Consider a two-level cache hierarchy with L1 and L2 caches. An application incurs 1.4 memory accesses per instruction on average. For this application, the miss rate of L1 cache

0.1, the L2 cache experiences, on average, 7 misses per 1000 instructions. The miss rate of L2 expressed correct to two decimal places is \_\_\_\_\_.

**Key: (0.05)**

**Exp:** 
$$\left. \begin{array}{l} \text{Number of memory access} \\ \text{in 1000 instructions} \end{array} \right\} = 1.4 \times 1000 = 1,400$$

$$\therefore \text{Miss Rate} = \frac{7}{1400 \times 0.1} = 0.05$$

9. Consider the following CPU processes with arrival times (in milliseconds) and length of CPU burst (in milliseconds) as given below:

| Process | Arrival time | Burst time |
|---------|--------------|------------|
| P1      | 0            | 7          |
| P2      | 3            | 3          |
| P3      | 5            | 5          |
| P4      | 6            | 2          |

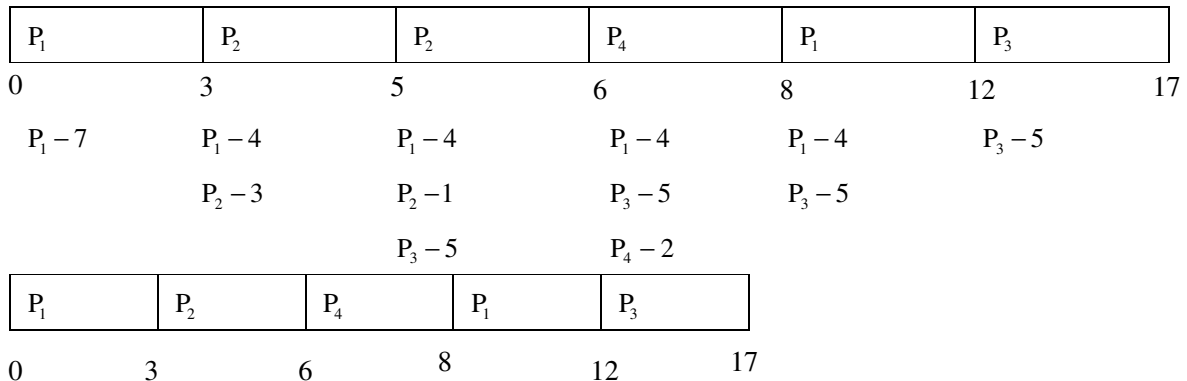
If the pre-emptive shortest remaining time first scheduling algorithm is used to schedule the processes., then the average waiting time across all processes is \_\_\_\_\_ milliseconds.

**Key: (3)**

**Exp:**

| PID            | AT | BT | CT | TAT | WT |
|----------------|----|----|----|-----|----|
| P <sub>1</sub> | 0  | 7  | 12 | 12  | 5  |
| P <sub>2</sub> | 3  | 3  | 6  | 3   | 0  |
| P <sub>3</sub> | 5  | 5  | 17 | 12  | 7  |
| P <sub>4</sub> | 6  | 2  | 8  | 2   | 0  |

**Gantt chart:**



$$\therefore \text{Average waiting time} = \frac{5+0+7+0}{4} = \frac{12}{4} = 3 \text{ms}$$

10. Threads of a process share
- (A) global variable but not heap.
  - (B) heap but not global variables.
  - (C) neither global variables nor heap.
  - (D) Both heap and global variables.

**Key:** (D)

**Exp:** Threads of a process can share all resources except stack and register set.

11. Let  $c_1, \dots, c_n$  be scalars, not all zero, such that  $\sum_{i=1}^n c_i a_i = 0$  where  $a_i$  are column vectors in  $\mathbb{R}^n$ . Consider the set of linear equations  $Ax = b$

where  $A = [a_1, \dots, a_n]$  and  $b = \sum_{i=1}^n a_i$ . The set of equations has

- (A) a unique solution at  $x = J_n$  where  $J_n$  denotes a  $n$ -dimensional vector of all 1
- (B) no solution
- (C) infinitely many solutions
- (D) finitely many solutions

**Key:** (C)

**Exp:** Since the scalars are not all zero

$\therefore$  The column vectors  $a_i$  for  $i=1, 2, \dots, n$  are linearly dependent

$\Rightarrow |A| = 0$  and  $b = \sum_{i=1}^n a_i \Rightarrow Ax = b$  has infinitely many solutions.

12. Consider the C code fragment given below.

```
typedef struct node {
 int data;
 node* next ;
} node;
void join (node* m, node* n) {
 node* p=n ;
 while (p->next !=NULL){
 p = p -> next ;
 }
 p->next = m;
}
```

Assuming that  $m$  and  $n$  point to valid NULL- terminated linked lists, invocation of join will

- (A) append list  $m$  to the end of list  $n$  for all inputs.
- (B) either cause a null pointer dereference or append list  $m$  to the end of list  $n$ .
- (C) cause a null pointer dereference for all inputs.
- (D) append list  $n$  to the end of list  $m$  for all inputs.

**Key: (B)**

**Exp:** While loop in Join Procedure moves the pointer 'p' to the last node of the list "n". And at the last statement, we are initializing the next of the last node of list n to start of list "m".

But in some cases it may dereference to null pointer.

13. The n-bit fixed-point representation of an unsigned real number real X uses  $f$  bits for the fraction part. Let  $i = n - f$ . The range of decimal values for X in this representation is

- (A)  $2^{-f}$  to  $2^i$       (B)  $2^{-f}$  to  $(2^i - 2^{-f})$       (C) 0 to  $2^i$       (D) 0 to  $(2^i - 2^{-f})$

**Key: (D)**

$$i = n - f . f$$

**Exp:** Max value = 111.....1(i times).111.....1(f times)

$$= 2^i - 1 + \left( \frac{1}{2} + \frac{1}{2^2} + \dots + \frac{1}{2^f} \right) = 2^i - 1 + \frac{2^f - 1}{2^f} = 2^i - 2^{-f}$$

$$\therefore 0 \text{ to } (2^i - 2^{-f})$$

14. Consider the following intermediate program in three address code

p = a - b

q = p \* c

p = u \* v

q = p + q

Which one of the following corresponds to a *static single assignment* form of the above code ?

(A)  $p_1 = a - b$

$q_1 = p_1 * c$

$p_1 = u * v$

$q_1 = p_1 + q_1$

(B)  $p_3 = a - b$

$q_4 = p_3 * c$

$p_4 = u * v$

$q_5 = p_4 + q_4$

(C)  $p_1 = a - b$

$q_1 = p_2 * c$

$p_3 = u * v$

$q_2 = p_4 + q_3$

(D)  $p_1 = a - b$

$q_1 = p * c$

$p_2 = u * v$

$q_2 = p + q$

**Key: (B)**

**Exp:** a-code violates condition for static single assignment since  $p_1$  is initialized twice

c-  $p_2, p_4, \&q_3$  are not initialized anywhere

d-  $q_2 = p + q$  is incorrect code

15. Consider the C struct defined below:

```
struct data {
```

```
 int marks [100];
```

```
char grade;
int cnumber;
};
struct data student;
```

The base address of student is available in register R1. The field student.grade can be accessed efficiently using

- (A) Post-increment addressing mode, (R1)+
- (B) Pre-decrement addressing mode, -(R1)
- (C) Register direct addressing mode, R1
- (D) Index addressing mode, X(R1), where X is an offset represented in 2's complement 16-bit representation.

**Key:** (D)

**Exp:** Direct access is possible with only index addressing mode.

16. Consider a TCP client and a TCP server running on two different machines. After completing data transfer, the TCP client calls **close** to terminate the connection and a FIN segment is sent to the TCP server. Server-side TCP responds by sending an ACK which is received by the client-side TCP. As per the TCP connections state diagram (RFC 793), in which state does the client-side TCP connection wait for the FIN from the sever-side TCP?

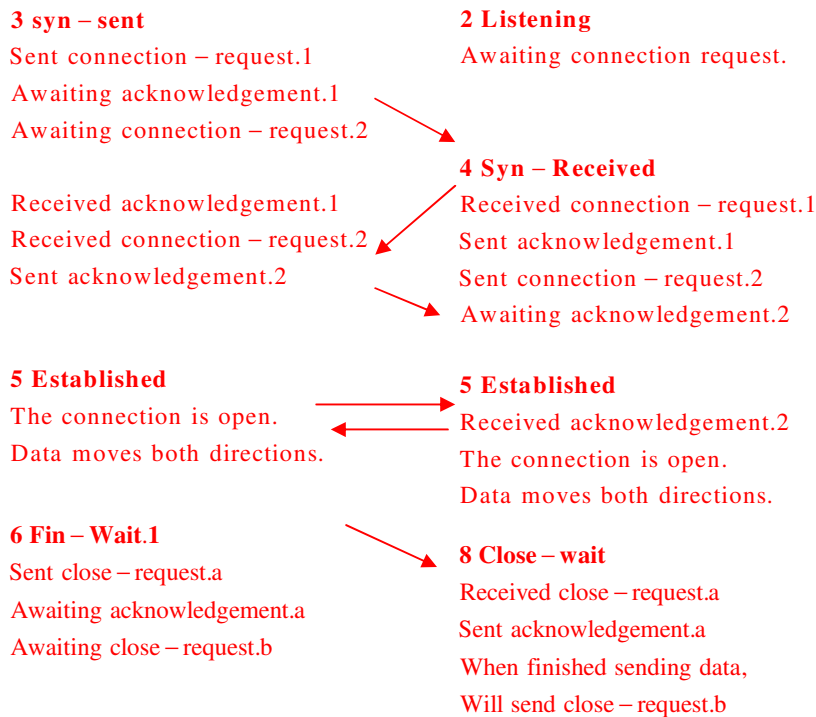
- (A) LAST-ACK
- (B) TIME-WAIT
- (C) FIN-WAIT-1
- (D) FIN-WAIT-2

**Key:** (D)

**Exp:** Client\*

Server\*

\*or vice-versa, though requests typically originate at clients.



**7 Fin – wait.2**

Received acknowledgement.a

Still awaiting close – request.b

Or

**10 closing**

Received close – request.b

Sent acknowledgement.b

Still awaiting acknowledgement.a

**11 Time – wait**

Received acknowledgement.a

Received close – request.b

Sent acknowledgement.b

Allowing time for delivery

Of acknowledgement.b

**9 Last – Ack**

Sent close – request.b

Awaiting acknowledgement.b

**1 closed**

A “fictional” state;

There is no connection.

**2 Listening**

Awaiting connection request.

17. Consider the following context-free grammar over the alphabet  $\Sigma = \{a, b, c\}$  with S as the start symbol.

$$S \rightarrow abScT \mid abcT$$

$$T \rightarrow bT \mid b$$

Which one of the following represents the language generated by the above grammar ?

- (A)  $\{(ab)^n (cb)^n \mid n \geq 1\}$
- (B)  $\{(ab)^n cb^{m_1} cb^{m_2} \dots cb^{m_n} \mid n, m_1, m_2, \dots, m_n \geq 1\}$
- (C)  $\{(ab)^n (cb^m)^n \mid m, n \geq 1\}$
- (D)  $\{(ab)^n (cb^n)^m \mid m, n \geq 1\}$

**Key:** (B)

**Exp:** The given Grammar over  $\Sigma = \{a, b, c\}$  with S as the start symbol is

$$S \rightarrow abScT \mid abcT$$

$$T \rightarrow bT \mid b$$

The minimum length string generated by the grammar is 1:

$$S \rightarrow abcT \rightarrow abcb ; \text{ hence all variable greater than 1.}$$

Other cases

$$S \rightarrow abScT \rightarrow ab abScT cT \rightarrow ab ab abScT cT cT \rightarrow \dots \rightarrow (ab)^n (cT)^n .$$

Here T can generate any number of b's starting with single b.

Hence The language is  $L = \{(ab)^n cb^{m_1} cb^{m_2} cb^{m_3} cb^{m_4} \dots cb^{m_n} \mid m_1, m_2, m_3, m_4, \dots, m_n \geq 1\}$

18. Consider the first-order logic sentence  $F: \forall z(\exists yR(x, y))$ . Assuming non-empty logical domains, which of the sentences below are *implied* by F?

I.  $\exists y(\exists xR(x, y))$

II.  $\exists y(\forall xR(x, y))$

III.  $\forall y(\exists xR(x, y))$

IV.  $\neg\exists x(\forall y\neg R(x, y))$

(A) IV only

(B) I and IV only

(C) II only

(D) II and III only

**Key:** (B)

**Exp:**  $\forall x(\exists yR(x, y)) \Rightarrow \exists y\exists xR(x, y)$

$\exists y\forall xR(x, y) \Rightarrow \forall x\exists yR(x, y)$

$\forall x\exists yR(x, y) \not\Rightarrow \exists y\forall xR(x, y)$

$\neg\exists x(\forall y\neg R(x, y)) \Leftrightarrow \forall x\exists yR(x, y)$

19. When two 8-bit numbers  $A_7\dots A_0$  and  $B_7\dots B_0$  in 2's complement representation (with  $A_0$  and  $B_0$  as the least significant bits) are added using a **ripple-carry adder**, the sum bits obtained are  $S_7\dots S_0$  and the carry bits are  $C_7\dots C_0$ . An overflow is said to have occurred if

(A) the carry bit  $C_7$  is 1

(B) all the carry bits ( $C_7\dots C_0$ ) are 1

(C)  $(A_7 \cdot B_7 \cdot S_7 + \overline{A_7} \cdot \overline{B_7} \cdot S_7)$  is 1

(D)  $(A_0 \cdot B_0 \cdot S_0 + \overline{A_0} \cdot \overline{B_0} \cdot S_0)$  is 1

**Key:** (C)

**Exp:** Overflow flag indicates an over flow condition for a signed operation. Some points to remember in a signed operation:

\* MSB is always reserved to indicate sign of the number.

\* Negative numbers are represented in 2's – complement.

\* An overflow results in invalid operation.

**2's complement overflow rules:**

\* If the sum of two positive numbers yields a negative result, the sum has overflowed.

\* If the sum of two negative number yields a positive result, the sum has overflowed.

\* Otherwise, the sum has not overflowed.

Overflow for signed numbers occurs when the carry-in into the MSB (most significant bit) is not equal to carry-out. Conveniently, an XOR-operation on these two bits can quickly determine if an overflow condition exists.

Therefore,  $((A_7 \cdot B_7)) \oplus S_7 = \overline{A_7} \cdot \overline{B_7} \cdot S_7 + A_7 \cdot B_7 \cdot S_7 = 1$  has overflowed.

20. Consider a database that has the relation schema EMP (EmpId, EmpName, and DeptName). An instance of the schema EMP and a SQL query on it are given below.

| EMP   |         |          |
|-------|---------|----------|
| EmpId | EmpName | DeptName |
| 1.    | XYA     | AA       |
| 2.    | XYB     | AA       |



|     |     |    |
|-----|-----|----|
| 3.  | XYC | AA |
| 4.  | XYD | AA |
| 5.  | XYE | AB |
| 6.  | XYF | AB |
| 7.  | XYG | AB |
| 8.  | XYH | AC |
| 9.  | XYI | AC |
| 10. | XYJ | AC |
| 11. | XYK | AD |
| 12. | XYL | AD |
| 13. | XYM | AE |

```
SELECT AVG(EC.Num)
FROM EC
WHERE (DeptName, Num) IN
 (SELECT DeptName, COUNT(EmpId) AS
 EC(DeptName, Num)
FROM EMP
GROUP BY DeptName)
```

The output of executing the SQL query is \_\_\_\_\_.

**Key:** (2.6)

**Exp:**

| EC        |     |
|-----------|-----|
| Dept Name | Num |
| AA        | 4   |
| AB        | 3   |
| AC        | 3   |
| AD        | 2   |
| AE        | 1   |

$$\text{Avg(NUM)} = \frac{13}{5} = 2.6$$

21. The following functional dependencies hold true for the relational schema R{V,W,X,Y,Z}:

- V → W
- VW → X
- Y → VX
- Y → Z

Which of the following is irreducible equivalent for this set of functional dependencies ?

- |                       |                       |                       |                       |
|-----------------------|-----------------------|-----------------------|-----------------------|
| (A) $V \rightarrow W$ | (B) $V \rightarrow W$ | (C) $V \rightarrow W$ | (D) $V \rightarrow W$ |
| $V \rightarrow X$     | $W \rightarrow X$     | $V \rightarrow X$     | $W \rightarrow X$     |
| $Y \rightarrow V$     | $Y \rightarrow V$     | $Y \rightarrow V$     | $Y \rightarrow V$     |
| $Y \rightarrow Z$     | $Y \rightarrow Z$     | $Y \rightarrow X$     | $Y \rightarrow X$     |
|                       |                       | $Y \rightarrow Z$     | $Y \rightarrow Z$     |

**Key:** (A)

**Exp:**  $V \rightarrow W, VW \rightarrow X, Y \rightarrow V, Y \rightarrow X, Y \rightarrow Z$  (W is extraneous)

$V \rightarrow W, V \rightarrow X, Y \rightarrow V, Y \rightarrow X, Y \rightarrow Z$

$\therefore Y \rightarrow X$  is redundant

$\therefore \{V \rightarrow W, V \rightarrow X, Y \rightarrow V, Y \rightarrow Z\}$

22. Consider the following functions from positive integers to real numbers:

$$10, \sqrt{n}, n, \log_2 n, \frac{100}{n}$$

The CORRECT arrangement of the above functions in increasing order of asymptotic complexity is:

- |                                                |                                                |
|------------------------------------------------|------------------------------------------------|
| (A) $\log_2 n, \frac{100}{n}, 10, \sqrt{n}, n$ | (B) $\frac{100}{n}, 10, \log_2 n, \sqrt{n}, n$ |
| (C) $10, \frac{100}{n}, \sqrt{n}, \log_2 n, n$ | (D) $\frac{100}{n}, \log_2 n, 10, \sqrt{n}, n$ |

**Key:** (B)

**Exp:**  $\frac{100}{n} < 10 < \log_2 n < \sqrt{n}, n$

23. Let T be a tree with 10 vertices. The sum of the degrees of all the vertices in T is \_\_\_\_\_.

**Key:** (18)

**Exp:** A tree with 10 vertices has 9 edges.

$$\text{As } \sum d(v_i) = 2|E|$$

$$\Rightarrow \sum d(v_i) = 2 \times 9 = 18$$

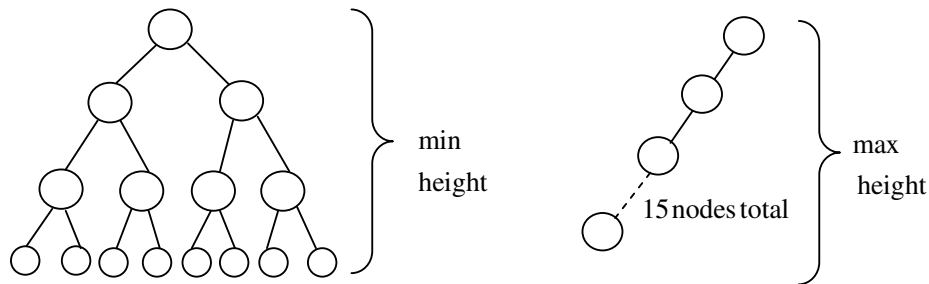
24. Let T be a binary search tree with 15 nodes. The minimum and maximum possible heights of T are :

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

- (A) 4 and 15 respectively  
 (B) 3 and 14 respectively  
 (C) 4 and 14 respectively  
 (D) 3 and 15 respectively

**Key: (B)**

**Exp:**



Min height =  $\text{floor}(\log_2 N) = \text{floor}(\log 15) = 3$

Max height = 14, when the tree is either left skewed or right skewed.

25. Consider the following C code:

```
#include <stdio.h>
int * assignval (int *x, int val) {
 *x = val;
 return x;
}
void main () {
 int * x= malloc (sizeof (int));
 if (NULL == x) return;
 x = assignval (x,0);
 if(x) {
 x=(int *) malloc (sizeof (int));
 if (NULL == x) return;
 x = assignval (x, 10);
 }
 printf("%d\n", *x);
 free (x);
}
```

The code suffers from which one of the following problems:

- (A) compiler error as the return of malloc is not typecast appropriately.
- (B) compiler error because the comparison should be made as  $x == \text{NULL}$  and not as shown.
- (C) compiles successfully but execution may result in dangling pointer.
- (D) compiles successfully but execution may result in memory leak.

**Key: (D)**

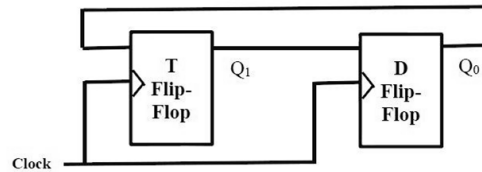
**Exp:** (A) is wrong. We don't need to cast the result as void \* is automatically and safely promoted to any other pointer type in this case.

(B) It is discarded for obvious reason.

- (C) is wrong, because dangling pointer is nothing but the pointer which is pointing to non-existing memory (deallocated or deleted memory) which is not happening here.
- (D) is the answer. When you are calling malloc second time, new location is assigned to x and previous memory location is lost and now we don't have no reference to that location resulting in memory leak.

**Q. No. 26 – 55 Carry Two Marks Each**

26. Consider a combination of T and D flip-flops connected as shown below. The output of the D flip-flop is connected to the input of the T flip-flop and the output of the T flip-flop is connected to the input of the D flip-flop.



Initially, both  $Q_0$  and  $Q_1$  are set to 1 ( before the 1<sup>st</sup> clock cycle). The outputs

- (A)  $Q_1Q_0$  after the 3<sup>rd</sup> cycle are 11 and after the 4<sup>th</sup> cycle are 00 respectively  
 (B)  $Q_1Q_0$  after the 3<sup>rd</sup> cycle are 11 and after the 4<sup>th</sup> cycle are 01 respectively  
 (C)  $Q_1Q_0$  after the 3<sup>rd</sup> cycle are 00 and after the 4<sup>th</sup> cycle are 11 respectively  
 (D)  $Q_1Q_0$  after the 3<sup>rd</sup> cycle are 01 and after the 4<sup>th</sup> cycle are 01 respectively

**Key: (B)**

**Exp:**

| CLK | $Q_1$ | $Q_0$ |
|-----|-------|-------|
| 0   | 1     | 1     |
| 1   | 0     | 1     |
| 2   | 1     | 0     |
| 3   | 1     | 1     |
| 4   | 0     | 1     |

After 3<sup>rd</sup> clock pulse :11

After 4<sup>th</sup> clock pulse: 01

27. The number of integers between 1 and 500 (both inclusive) that are divisible by 3 or 5 or 7 is \_\_\_\_\_.

**Key: (271)**

**Exp:**  $D_3 = \{\text{integers between 1 to 500 divisible by 3}\}$

$D_5 = \{\text{integers between 1 to 500 divisible by 5}\}$

$D_7 = \{\text{integers between 1 to 500 divisible by 7}\}$

To find number of integers between 1 to 500 that are divisible by 3 or 5 or 7 is to find

$$\begin{aligned}
 & |D_3 \cup D_5 \cup D_7| \\
 &= [|D_3| + |D_5| + |D_7|] - [|D_3 \cap D_5| + |D_3 \cap D_7| + |D_5 \cap D_7|] + [|D_3 \cap D_5 \cap D_7|] \\
 &= \left( \left\lfloor \frac{500}{3} \right\rfloor + \left\lfloor \frac{500}{5} \right\rfloor + \left\lfloor \frac{500}{7} \right\rfloor \right) - \left( \left\lfloor \frac{500}{15} \right\rfloor + \left\lfloor \frac{500}{21} \right\rfloor + \left\lfloor \frac{500}{35} \right\rfloor \right) + \left\lfloor \frac{500}{105} \right\rfloor \\
 &= (166 + 100 + 71) - (33 + 23 + 14) + 4 \\
 &= 337 - 70 + 4 = 271
 \end{aligned}$$

28. Consider a RISC machine where each instruction is exactly 4 bytes long. Conditional and unconditional branch instructions use PC- relative addressing mode with Offset specified in bytes to the target location of the branch instruction. Further the Offset is always with respect to the address of the next instruction in the program sequence. Consider the following instruction sequence.

| <u>Instr. No.</u> | <u>Instruction</u> |
|-------------------|--------------------|
| i:                | add R2, R3, R4     |
| i + 1:            | sub R5, R6, R7     |
| i + 2:            | cmp R1, R9, R10    |
| i + 3:            | beq R1, Offset     |

If the target of the branch instruction is i, then the decimal value of the Offset is \_\_\_\_\_.

**Key:** (-16)

**Exp:**  $I_1$     0 – 3  
 $I_2$     4 – 7  
 $I_3$     8 – 11  
 $I_4$     12 – 15  
          16 –

$I_4$  is the branch instruction &  $I_1$  is the target.

$0 = 16 + \text{relative value}$

$\therefore \text{relative value} = -16$

29. Consider the C functions foo and bar given below:

```

int foo (int val) {
 int x = 0;
 while (val > 0) {
 x = x + foo (val --);
 }
 return val ;
}

int bar (int val) {
 int x = 0;
 while (val > 0) {
 x = x + bar (val – 1) ;
 }
}

```

```

 }
return val ;
}

```

Invocations of foo (3) and bar (3) will result in:

- (A) Return of 6 and 6 respectively.
- (B) Infinite loop and abnormal termination respectively.
- (C) Abnormal termination and infinite loop respectively.
- (D) Both terminating abnormally

**Key: (B)**

**Exp:** Foo (3) calls foo (3) which in turn calls foo(3). This goes on infinite number of times which causes memory overflow and causes abnormal termination.

Bar(3) → bar (2) → bar (1) → bar (0) (return 0) from here onwards bar (1) will call bar (0) and bar (0) will return 0 to bar (1) & this goes on forever without causing memory overflow.

30. In a RSA cryptosystem a participant A uses two prime numbers  $p = 13$  and  $q = 17$  to generate her public and private keys. If the public key of A is 35. Then the private key of A is \_\_\_\_\_.

**Key: (11)**

**Exp:**

| Given Data | As per RSA Algorithm                                              |
|------------|-------------------------------------------------------------------|
| $p=13$     | <b>Step 1:</b> Calculate $n = p \times q = 13 \times 17 = 221$    |
| $q=17$     | <b>Step 2:</b> Calculate $\phi(n) = (p-1)(q-1) = (12)(16) = 192$  |
| $e=35$     | <b>Step 3:</b> $de \bmod \phi(n) = 1$ (or) $de = 1 \bmod \phi(n)$ |
| $d=?$      | $\Rightarrow d \times 35 \bmod 192 = 1 \Rightarrow d = 11$        |

31. Let A be an array of 31 numbers consisting of sequence of 0's followed by a sequence of 1's. The problem is to find the smallest index  $i$  that  $A[i]$  is 1 by probing the minimum numbers of locations in A. The *worst case* number of probes performed by an *optimal* algorithm is \_\_\_\_\_.

**Key: (5)**

**Exp:** In the given array the elements are 0's followed by 1's, which means array is already sorted.

So we can apply binary search. At each stage, we compare  $A\left[\frac{\text{low} + \text{high}}{2}\right]$ .

[Assuming 'A' is an array of 31 elements] with '1' and if it is 1 we check the left part recursively and if it is '0' we check the right part of the array recursively, which takes  $\log_2 31$  comparisons in the worst case.

32. If G is grammar with productions

$$S \rightarrow SaS \mid aSb \mid bSa \mid SS \mid \epsilon$$

where S is the start variable, then which one of the following is not generated by G?

- (A) abab                      (B) aaab                      (C) abbaa                      (D) babba

**Key: (D)**

**Exp:** 1.  $S \rightarrow SS \rightarrow aSbS \rightarrow abS \rightarrow abaSb \rightarrow abab$

2.  $S \rightarrow aSb \rightarrow aSaSb \rightarrow aaaSb \rightarrow aaab$

3.  $S \rightarrow SS \rightarrow aSbS \rightarrow abS \rightarrow abbSa \rightarrow abbSaSa \rightarrow abbaa$

Given grammar generates all strings where  $n(a) \geq n(b)$

33. The value of  $\lim_{x \rightarrow 1} \frac{x^7 - 2x^5 + 1}{x^3 - 3x^2 + 2}$

- (A) is 0                      (B) is -1                      (C) is 1                      (D) does not exist

**Key: (C)**

**Exp:**  $\lim_{x \rightarrow 1} \frac{x^7 - 2x^5 + 1}{x^3 - 3x^2 + 2} = \lim_{x \rightarrow 1} \frac{7x^6 - 10x^4}{3x^2 - 6x} = 1$ . (Using L-Hospital's rule)

34. Instructions execution in a processor is divided into 5 stages. Instruction Fetch (IF), Instruction Decode (ID), Operand Fetch (OF), Execute (EX), and Write Back (WB), These stages take **5,4,20, 10 and 3 nanoseconds (ns)** respectively. A pipelined implementation of the processor requires buffering between each pair of consecutive stages with a delay of 2ns. Two pipelined implementations of the processor are contemplated.

- (i) a naïve pipeline implementation (NP) with 5 stages and  
 (ii) an efficient pipeline (EP) where the OF stage is divided into stages OF1 and OF2 with execution times of 12 ns and 8 ns respectively.

The speedup (correct to two decimal places) achieved by EP over NP in executing 20 independent instructions with no hazards is \_\_\_\_\_.

**Key: (1.508)**

**Exp:** Given,

For Navie pipeline (NP)

Number of stages (k) = 5

$$T_p = \max(\text{stage delay} + \text{buffer delay})$$

$$T_p = \max(7, 6, 22, 12, 5) = 22 \text{ n sec.}$$

Number of instructions (n) = 20

So, erection time for navie pipeline

$$ET_{NP} = (k + n - 1) \times T_p = (5 + 20 - 1) \times 22 = 528 \text{ n sec}$$

Now, for efficient pipeline

$$k = 6, n = 20, T_p = 14 \text{ n sec.}$$

$$E_{EP} = (k + n - 1) \times T_p = (6 + 20 - 1) \times 14 = 350 \text{ n sec.}$$

$$\text{Therefore, Speedup (s)} = \frac{ET_{NP}}{E_{EP}} = \frac{528}{350}$$

$$\text{Speedup (s)} = 1.508$$

35. Consider a database that has the relation schemas EMP(EmpId, EmpName, DepId). And DEPT(DeptName, DeptId). Note that the DeptId can be permitted to be NULL in the relation EMP. Consider the following queries on the database expressed in tuple relational calculus.

$$(I) \{t | \exists u \in EMP(t[EmpName] = u[EmpName] \wedge \forall v \in DEPT(t[DeptId] \neq v[DeptId]))\}$$

$$(II) \{t | \exists u \in EMP(t[EmpName] = u[EmpName] \wedge \exists v \in DEPT(t[DeptId] \neq v[DeptId]))\}$$

$$(III) \{t | \exists u \in EMP(t[EmpName] = u[EmpName] \wedge \exists v \in DEPT(t[DeptId] \neq v[DeptId]))\}$$

Which of the above queries are safe?

- (A) (I) and (II) only
- (B) (I) and (III) only
- (C) (II) and (III) only
- (D) (I), (II) and (III)

**Key: (D)**

**Exp:** Query which generates infinite number of tuples is called unsafe query. In the given question all the given queries generate finite number of tuples.

36. Recall that Belady’s anomaly is that the pages-fault rate may increase as the number of allocated frames increases. Now consider the following statements:

S1: *Random page replacement* algorithm (where a page chosen at random is replaced)

suffers from Belady’s anomaly

S2: *LRU page replacement* algorithm suffers from Belady’s anomaly

Which of the following is CORRECT ?

- (A) S1 is true, S2 is true
- (B) S1 is true, S2 is false
- (C) S1 is false, S2 is true
- (D) S1 is false, S2 is false

**Key: (B)**

**Exp:** **Statement 1** is “TRUE”. Because there can be a case when page selected to be replaced is by FIFO policy.

**Statement 2** is “FALSE”. Because LRU page replacement algorithm does not suffers from Belady’s Anomaly. Only FIFO page replacement algorithm suffers from Belady’s Anomaly.

37. The output of executing the following C program is \_\_\_\_\_.

```
#include <stdio.h>
int total (int v) {
while (v) {
count += v & 1;
v>>= 1;
}
return count;
}
void main () {
static int x = 0;
int i = 5;
for (; i> 0; i--) {
```



```

 x=x + total (i) ;
}
printf (“%d\n”, x) ;
}

```

**Key: (23)**

**Exp:** Count in the function total is static .

| i | Count | total(i) |
|---|-------|----------|
| 5 | 0     | 2        |
| 4 | 2     | 3(2+1)   |
| 3 | 3     | 5(3+2)   |
| 2 | 5     | 6(5+1)   |
| 1 | 6     | 7(6+1)   |
|   |       | = 23     |

38. Consider the following C program.

```

#include <stdio.h>
#include <string.h>
void printlength (char *s, char *t) {
 unsigned int c = 0;
 int len = ((strlen(s) - strlen (t)) > c) ? strlen(s); strlen(t);
 printf (“%d\n”, len);
}
void main () {
 char *x = “abc”;
 char *y =”defgh”;
 printlength (x,y);
}

```

Recall that strlen is defined in string.h as returning a value of type size\_t, which is an unsigned int. The output of the program is \_\_\_\_\_.

**Key: (3)**

**Exp:** x is pointer of string “abc” which is length 3.

S is pointer, that pointed x.

y is pointer of string “defgh” which is length 5.

t is pointer that pointed y.

Now,  $((strlen(s) - strlen(t)) > c)$  is  $((3 - 5) > 0)$  is returns true, since  $(3 - 5 = -2)$  is non-zero value so, ternary operator ‘?’ is returned strlen(s) which is 3 and assigned to len because ternary- operator returns first if condition is true else second. Therefore, final value is printed 3.

39. Consider the following languages over the alphabet  $\Sigma = \{a, b, c\}$

Let  $L_1 = \{a^n b^n c^m \mid m, n \geq 0\}$  and  $L_2 = \{a^m b^n c^n \mid m, n \geq 0\}$

Which of the following are context-free languages ?

I.  $L_1 \cup L_2$

II.  $L_1 \cap L_2$

(A) I only

(B) II only

(C) I and II

(D) Neither I nor II

**Key:** (A)

**Exp:** The language given over alphabets  $\Sigma = \{a, b, c\}$  as  $L_1 = \{a^n b^n c^m \mid n, m \geq 0\}$  and  $L_2 = \{a^m b^n c^n \mid n, m \geq 0\}$ .

$L_1 \cup L_2 = \{a^n b^m c^k \mid n=m \text{ or } m=k, n, m \geq 0\}$  is a context free language. The context free grammar is:

$$S \rightarrow AB|CD$$

$$A \rightarrow aAb|c$$

$$B \rightarrow cB|c$$

$$C \rightarrow aC|c$$

$$D \rightarrow bSc|c$$

$L_1 \cap L_2 = \{a^n b^m c^k \mid n=m \text{ and } m=k, n, m \geq 0\}$  or  $\{a^n b^n c^n \mid n \geq 0\}$  is a non context free language.

40. Consider a 2-way set associative cache with 256 blocks and uses LRU replacement, Initially the cache is empty. Conflict misses are those misses which occur due the contention of multiple blocks for the same cache set. Compulsory misses occur due to first time access to the block. The following sequence of accesses to memory blocks.

(0,128,256,128,0,128,256,128,1,129,257,129,1,129,257,129)

is repeated 10 times. The number of *conflict misses* experienced by the cache is \_\_\_\_\_.

**Key:** (76)

**Exp:** A miss is not considered a conflict miss if the block is accessed for the first time.

1<sup>st</sup> round: (2+2) misses

2<sup>nd</sup> round: (4+4) misses

$\therefore$  Total =  $4 + (8 \times 9) = 76$  conflict misses

41. Let  $u$  and  $v$  be two vectors in  $\mathbf{R}^2$  whose Euclidean norms satisfy  $\|u\| = 2\|v\|$ . What is the value of  $\alpha$  such that  $w = u + \alpha v$  bisects the angle between  $u$  and  $v$  ?

(A) 2

(B) 1/2

(C) 1

(D) -1/2

**Key:** (A)

**Exp:** Let  $u = \begin{pmatrix} 2 \\ 0 \end{pmatrix}$  and  $v = \begin{pmatrix} 0 \\ 1 \end{pmatrix}$

$$\Rightarrow \|u\| = z \cdot \|v\| \text{ and } w = \begin{pmatrix} 2 \\ \alpha \end{pmatrix}$$

Now  $\cos(u, w) = \cos(v, w)$

$$\Rightarrow \frac{4}{(2)\sqrt{\alpha^2 + 4}} = \frac{\alpha}{(1)\sqrt{\alpha^2 + 4}} \Rightarrow \alpha = 2$$

42. Consider the following grammar:
- stmt  $\rightarrow$  if expr then else expr; stmt |  $\emptyset$
- expr  $\rightarrow$  term relop term | term
- term  $\rightarrow$  id | number
- if  $\rightarrow$  a | b | c
- number  $\rightarrow$  [0–9]

where **relop** is a relational operate (e.g <, >, .....) --- $\emptyset$  refers to the empty statement, and **if**, **then**, **else** are terminals.

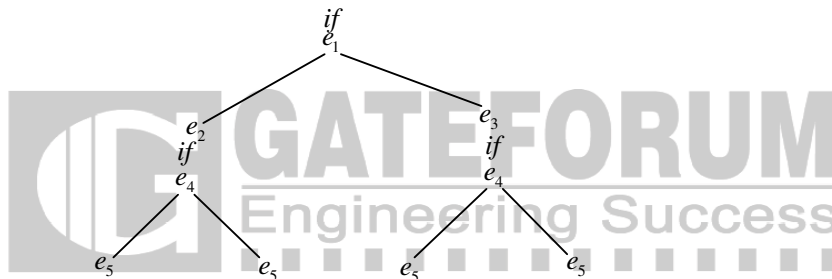
Consider a program P following the above grammar containing ten **if** terminals. The number of control flows paths in P is \_\_\_\_\_. For example the program

**if**  $e_1$  **then**  $e_2$  **else**  $e_3$

has 2 controls flow paths  $e_1 \rightarrow e_2$  and  $e_1 \rightarrow e_3$

**Key:** (1024)

**Exp:** For 2 “if statements”,  $2^2=4$  control flow paths are possible:



So for 10 “If statements”,  $2^{10}$  control flow paths will be there.

43. In a database system, unique time stamps are assigned to each transaction using Lamport’s logical clock . Let  $TS(T_1)$  and  $TS(T_2)$  be the timestamps of transactions  $T_1$  and  $T_2$  respectively. Besides,  $T_1$  holds a lock on the resource R, and  $T_2$  has requested a conflicting lock on the same resource R. The following algorithm is used to prevent deadlocks in the database system assuming that a killed transaction is restarted with the same timestamp.

if  $TS(T_2) < TS(T_1)$  then

$T_1$  is killed

else  $T_2$  waits.

Assume any transactions that is not killed terminates eventually. Which of the following is TRUE about the database system that uses the above algorithm to prevent deadlocks?

- (A) The database system is both deadlock-free and starvation- free.
- (B) The database system is deadlock- free, but not starvation-free.
- (C) The database system is starvation-free but not deadlock- free.
- (D) The database system is neither deadlock- free nor starvation-free.

**Key:** (A)

**Exp:** Elder kills younger and youngers waits on elder. So both are not waiting for each other. Hence no deadlock and there won’t be any starvation as well because the transaction who got killed will be starting with same time stamp.

44. Let A and B be infinite alphabets and let # be a symbol outside both A and B. Let  $f$  be a total functional from  $A^*$  to  $B^*$ . We say  $f$  is *computable* if there exists a Turing machine M which given an input  $x$  in  $A^*$ , always halts with  $f(x)$  on its tape. Let  $L_f$  denote the language  $\{x \# f(x) \mid x \in A^*\}$ . Which of the following statements is true:
- (A)  $f$  is computable if and only if  $L_f$  is recursive.  
 (B)  $f$  is computable if and only if  $L_f$  is recursively enumerable.  
 (C) If  $f$  is computable then  $L_f$  is recursive, but not conversely.  
 (D) If  $f$  is computable then  $L_f$  is recursively enumerable, but not conversely.

**Key:** (A)

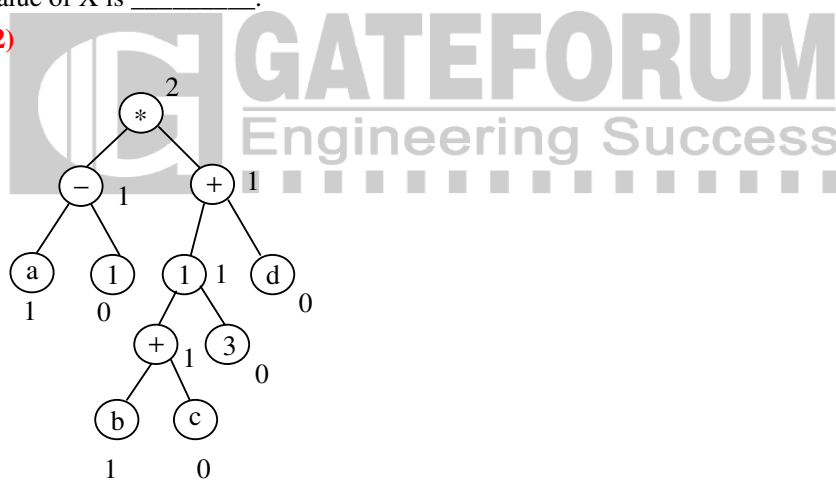
**Exp:** A TM is recursive iff it halts for every input string (either in accept or reject state).

Here, a computable function is defined in a similar way.

45. Consider the expression  $(a-1)^*(((b+c)/3)+d)$ . Let X be the minimum number of registers required by an *optimal* code generation (without any register spill) algorithm for a load/store architecture in which (i) only loads and store instructions can have memory operands and (ii) arithmetic instructions can have only register or immediate operands. The value of X is \_\_\_\_\_.

**Key:** (2)

**Exp:**



The given expression is  $(a-1)^*(((b+c)/3)+d)$

The optimal generated code is :

|                                   |                                                 |
|-----------------------------------|-------------------------------------------------|
| LOAD R <sub>1</sub> b             | R <sub>1</sub> ← b                              |
| LOAD R <sub>2</sub> C             | R <sub>2</sub> ← c                              |
| ADD R <sub>1</sub> R <sub>2</sub> | R <sub>1</sub> ← R <sub>1</sub> +R <sub>2</sub> |
| DIV R <sub>1</sub> 3              | R <sub>1</sub> ← R <sub>1</sub> /3              |
| LOAD R <sub>2</sub> d             | R <sub>2</sub> ← d                              |
| ADD R <sub>1</sub> R <sub>2</sub> | R <sub>1</sub> ← R <sub>1</sub> +R <sub>2</sub> |
| LOAD R <sub>2</sub> a             | R <sub>2</sub> ← a                              |
| SUB R <sub>2</sub> 1              | R <sub>2</sub> ← R <sub>2</sub> -1              |
| MUL R <sub>2</sub> R <sub>1</sub> | R <sub>2</sub> ← R <sub>2</sub> *R <sub>1</sub> |

46. Let  $G = (V, E)$  be any connected undirected edge-weighted graph. The weights of the edges in  $E$  are positive and distinct. Consider the following statements:

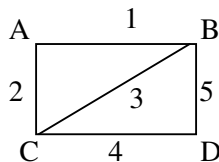
- (I) Minimum spanning tree of  $G$  is always unique.
- (II) Shortest path between any two vertices of  $G$  is always unique.

Which of the above statements is/are necessarily true?

- (A) (I) only
- (B) (II) only
- (C) Both (I) and (II)
- (D) Neither (I) nor (II)

**Key:** (A)

**Exp:**



Shortest path from B to C are two B-A-C and B-C both of weight '3'

47. A multithreaded program  $P$  executes with  $x$  number of threads and uses  $y$  number of locks for ensuring mutual exclusion while operating on shared memory locations. All locks in the program are *non-reentrant*, i.e., if a thread holds a lock  $l$ , then it cannot re-acquire lock  $l$  without releasing it. If a thread is unable to acquire a lock, it blocks until the lock becomes available. The *minimum* value of  $x$  and the *minimum* value of  $y$  together for which execution of  $P$  can result in a deadlock are:

- (A)  $x = 1, y = 2$
- (B)  $x = 2, y = 1$
- (C)  $x = 2, y = 2$
- (D)  $x = 1, y = 1$

**Key:** (C)

**Exp:** As per given question, there ' $x$ ' number of threads and ' $y$ ' number of locks for ensuring mutual exclusion while operating on shared memory locations

**Option (A):  $x=1; y=2$**

Means that 1 thread and 2 locks clearly showing that no deadlock situation

**Option (B):  $x=2; y=1$**

Means that 2 threads and 1 lock → No deadlock situation

After usage of lock by 1 thread, it can release that lock and then 2nd thread can be used that lock. So no deadlock

**Option(C):  $x=2; y=2$**

Means that 2 threads and 2 locks → Deadlock can arise

Both threads can hold 1 lock and can wait for release of another lock

**Option(D)  $x=1; y=1$**

Means that 1 thread and 1 lock → No deadlock situation

Hence **Option(C)** is correct.

48. The values of parameters for the Stop-and – Wait ARQ protocol are as given below:

Bit rate of the transmission channel = 1Mbps

Propagation delay from sender to receiver = 0.75 ms

Time to process a frame = 0.25ms

Number of bytes in the information frame = 1980

Number of bytes in the acknowledge frame = 20

Number of overhead bytes in the information frame = 20

Assume that there are no transmission errors. Then the transmission efficiency (expressed in percentage) of the Stop-and-Wait ARQ protocol for the above parameters is \_\_\_\_\_ (correct to 2 decimal places)

**Key: (89.33)**

**Exp:** Given Data:

$B = 1\text{Mbps}$

$T_{\text{proc}} = 0.25\text{ms}$

$T_p = 0.75\text{ms}$

$L = 1980\text{ Bytes}$

$L_{\text{OH}} = 20\text{ Bytes}$

$L_A = 20\text{ Bytes}$

Efficiency ( $\eta$ ) = ?

$$(i) T_x = \frac{L}{B} = \frac{(1980 + 20) \times 8}{10^6} = \frac{2 \times 8 \times 10^3}{10^6} = 16\text{ ms}$$

$$(ii) T_{\text{ACK}} = \frac{L_A}{B} = \frac{20 \times 8}{10^6} = 0.16\text{ ms}$$

In stop-and-wait ARQ, efficiency

$$\eta = \frac{T_x}{T_x + T_{\text{ACK}} + 2T_p + T_{\text{proc}}} = \frac{16\text{ ms}}{17.91\text{ms}} = 0.8933 \approx 89.33\%$$

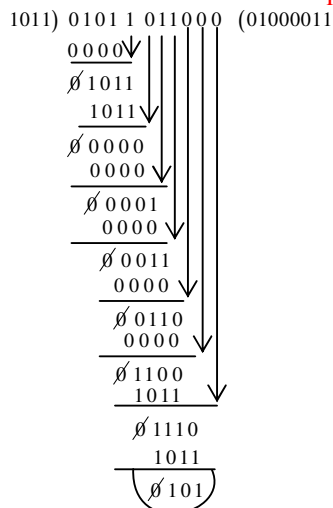
49. A computer network uses polynomials over  $GF(2)$  for error checking with 8 bits as information bits and uses  $x^3 + x + 1$  as the generator polynomial to generate the check bits. In this network, the message 01011011 is transmitted as

- (A) 01011011010 (B) 01011011011 (C) 01011011101 (D) 01011011100

**Key: (C)**

**Exp:** Given generator polynomial  $G(x) = x^3 + x + 1 \Rightarrow 1011$

message  $m(x) = 01011011$



50. Let p, q, and r be propositions and the expression  $(p \rightarrow q) \rightarrow r$  be a contradiction. Then, the expression  $(r \rightarrow p) \rightarrow q$  is

- (A) a tautology
- (B) a contradiction
- (C) always TRUE when p is FALSE
- (D) always TRUE when q is TRUE

**Key: (D)**

**Exp:**  $(p \rightarrow q) \rightarrow r$  is contradiction only when

| p | q | r |
|---|---|---|
| T | T | F |
| F | T | F |
| F | F | F |

And now for the above combination, the expression  $(r \rightarrow p) \rightarrow q$  is always true when q is true. When q is false in the above combination (third one)  $(r \rightarrow p) \rightarrow q$  will be false.

51. A cache memory unit with capacity of N words and block size of B words is to be designed. If it is designed as a direct mapped cache, the length of the TAG field is 10 bits. If the cache unit is now designed as a 16-way set-associative cache, the length of the TAG field is \_\_\_\_\_ bits.

**Key: (14)**

**Exp:** Total bits =  $10 + \underbrace{\log_2 \left( \frac{N}{B} \right)}_{\text{\# of blocks}} + \underbrace{\log_2 B}_{\text{Offset}}$

$$10 + \log_2(N) = \log_2 \left( \frac{N}{16} \right) + T$$

where T is the required length of TAG field

$$\therefore T = 14$$

52. Consider the following two functions.

```
void fun1(int n) {
 if (n == 0) return;
 printf ("%d" , n);
 fun2 (n - 2);
 printf ("%d" , n);
}

void fun2(int n) {
 if (n == 0) return ;
 printf ("%d" , n);
 fun1(++n) ;
 printf ("%d" , n);
}
```

The output printed when fun1 (5) is called is

- (A) 53423122233445
- (B) 53423120112233
- (C) 53423122132435
- (D) 53423120213243

**Key: (A)**

**Exp:** In this the fun1() is calling fun2() after printing value and after returning from fun2(), it prints the same value. In the fun2() also the same thing happens So by looking options we can judge the correct sequence of output.

53. Consider a database that has the relation schema CR (StudentName, CourseName). An instance of the schema CR is as given below.

| CR           |             |
|--------------|-------------|
| Student Name | Course Name |
| SA           | CA          |
| SA           | CB          |
| SA           | CC          |
| SB           | CB          |
| SB           | CC          |
| SC           | CA          |
| SC           | CB          |
| SC           | CC          |
| SD           | CA          |
| SD           | CB          |
| SD           | CC          |
| SD           | CD          |
| SE           | CD          |
| SE           | CA          |
| SE           | CB          |
| SF           | CA          |
| SF           | CB          |
| SF           | CC          |

The following query is made on the database.

$$T1 \leftarrow \pi_{\text{CourseName}} (\sigma_{\text{StudentName}='SA'} (CR))$$

$$T2 \leftarrow CR \div T1$$

The number of rows in T2 is \_\_\_\_\_.

**Key:** (4)

**Exp:**  $T1 = \{CA, CB, CC\}$

$T2 = \{SA, SC, SD, SF\}$

54. Let A be  $n \times n$  real valued square symmetric matrix of rank 2 with  $\sum_{i=1}^n \sum_{j=1}^n A_{ij}^2 = 50$ . Consider the following statements.

(I) One eigen value must be in  $[-5, 5]$





**General Aptitude**

**Q. No. 1 - 10 Carry One Mark Each**

1. Research in the workplace reveals that people work for many reason \_\_\_\_\_.  
 (A) money beside (B) beside money (C) money besides (D) besides money

**Key: (D)**

2. After Rajendra chola returned from his voyage to Indonesia, he \_\_\_\_\_ to visit the temple in Thanjavur.  
 (A) was wishing (B) is wishing (C) wished (D) had wished

**Key: (C)**

3. Rahul Murali, Srinivas and Arul are seated around a square table. Rahul is sitting to the left of Murali. Srinivas is sitting to the right of Arul. Which of the following pairs are seated opposite each other ?

- (A) Rahul and Murali (B) Srinivas and Arul  
 (C) Srinivas and Murali (D) Srinivas and Rahul

**Key: (C)**

**Exp:**



4. Find the smallest number y such that  $y \times 162$  is a perfect cube.  
 (A) 24 (B) 27 (C) 32 (D) 36

**Key: (D)**

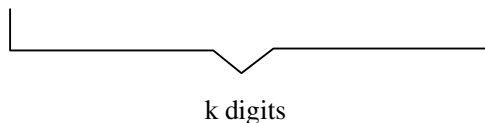
**Exp:**

Factorization of 162 is  $2 \times 3 \times 3 \times 3 \times 3$   
 $y \times 162$  is a perfect cube  
 $y \times 2 \times 3 \times 3 \times 3 \times 3 = \text{Perfect cube}$   
 For perfect cube 2's & 3's are two more required each.

5. The probability that a k-digit number does NOT contain the digits 0,5, or 9 is  
 (A)  $0.3^k$  (B)  $0.6^k$  (C)  $0.7^k$  (D)  $0.9^k$

**Key: (C)**

**Exp:**

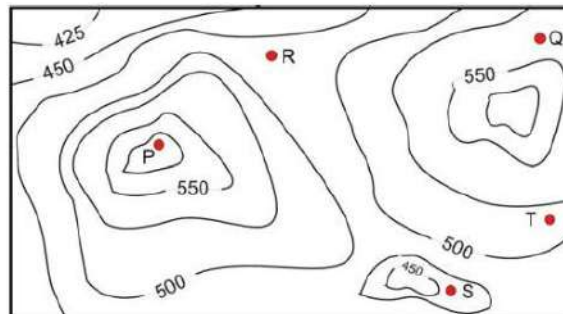


Each digit can be filled in 7 ways as 0, 5 and 9 are not allowed. So each of these places can be filled by 1, 2, 3, 4, 6, 7, 8.

So required probability is  $\left(\frac{7}{10}\right)^k$  or  $0.7^k$ .

**Q. No. 6 – 10 Carry Two Marks Each**

6. A contour line joins locations having the same height above the mean sea level. The following is a contour plot of a geographical region. Contour lines are shown at 25m intervals in this plot. If in a flood, the water level rises to 525m, which of villages P,Q, R, S,T get submerged ?



- (A) P,Q      (B) P,Q,T      (C) R,S,T      (D) Q,R,S

**Key:** (C)

**Exp:** The given contour is a hill station, the peak point of this hill station is P, it is under a contour of 550 . At floods, the water level is 525m. So the village of R, S and T are under a contour of 500. Therefore these villages are submerged.

7. “The hold of the nationalist imagination on our colonial past is such that anything inadequately or improperly nationalist is just not history”  
Which of the following statements best reflects the author’s opinion ?
- (A) Nationalists are highly imaginative.  
(B) History is viewed through the filter of nationalism.  
(C) Our colonial past never happened.  
(D) Nationalism has to be both adequately and properly imagined.

**Key:** (B)

8. The expression  $\frac{(x+y)-|x-y|}{2}$  is equal to

- (A) the maximum of x and y      (B) the minimum of x and y  
(C) 1      (D) None of the above

**Key:** (B)

**Exp:** If  $x > y$ ; then  $|x - y| = x - y$

$$\text{Exp} = \frac{x + y - (x - y)}{2} = y_{\min}$$

If  $x < y$ ; then  $|x - y| = -(x - y) = y - x$

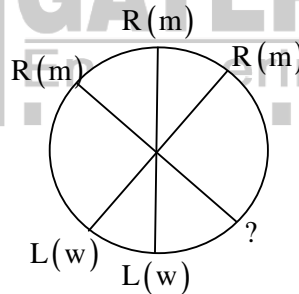
$$\text{Exp} = \frac{x + y - (y - x)}{2} = x_{\min}$$

$\therefore$  The expression  $\frac{(x + y) - |x - y|}{2}$  is equal to minimum of  $x$  &  $y$

9. Six people are seated around a circular table. There are at least two men and two women . There are at least three right-handed persons. Every woman has a left-handed person to her immediate right. None of the women are right-handed. The number of women at the table is
- (A) 2 (B) 3  
(C) 4 (D) Cannot be determined

**Key:** (A)

**Exp:** Out of six people, 3 place definitely occupied by right handed people as atleast 2 women are there so these two will sit adjacently. Now as only one seat is left it will be occupied by a left handed man because on right side of this seat is sitting an right handed man.



Therefore, answer should be 2 women.

10. Arun, Gulab, Neel and Shweta must choose one shirt each from a pile of four shirts coloured red, pink, blue and white respectively. Arun dislikes the colour red and Shweta dislikes the colour white. Gulab and Neel like all the colours. In how many different ways can they choose the shirts so that no one has a shirt with a colour he or she dislikes ?
- (A) 21 (B) 18 (C) 16 (D) 14

**Key:** (D)

**Exp:** As there are 4 people A,G,N,S and 4 colours so without any restriction total ways have to be  $4 \times 4 = 16$

Now, Arun  $\rightarrow$  dislikes Red and

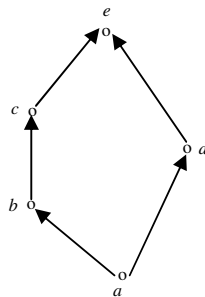
Shweta  $\rightarrow$  dislikes white

So  $16 - 2 = 14$  ways

**Computer Science and Information Technology**

**Q. No. 1 – 25 Carry One Mark Each**

1. Consider the set  $X = \{a, b, c, d, e\}$  under the partial ordering  
 $R = \{(a, a), (a, b), (a, c), (a, d), (a, e), (b, b), (b, c), (b, e), (c, c), (c, e), (d, d), (d, e), (e, e)\}$ .  
 The Hasse diagram of the partial order  $(X, R)$  is shown below.



The minimum number of ordered pairs that need to be added to  $R$  to make  $(X, R)$  a lattice is \_\_\_\_\_.

**Key: (0)**

**Exp:** Given POSET is already a lattice so no need to add any ordered pairs.

2. Which of the following statements about parser is/are CORRECT?  
 I. Canonical LR is more powerful than SLR.  
 II. SLR is more powerful than LALR  
 III. SLR is more powerful than Canonical LR.  
 (A) I only                      (B) II only                      (C) III only                      (D) II and III only

**Key: (A)**

**Exp:** Bottom up parsers in decreasing order of their power:  $CLR \gg LALR \gg SLR \gg LR$  (0)

The given statements:

- I. Canonical LR is more powerful than SLR is **CORRECT**.  
 II. SLR is more powerful than LALR is **INCORRECT**  
 III. SLR is more powerful than Canonical LR is **INCORRECT**.

3. Match the following:

|           |                              |             |                                                  |
|-----------|------------------------------|-------------|--------------------------------------------------|
| <b>P.</b> | static char var;             | <b>i.</b>   | Sequence of memory locations to store addresses  |
| <b>Q.</b> | m= malloc (10);<br>m = NULL; | <b>ii.</b>  | A variable located in data section of memory     |
| <b>R.</b> | char * ptr [10]              | <b>iii.</b> | Request to allocate a CPU register to store data |
| <b>S.</b> | register int var1;           | <b>iv.</b>  | A lost memory which cannot be freed              |

- (A) P-(ii), Q-(iv), R-(i), S-(iii)                      (B) P-(ii), Q-(i), R-(iv), S-(iii)  
 (C) P-(ii), Q-(iv), R-(iii), S-(i)                      (D) P-(iii), Q-(iv), R-(i), S-(ii)

**Key: (A)**

**Exp: P. static char var:**

var is defined as character variable whose associated storage class is static because of this it is given memory from data segment .

**Q. m = malloc(10);  
m = NULL;**

10 contiguous bytes of memory is allocated is address of first byte is stored in 'm' and later it is updated with NULL. Now we lost the address of first bytes of that chunk of memory completely. So we can't free that space as we need the address of first byte to free it up

**R. char \* ptr [10]:**

ptr is an array of 10 pointers pointing to character variables.

**S. register int var1:**

Suggesting the compiler to store the var1 "value" in CPU register.

4. Let  $L_1, L_2$  be any two context free languages and  $R$  be any regular language. Then which of the following is/are CORRECT ?

- I.  $L_1 \cup L_2$  is context – free                      II.  $\overline{L_1}$  is context – free  
 III.  $L_1 - R$  is context – free                      IV.  $L_1 \cap L_2$  is context – free  
 (A) I, II and IV only                      (B) I and III only  
 (C) II and IV only                      (D) I only

**Key: (B)**

**Exp:** Given  $L_1$  and  $L_2$  are context free languages and  $R$  is a regular language.

I.  $L_1 \cup L_2$  is context free is **CORRECT**, context free language are closed under union operation.

II.  $\overline{L_1}$  is context free is **INCORRECT**, context free languages are not closed under complement operation.

III.  $L_1 - R$  is Context free is **CORRECT**.

$L_1 - R = L_1 \cap \overline{R}$ , Context free intersection Regular is always Context free.

IV.  $L_1 \cap L_2$  is context free is **INCORRECT**; context free languages are not closed under complement operation.

5.  $G$  is undirected graph with  $n$  vertices and 25 edges such that each vertex of  $G$  has degree at least 3. Then the maximum possible value of  $n$  is \_\_\_\_\_.

**Key: (16)**

**Exp:** If every vertex has degree at least  $k$  then

$$K|V| \leq 2(E)$$

$$3|V| \leq 2 \times 25$$

$$|V| \leq \left\lfloor \frac{50}{3} \right\rfloor$$

$$|V| \leq 16$$

6. Let p, q, r denote the statements “It is raining”, “It is cold”, and “It is pleasant,” respectively. Then the statement “It is not raining and it is pleasant, and it is not pleasant only if it is raining and it is cold” is represented by

(A)  $(\neg p \wedge r) \wedge (\neg r \rightarrow (p \wedge q))$

(B)  $(\neg p \wedge r) \wedge ((p \wedge q) \rightarrow \neg r)$

(C)  $(\neg p \wedge r) \vee ((p \wedge q) \rightarrow \neg r)$

(D)  $(\neg p \wedge r) \vee (r \rightarrow (p \wedge q))$

**Key:** (A)

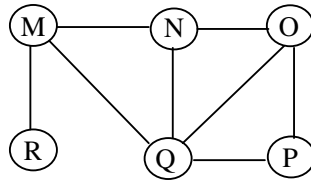
**Exp:** X only if Y is same as  $X \Rightarrow Y$

“it is not raining and it is pleasant” =  $\neg p \wedge r$

“it is not pleasant only if it is raining and it is cold” =  $\neg r \rightarrow (p \wedge q)$

$$\therefore (\neg p \wedge r) \wedge (\neg r \rightarrow (p \wedge q))$$

7. The Breadth First Search (BFS) algorithm has been implemented using the queue data structure. Which one of the following is a possible order of visiting the nodes in the graph below?



(A) MNOPQR

(B) NQMPOR

(C) QMNROP

(D) POQNMR

**Key:** (D)

**Exp:** **BFS:** Start at root (some arbitrary node of a graph, sometimes referred to as “search key”) and explore the neighbor nodes first, before moving to the next level neighbors.

8. Let  $P = \begin{bmatrix} 1 & 1 & -1 \\ 2 & -3 & 4 \\ 3 & -2 & 3 \end{bmatrix}$  and  $Q = \begin{bmatrix} -1 & -2 & -1 \\ 6 & 12 & 6 \\ 5 & 10 & 5 \end{bmatrix}$  be two matrices.

Then the rank of  $P + Q$  is \_\_\_\_\_.

**Key:** (2)

**Exp:**

$$P+Q = \begin{bmatrix} 0 & -1 & 12 \\ 8 & 9 & 10 \\ 8 & 8 & 8 \end{bmatrix}$$

$$R_1 \leftrightarrow R_2 \sim \begin{bmatrix} 8 & 9 & 10 \\ 0 & -1 & -2 \\ 1 & 1 & 1 \end{bmatrix}$$

$$\frac{R_3}{8}$$

$$8R_3 - R_1 \sim \begin{bmatrix} 8 & -9 & 10 \\ 0 & -1 & -2 \\ 0 & -1 & -2 \end{bmatrix}$$

$$R_3 - R_2 \sim \begin{bmatrix} 8 & -9 & 10 \\ 0 & -1 & -2 \\ 0 & 0 & 0 \end{bmatrix}$$

∴ Rank is 2

9. Consider socket API on a Linux machine that supports connected UDP sockets. A connected UDP socket is a UDP socket on which **connect** function has already been called. Which of the following statements is/are CORRECT ?

- I. A connected UDP socket can be used to communicate with multiple peers simultaneously.
- II. A process can successfully call **connect** function again for an already connected UDP socket.

(A) I only                      (B) II only                      (C) Both I and II                      (D) Neither I nor IIs

**Key: (B)**

**Exp:** A process with a connected UDP socket can call connect again for that socket for one of two reasons:

- (1) To specify a new IP address and port.
- (2) To unconnect the socket.

10. The minimum possible number of states of a deterministic automaton that accepts the regular language

$$L = \{w_1aw_2 \mid w_1, w_2 \in \{a, b\}^*, |w_1| = 2, |w_2| \geq 3\}$$
 is \_\_\_\_\_.

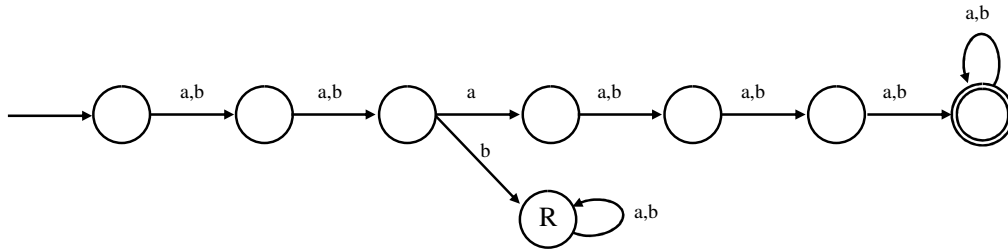
**Key: (8)**

**Exp:** The Given regular language is

$$L = \{w_1aw_2 \mid w_1, w_2 \in \{a, b\}^*, |w_1| = 2 \mid w_2| \geq 3\}$$

The minimal Deterministic finite automata accepting L is:





11. Consider the following tables T1 and T2.

| P | Q |
|---|---|
| 2 | 2 |
| 3 | 8 |
| 7 | 3 |
| 5 | 8 |
| 6 | 9 |
| 8 | 5 |
| 9 | 8 |

| R | S |
|---|---|
| 2 | 2 |
| 8 | 3 |
| 3 | 2 |
| 9 | 7 |
| 5 | 7 |
| 7 | 2 |

In table T1, **P** is the primary key and **Q** is the foreign key referencing **R** in table T2 with on-delete cascade and on-update cascade. In table T2, **R** is the primary key and **S** is the foreign key referencing **P** in table T1 on-delete set NULL and on-update cascade. In order to delete record  $\langle 3,8 \rangle$  from table T1, the number of additional records that need to be deleted from table T1 is \_\_\_\_\_.

**Key: (0)**

**Exp: Only (8,3) will be deleted from T2.**

12. Which of the following is/are shared by all the threads in a process ?

**I.** Program counter

**II.** Stack

**III.** Address space

**IV.** Registers

(A) I and II only

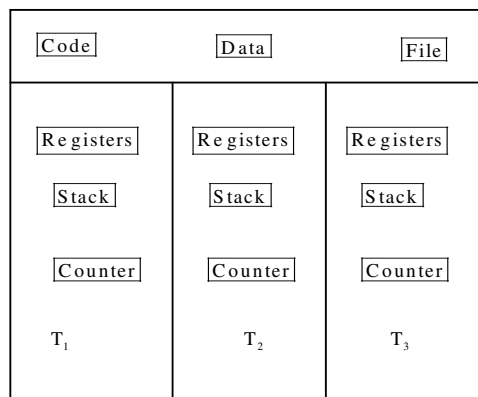
(B) III only

(C) IV only

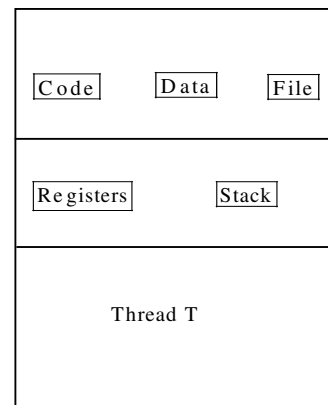
(D) III and IV only

**Key: (B)**

**Exp:**



Single process P with 3 threads Multi threading



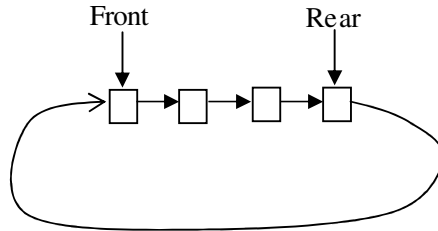
Single threaded process

13. A circular queue has been implemented using a single linked list where each node consists of a value and a single pointer pointing to the next node. We maintain exactly two external pointers **FRONT** and **REAR** pointing to the front node and the rear node of the queue, respectively. Which of the following statements is/are **CORRECT** for such a circular queue, so that insertion and deletion operation can be performed in  $O(1)$  time ?

- I. Next pointer of front node points to the rear node.
  - II. Next pointer of rear node points to the front node.
- (A) I only                    (B) II only                    (C) Both I and II                    (D) Neither I nor II

**Key: (B)**

**Exp:** Next pointer of the front node would point to the second node, if any.



14. Given the following binary number in 32-bit (single precision) IEEE-754 format:  
00111110011011010000000000000000

- The decimal value closest to this floating- point number is
- (A)  $1.45 \times 10^1$                     (B)  $1.45 \times 10^{-1}$                     (C)  $2.27 \times 10^{-1}$                     (D)  $2.27 \times 10^1$

**Key: (C)**

**Exp:** Sign

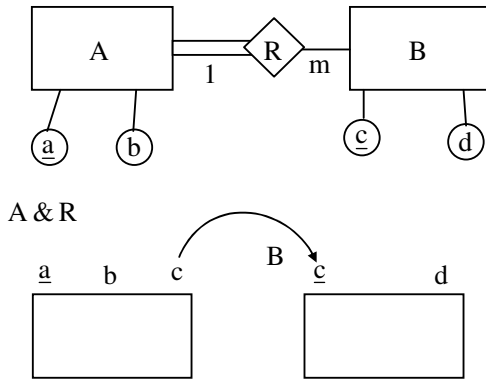
$$\begin{array}{l}
 0 \quad 01111100 \quad \quad \quad 110110100000000000000000 \\
 +1 \quad 124 \\
 +1 \quad 2^{-3} \quad \quad \quad [2^{-1} + 2^{-2} + \text{-----}] \\
 \quad \quad \quad [1+]0.8515625 \quad \quad \quad =0.227....
 \end{array}$$

15. An ER model of a database consists of entity types A and B. These are connected by a relationship R which does not have its own attribute. Under which one of the following conditions, can the relational table for R be merged with that of A?

- (A) Relationship R is one-to-many and the participation of A in R is total
- (B) Relationship R is one-to-many and the participation of A in R is partial
- (C) Relationship R is many-to-one and the participation of A in R is total
- (D) Relationship R is many-to-one and the participation of A in R is partial

**Key: (C)**

**Exp:**



**Note:** only M ! N relationship needs exclusive table: If a relationship is 1 ! M or M ! 1 then that relation could be included in the many side table with the help of foreign key concept.

16. Match the algorithms with their time complexities:

| Algorithm |                                               | Time complexity |                    |
|-----------|-----------------------------------------------|-----------------|--------------------|
| P.        | Towers of Hanoi with $n$ disks                | i.              | $\theta(n^2)$      |
| Q.        | Binary search given $n$ sorted numbers        | ii.             | $\theta(n \log n)$ |
| R.        | Heap sort given $n$ numbers at the worst case | iii.            | $\theta(2^n)$      |
| S.        | Addition of two $n \times n$ matrices         | iv.             | $\theta(\log n)$   |

- (A) P-(iii),Q-(iv), R-(i), S-(ii)                      (B) P-(iv),Q-(iii), R-(i), S-(ii)  
 (C) P-(iii),Q-(iv), R-(ii), S-(i)                      (D) P-(iv),Q-(iii), R-(ii), S-(i)

**Key:** (C)

**Exp:** P. Towers of Hanoi  $\Rightarrow T(n) = 2T(n-1) + 1 \Rightarrow \theta(2^n)$

Q. Binary search  $\Rightarrow T(n) = T\left(\frac{n}{2}\right) + C \Rightarrow \theta(\log n)$

R. Heap sort  $\Rightarrow \theta(n \log n)$

S. Addition of two  $n \times n$  matrices  $\Rightarrow \theta(n^2)$

17. Match the following according to input (from the left column) to the compiler phase (in the right column) that processes it.

| Column-1 |                             | Column-2 |                   |
|----------|-----------------------------|----------|-------------------|
| P.       | Syntax tree                 | i.       | Code generator    |
| Q.       | Character stream            | ii.      | Syntax analyzer   |
| R.       | Intermediate representation | iii.     | Semantic analyzer |
| S.       | Token stream                | iv.      | Lexical analyzer  |

- (A) P-(ii),Q-(iii), R-(iv), S-(i)                      (B) P-(ii),Q-(i), R-(iii), S-(iv)  
 (C) P-(iii),Q-(iv), R-(i), S-(ii)                      (D) P-(i),Q-(iv), R-(ii), S-(iii)

**Key:** (C)

**Exp:** Lexical Analysis phase processes character stream and generates tokens, e.g. identifier or keywords.

Tokens are processed by Syntax analysis analyzer.

Syntax tree is processed by Semantic analyzer.

Intermediate code such as 3 –address code is used for code generation process.

18. Consider the following statements about the routing protocols, Routing Information Protocol (RIP) and Open Shortest Path First (OSPF) in an IPv4 network.

- I. RIP uses distance vector routing  
 II. RIP packets are sent using UDP  
 III. OSPF packets are sent using TCP  
 IV. OSPF operation is based on link-state routing

Which of the statements above are CORRECT?

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

**Key:** (C)

**Exp:** **Statement (1):** RIP uses distance vector routing. “CORRECT”

RIP is one of the oldest DVR protocol which employ the hop count as a routing metric.

**Statement (2):** RIP packets are sent using UDP. “CORRECT”

RIP uses the UDP as its transport protocol, and is assigned the reserved port no 520.

**Statement (3):** OSPF packets are sent using TCP. “INCORRECT”

OSPF does not use a transport protocol , such as UDP (or) TCP, but encapsulates its data directly in IP packets.

**Statement (4):** OSPF operation is based on link state routing. “CORRECT”

OSPF is a routing protocol which uses link state routing (LSR) and works within a single autonomous system.

Hence Option “C” is correct.

19. If  $f(x) = R \sin\left(\frac{\pi x}{2}\right) + S, f'\left(\frac{1}{2}\right) = \sqrt{2}$  and  $\int_0^1 f(x) dx = \frac{2R}{\pi}$ , then the constants R and S are, respectively

- (A)  $\frac{2}{\pi}$  and  $\frac{16}{\pi}$                       (B)  $\frac{2}{\pi}$  and 0                      (C)  $\frac{4}{\pi}$  and 0                      (D)  $\frac{4}{\pi}$  and  $\frac{16}{\pi}$

**Key:** (C)

**Exp:**  $f'(x) = \frac{R\pi}{2} \cos\left(\frac{\pi x}{2}\right)$

$$\Rightarrow f'(1/2) = \sqrt{2} \text{ gives } \frac{R\pi}{2\sqrt{2}} = \sqrt{2} \Rightarrow R = \frac{4}{\pi}$$

$$\text{Also } \int_0^1 f(x) dx = \frac{2R}{\pi} \text{ gives } \frac{-2R}{\pi} \left( \cos \frac{\pi x}{2} \right)_0^1 + S(x)_0^1 = 2R/\pi$$

$$\Rightarrow S=0$$

20. In a file allocation system, which of the following allocation schemes(s) can be used if no external fragmentation is allowed?

- I. Contiguous      II. Linked      III. Indexed  
 (A) I and III only      (B) II only      (C) III only      (D) II and III only

**Key:** (D)

**Exp:** Contiguous allocation suffer from external fragmentation. But linked and indexed allocation schemes free from external fragmentation. Hence, option D is correct.

21. Consider a quadratic equation  $x^2 - 13x + 36 = 0$  with coefficients in a base b. The solutions of this equation in the same base b are  $x = 5$  and  $x = 6$ . Then  $b =$  \_\_\_\_\_.

**Key:** (8)

**Exp:** Clearly  $13 = 1 \times 10 + 3$  and  $36 = 3 \times 10 + 6 \Rightarrow$  base  $b = 10$

The quadratic equation with solutions  $x = 5$  and  $x = 6$  is  $x^2 - 11x + 30 = 0$

According to the given condition, we have  $b + 3 = 11$  and  $3b + 6 = 30 \Rightarrow b = 8$

Answer is 8.

**Alternate solution:**

$$x^2 - 13x + 36 = 0 \text{ (given quadratic equation)}$$

$$\text{In base } b, 13 = 1 \times b^1 + 3 \times b^0 = b + 3 \text{ and}$$

$$36 = 3 \times b^1 + 6 \times b^0 = 3b + 6$$

$$\text{So the equation becomes } x^2 - (b + 3)x + (3b + 6) = 0$$

Since  $x=5$  is a solution

$$\therefore 5^2 - (b + 3)5 + (3b + 6) = 0 \Rightarrow b = 8$$

Similarly, by putting  $x = 6$ , we get  $b = 8$

22. Identify the language generated by the following grammar, where S is start variable.

$$S \rightarrow XY$$

$$X \rightarrow aX | a$$

$$Y \rightarrow aYb | \epsilon$$

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

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

**Key:** (C)

**Exp:** The given grammar with S as start symbol is

$$S \rightarrow XY$$

$$X \rightarrow aX|a$$

$$Y \rightarrow aYb|c$$

From Non terminal  $X$  we can generate any number of  $a$ 's including a single ' $a$ ' and from  $Y$  equal number of  $a$ 's and  $b$ 's.

$$\text{Hence } L = \{a^m b^n \mid m > n, n \geq 0\}$$

23. The representation of the value of a 16-bit unsigned integer  $X$  in hexadecimal number system is  $BCA9$ . The representation of the value of  $X$  in octal number system is

(A) 571244                      (B) 736251                      (C) 571247                      (D) 136251

**Key:** (D)

**Exp:**  $(BCA9)_{16} \rightarrow (136251)_8$

Convert hexadecimal to octal number system.

24. Consider the following function implemented in C:

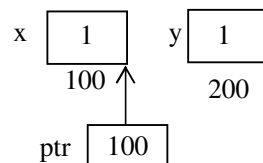
```
void printxy (int x, int y) {
 int *ptr ;
 x = 0;
 ptr = &x;
 y = * ptr;
 * ptr = 1;
 print f ("%d, %d," x, y);
}
```

The output of invoking  $\text{printxy}(1, 1)$  is

(A) 0,0                      (B) 0,1                      (C) 1,0                      (D) 1,1

**Key:** (C)

**Exp:**



$\therefore 1,0$  is printed

25. The maximum number of IPv4 router addresses that can be listed in the record route (RR) option field of an IPv4 header is \_\_\_\_\_.

**Key:** (9)

**Exp:** A record route option is used to record the internet routers that handles the datagram. It can list up to nine router addresses. It can be used for debugging and management purpose.

**Q. No. 26 – 55 Carry Two Marks Each**

26. Consider a binary code that consists of only four valid code words as given below:

00000,01011,10101,11110

Let the minimum Hamming distance of the code be  $p$  and the maximum number of erroneous bits that can be corrected by the code be  $q$ . Then the values of  $p$  and  $q$  are

- (A)
- $p = 3$
- and
- $q = 1$
- (B)
- $p = 3$
- and
- $q = 2$
- 
- (C)
- $p = 4$
- and
- $q = 1$
- (D)
- $p = 4$
- and
- $q = 2$

**Key:** (A)**Exp:** Given :

code1 00000

code2 01011

code3 10101

code4 11110

Hamming distance between code 1 and code 2 is 3.

Hamming distance between code 1 and code 3 is 3.

Hamming distance between code 1 and code 4 is 4.

Hamming distance between code 2 and code 3 is 4.

Hamming distance between code 2 and code 4 is 3.

Hamming distance between code 3 and code 4 is 3.

So, as per Hamming code, minimum Hamming distance of all code words is considered as Hamming distance i.e., 3 ( $p$ ).

Now, the max number of erroneous bits that can be corrected by the Hamming code is  $2d + 1$ .  
So,

$$2d + 1 = 3 \Rightarrow d = 1$$

So option A is correct.

27. A system shares 9 tape drives. The current allocation and maximum requirement of tape drives for three processes are shown below:

| Process | Current Allocation | Maximum Requirement |
|---------|--------------------|---------------------|
| P1      | 3                  | 7                   |
| P2      | 1                  | 6                   |
| P3      | 3                  | 5                   |

Which of the following best describes current state of the system ?

- (A) Safe, Deadlocked (B) Safe, Not Deadlocked
- 
- (C) Not Safe, Deadlocked (D) Not Safe, Not deadlocked

**Key:** (B)

**Exp:**

| PID            | Current Allocation | Max need | Available | Need |
|----------------|--------------------|----------|-----------|------|
| P <sub>1</sub> | 3                  | 3        | 2         | 4    |
| P <sub>2</sub> | 1                  | 6        | -         | 5    |
| P <sub>3</sub> | 3                  | 5        | -         | 2    |

With the above state of systems, we can get the following 2 safe sequences.

(1)  $\langle P_3, P_2, P_1 \rangle$

(2)  $\langle P_3, P_1, P_2 \rangle$

Hence, system is in safe state, no deadlocked option B is correct.

28. Two transactions T<sub>1</sub> and T<sub>2</sub> are given as:

T<sub>1</sub> : r<sub>1</sub>(X) w<sub>1</sub>(X) r<sub>1</sub>(Y) w<sub>1</sub>(Y)

T<sub>2</sub> : r<sub>2</sub>(Y) w<sub>2</sub>(Y) r<sub>2</sub>(Z) w<sub>2</sub>(Z)

where r<sub>i</sub>(V) denotes a read operation by transaction T<sub>i</sub> on a variable V and w<sub>i</sub>(V) denotes a write operations by transaction T<sub>i</sub> on a variable V. The total number of conflict serializable schedules that can be formed by T<sub>1</sub> and T<sub>2</sub> is \_\_\_\_\_.

**Key:** (54)

**Exp:** Conflict conditions RW WR WW

∴ 5 conflicts

|                                 |                    |                    |                    |
|---------------------------------|--------------------|--------------------|--------------------|
| T <sub>1</sub> - T <sub>2</sub> |                    |                    |                    |
| a                               | b                  | c                  | d                  |
| r <sub>1</sub> (X)              | w <sub>1</sub> (X) | r <sub>1</sub> (Y) | w <sub>1</sub> (Y) |
| r <sub>2</sub> (Y)              | w <sub>2</sub> (Y) | r <sub>2</sub> (Z) | r <sub>2</sub> (Z) |
| 1                               | 2                  | 3                  | 4                  |

**Constraints:**

a < b < c < d

1 < 2 < 3 < 4

d < 1 (or) 2 < c

only 1 way

Total = 70 = 70 - (12 + 5)

|            |          |
|------------|----------|
| ↙          | ↘        |
| a, b, c, d | a, b, c  |
| before 2   | before 2 |

Therefore, 53 + 1 = 54



29. If  $w, x, y, z$  are Boolean variables, then which one of the following is INCORRECT ?
- (A)  $wx + w(x + y) + x(x + y) = x + wy$
- (B)  $\overline{wx}(y + \overline{z}) + \overline{wx} = \overline{w} + x + \overline{yz}$
- (C)  $(w\overline{x}(y + x\overline{z}) + \overline{wx})y = x\overline{y}$
- (D)  $(w + y)(wxy + wyz) = wxy + wyz$

**Key:** (C)

**Exp:**

(A) LHS:  $wx + w(x + y) + x(x + y) = x + wy$

RHS:

$$\Rightarrow wx + wx + wy + xx + xy$$

$$\Rightarrow wx + wy + x + xy \quad [ \because xx = x ]$$

$$\Rightarrow x[1 + y + w] + wy \quad [ \because 1 + x = 1 ]$$

$$\Rightarrow x + wy$$

$$\Rightarrow \text{L.H.S} = \text{R.H.S}$$

(B) L.H.S:  $\overline{wx}(y + \overline{z}) + \overline{wx} = \overline{wx} + \overline{yz}$

R.H.S:  $\overline{wx}(y + \overline{z}) + \overline{wx}$

Apply De' Morgan theorem

$$\Rightarrow \overline{wx} + (\overline{y + \overline{z}}) + \overline{wx} [ \overline{x + y} = \overline{x} \cdot \overline{y} ]$$

$$\Rightarrow (\overline{w} + x) + (\overline{yz}) + \overline{wx}$$

$$\Rightarrow \overline{w} + x + \overline{yz} + \overline{wx}$$

$$\Rightarrow \overline{w} + x + \overline{yz} = \text{R.H.S}$$

$$\text{L.H.S} = \text{R.H.S}$$

(C)  $\{ [ \overline{wx}(y + \overline{z}) ] + \overline{wx} \} y = x\overline{y}$

$$\text{L.H.S} \neq \text{R.H.S}$$

(D) L.H.S:  $(w + y)(wxy + wyz) = wxy + wyz$

$$(w + y)(wxy + wyz)$$

$$\Rightarrow wxy + wyz + wxy + wyz$$

$$\Rightarrow wxy + wyz$$

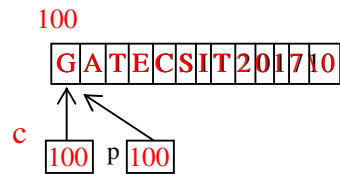
$$\text{L.H.S} = \text{R.H.S}$$

```
30. Consider the following C Program.
#include <stdio.h>
#include <string.h>
int main () {
 char* c = "GATECSIT2017";
 char* p = c;
 printf("%d", (int) strlen (c+2[p]-6[p]-1));
 return 0;
}
```

The output of the program is \_\_\_\_\_.

**Key:** (2)

**Exp:**



$$\text{strlen}(c + 2[p] - 6[p] - 1)$$

$$\begin{matrix} \downarrow & \downarrow & \downarrow \\ 100 + T - & & I - 1 \end{matrix}$$

**Note:** Whenever we have characters in the arithmetic expressions, we can replace those with their ASCII values

$$\text{Strlen}(100 + x + 11 - x - 1) \text{ [assume } x \text{ has the ASCII value of } I]$$

$$\Rightarrow \text{Strlen}(110)$$

$\therefore$  2 is printed

31. P and Q are considering to apply for a job. The probability that P applies for the job is  $\frac{1}{4}$ .

The probability that P applies for the job given that Q applies for the job is  $\frac{1}{2}$ , and the

probability that Q applies for the job given that P applies for the job is  $\frac{1}{3}$ . Then the probability that P does not apply for the job given that Q does not apply for the job is

- (A)  $\frac{4}{5}$                       (B)  $\frac{5}{6}$                       (C)  $\frac{7}{8}$                       (D)  $\frac{11}{12}$

**Key:** (A)

**Exp:** Let A,B be the events denote that P, Q respectively applies for a job

$$\Rightarrow \text{Pr}(A) = \frac{1}{4}, \text{Pr}(A/B) = \frac{1}{2} \text{ --- (1) and } \text{Pr}(B/A) = \frac{1}{3} \text{ --- (2)}$$

$$(2) \text{ gives } \text{Pr}(A \cap B) = \frac{1}{12}$$

$$\therefore (1) \text{ gives } \Pr(B) = \frac{1}{6}$$

$$\therefore \Pr\left(\frac{\bar{A}}{B}\right) = \frac{\Pr(\bar{A} \cap \bar{B})}{\Pr(\bar{B})} = \frac{1 - \Pr(A \cup B)}{1 - \Pr(B)} = \frac{1 - \left(\frac{1}{4} + \frac{1}{6} - \frac{1}{12}\right)}{1 - \frac{1}{6}} = \frac{2}{3} \times \frac{6}{5} = \frac{4}{5}$$

$$\left( \text{Here } \Pr \text{ is Probability and } P(A/B) = \frac{P(A \cap B)}{P(B)} \right)$$

32. If the characteristics polynomial of  $3 \times 3$  matrix  $M$  over  $\mathbb{R}$  ( the set of real numbers) is  $\lambda^3 - 4\lambda^2 + a\lambda + 30, a \in \mathbb{R}$ , and one eigenvalue of  $M$  is 2, then the largest among the absolute values of the eigenvalues of  $M$  is \_\_\_\_\_.

**Key:** (5)

**Exp:**  $E(X) = 5 \Rightarrow (X^2) = 30$ , where  $X \sim P(\lambda), \lambda = 5$

$$\therefore E[(X+2)^2] = E(X^2) + 4E(X) + 4 = 30 + 20 + 4 = 54$$

$$\left( \because V(X) = E(X^2) - (E(X))^2 \right)$$

Since one eigen value of  $M$  is 2

$$\therefore 2^3 - 4(2)^2 + a(2) + 30 = 0$$

$$\Rightarrow a = -11$$

$\therefore$  Characteristic polynomial is

$$\lambda^3 - 4\lambda^2 - 11\lambda + 30 = 0$$

$$(\lambda - 2)(\lambda - 5)(\lambda + 3) = 0$$

$$\therefore \lambda = 2, 5, -3$$

Largest absolute value of ' $\lambda$ ' is 5

33. Consider the following expression grammar  $G$ :

$$E \rightarrow E - T \mid T$$

$$T \rightarrow T + F \mid F$$

$$F \rightarrow (E) \mid id$$

Which of the following grammars is not left recursive, but is equivalent to  $G$ ?

(A)  $E \rightarrow E - T \mid T$

$$T \rightarrow T + F \mid F$$

$$F \rightarrow (E) \mid id$$

(B)  $E \rightarrow TE'$

$$E' \rightarrow -TE' \mid \epsilon$$

$$T \rightarrow T + F \mid F$$

$$F \rightarrow (E) \mid id$$

- |                              |                                    |
|------------------------------|------------------------------------|
| (C) $E \rightarrow TX$       | (D) $E \rightarrow TX   (TX)$      |
| $X \rightarrow -TX \epsilon$ | $X \rightarrow -TX   +TX \epsilon$ |
| $T \rightarrow FY$           | $T \rightarrow id$                 |
| $Y \rightarrow +FY \epsilon$ |                                    |
| $F \rightarrow (E)   id$     |                                    |

**Key:** (C)

**Exp:** The rule for removal of left recursion is

$A \rightarrow A\alpha | \beta$  will be

$A \rightarrow \beta A'$

$A' \rightarrow \alpha A' | \epsilon$

The given grammar is:

$E \rightarrow E - T | T$ ; in this  $\alpha$  is “- T” and  $\beta$  is T

$T \rightarrow T + F | F$ , In this  $\alpha$  is “+ F” and  $\beta$  is F

$F \rightarrow (E) | id$

Hence after removal of the left recursion:

$E \rightarrow TX$

$X \rightarrow -TX | \epsilon$

$T \rightarrow FY$

$Y \rightarrow +FY | \epsilon$

$F \rightarrow (E) | id$

34. In a two-level cache system, the access times of  $L_1$  and  $L_2$  caches are 1 and 8 clock cycles, respectively. The miss penalty from  $L_2$  cache to main memory is 18 clock cycles. The miss rate of  $L_1$  cache is twice that of  $L_2$ . The average memory access time (AMAT) of this cache system is 2 cycles. This miss rates of  $L_1$  and  $L_2$  respectively are :

- |                       |                       |
|-----------------------|-----------------------|
| (A) 0.111 and 0.056   | (B) 0.056 and 0.111   |
| (C) 0.0892 and 0.1784 | (D) 0.1784 and 0.0892 |

**Key:** (A)

**Exp:**  $2 = 1 + 2m \times 8 + m \times 18$

$$\therefore m = \frac{1}{34}$$

35. Consider two hosts X and Y, connected by a single direct link of rate  $10^6$  bits/sec. The distance between the two hosts is 10,000 km and the propagation speed along the link is

$2 \times 10^8$  m/sec. Host X sends a file of 50,000 bytes as one large message to host Y continuously. Let the transmission and propagation delays be  $p$  milliseconds and  $q$  milliseconds, respectively. Then the values of  $p$  and  $q$  are

- |                            |                            |
|----------------------------|----------------------------|
| (A) $p = 50$ and $q = 100$ | (B) $p = 50$ and $q = 400$ |
| (C) $p = 100$ and $q = 50$ | (D) $p = 400$ and $q = 50$ |

**Key:** (D)

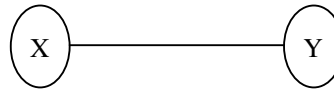
**Exp:** Given data

$$B = 10^6 \text{ bits / sec}$$

$$d = 10,000 \text{ km} = 10^4 \times 10^3 \text{ m}$$

$$V = 2 \times 10^8 \text{ m / s}$$

$$L = 50,000 \text{ Bytes}$$



$$\therefore \text{Transmission time (p)} = \frac{L}{B} = \frac{50,000 \times 8}{10^6} = 400 \text{ ms}$$

$$\therefore \text{Propagation Time (q)} = \frac{d}{v} = \frac{10^7}{2 \times 10^8} = 50 \text{ ms}$$

36. Consider the recurrence function

$$T(n) = \begin{cases} 2T(\sqrt{n}) + 1, & n > 2 \\ 2, & 0 < n \leq 2 \end{cases}$$

Then  $T(n)$  in terms of  $\theta$  notation is

- (A)  $\theta(\log \log n)$       (B)  $\theta(\log n)$       (C)  $\theta(\sqrt{n})$       (D)  $\theta(n)$

**Key: (B)**

**Exp:**  $T(n) = 2T(\sqrt{n}) + 1$

Put  $n = 2^k$

$$T(2^k) = 2T(2^{k/2}) + 1$$

Assume  $T(2^k) = \delta(K)$

$$\Rightarrow \delta(K) = 2\delta\left(\frac{K}{2}\right) + 1$$

By master's theorem

$$\delta(K) = \theta(K)$$

$$T(2^k) = \theta(K)$$

$$T(n) = \theta(\log n) \quad \because 2^k = n$$

37. If a random variable  $X$  has a Poisson distribution with mean 5, then the expectation

$$E[(X+2)^2] \text{ equals } \underline{\hspace{2cm}}.$$

**Key: (54)**

**Exp:**  $E(X) = 5 \Rightarrow E(X^2) = 30$ , where  $X \sim P(\lambda), \lambda = 5$

$$\therefore E[(X+2)^2] = E(X^2) + 4E(X) + 4$$

$$= 30 + 20 + 4 = 54$$

$$\left( \because V(X) = E(X^2) - (E(X))^2 \right)$$

38. Consider the following C function

```
int fun (int n) {
 int i, j;
 for (i = 1; i <= n; i++) {
 for (j = 1; j < n; j+=i) {
 printf ("%d %d", i, j);
 }
 }
}
```

Time complexity of fun in terms of  $\theta$  notation is

- (A)  $\theta(n\sqrt{n})$       (B)  $\theta(n^2)$       (C)  $\theta(n \log n)$       (D)  $\theta(n^2 \log n)$

**Key:** (C)

**Exp:** for  $i = 1$

$j$  will run from 1 to  $n$  by incrementing by '1' in each step  $\Rightarrow$  ' $j$ ' will run for  $n$  times

For  $i = 2$

$j$  will run from 1 to  $n$  by incrementing by '2' in each step  $\Rightarrow$   $j$  will run for  $\frac{n}{2}$  times and so on

$$\begin{aligned} \text{Time Complexity}(T_c) &= n + \frac{n}{2} + \frac{n}{3} + \dots + \frac{n}{n} \\ &= n \left( 1 + \frac{1}{2} + \frac{1}{3} + \dots + \frac{1}{n} \right) = \theta(n \log n) \end{aligned}$$

39. The pre-order traversal of a binary search tree is given by 12, 8, 6, 2, 7, 9, 10, 16, 15, 19, 17, 20. Then the post-order traversal of this tree is:

- (A) 2,6,7,8,9,10,12,15,16,17,19,20      (B) 2,7,6,10,9,8,15,17,20,19,16,12  
(C) 7,2,6,8,9,10,20,17,19,15,16,12      (D) 7,6,2,10,9,8,15,16,17,20,19,12

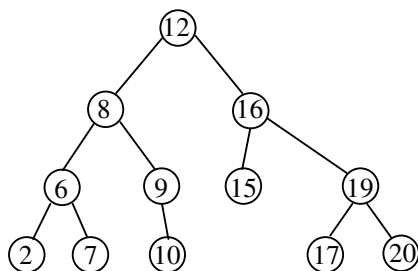
**Key:** (B)

**Exp:** Given: Preorder !      12, 8, 6, 2, 7, 9, 10, 16, 15, 19, 17, 20

In order!      2, 6, 7, 8, 9, 10, 12, 15, 16, 17, 19, 20

**Note:** BST In order will give ascending order

Corresponding BST is



$\therefore$  Post order is 2, 7, 6, 10, 9, 8, 15, 17, 20, 19, 16, 12

40. Consider the C program fragment below which is meant to divide  $x$  by  $y$  using repeated subtractions. The variables  $x$ ,  $y$ ,  $q$  and  $r$  are all unsigned int.

```
while (r >= y) {
 r = r - y;
 q = q + 1;
}
```

Which of the following conditions on the variables  $x$ ,  $y$ ,  $q$  and  $r$  before the execution of the fragment will ensure that the loop terminates in a state satisfying the condition  $x == (y * q + r)$ ?

- (A)  $(q == r) \ \&\& \ (r == 0)$   
 (B)  $(x > 0) \ \&\& \ (r == x) \ \&\& \ (y > 0)$   
 (C)  $(q == 0) \ \&\& \ (r == x) \ \&\& \ (y > 0)$   
 (D)  $(q == 0) \ \&\& \ (y > 0)$

**Key:** (C)

**Exp:** Given, program is:

```
while (r >= y){
 r = r - y;
 q = q + 1;
}
```

If we want to final value as  $x == (y * q + r)$ . Then initial value of  $r$  should be equal to  $x$  (Since  $y$  is subtracted from  $r$  each time in given code).  $q$  incremented by 1 ( $q$  is quotient here). To avoid undefined behavior, value of  $y$  should be greater than zero.

Therefore,  $(q == 0) \ \&\& \ (r == x) \ \&\& \ (y > 0)$

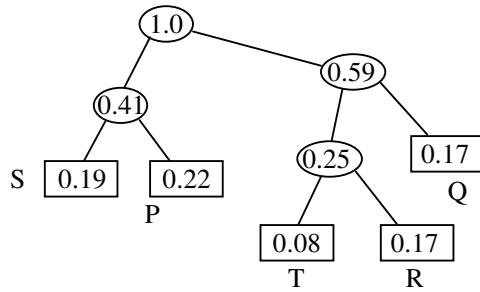
41. A message is made up entirely of characters from the set  $X = \{P, Q, R, S, T\}$ . The table of probabilities for each of the characters is shown below:

| Character    | Probability |
|--------------|-------------|
| P            | 0.22        |
| Q            | 0.34        |
| R            | 0.17        |
| S            | 0.19        |
| T            | 0.08        |
| <b>Total</b> | 1.00        |

If a message of 100 characters over  $X$  is encoded using Huffman coding, then the expected length of the encoded message in bits is \_\_\_\_\_

**Key:** (225)

**Exp:** Huffman tree is as follows



Average length of the character  
 $= 2(0.19 + 0.22) + 2(0.34) + 3(0.08 + 0.17)$   
 $= 2(0.41) + 2(0.34) + 3(0.25)$   
 $= 0.82 + 0.68 + 0.75$   
 $= 2.25 \text{ bits}$   
 $\therefore \text{Message length} = 100 \times 2.25 \text{ bits} = 225 \text{ bits}$

42. The next state table of a 2-bit saturating up-counter is given below.

|       |       |         |         |
|-------|-------|---------|---------|
| $Q_1$ | $Q_0$ | $Q_1^+$ | $Q_0^+$ |
| 0     | 0     | 0       | 1       |
| 0     | 1     | 1       | 0       |
| 1     | 0     | 1       | 1       |
| 1     | 1     | 1       | 1       |

The counter is built as a synchronous sequential circuit using T flip-flops. The expression for  $T_1$  and  $T_0$  are

- (A)  $T_1 = Q_1 Q_0, \quad T_0 = \overline{Q_1} \overline{Q_0}$
- (B)  $T_1 = \overline{Q_1} Q_0, \quad T_0 = \overline{Q_1} + \overline{Q_0}$
- (C)  $T_1 = Q_1 + Q_0, \quad T_0 = \overline{Q_1} + \overline{Q_0}$
- (D)  $T_1 = Q_1 Q_0, \quad T_0 = \overline{Q_1} + \overline{Q_0}$

**Key: (B)**

**Exp:**

|       |       |         |         |       |       |
|-------|-------|---------|---------|-------|-------|
| $Q_1$ | $Q_0$ | $Q_1^+$ | $Q_0^+$ | $T_1$ | $T_0$ |
| 0     | 0     | 0       | 1       | 0     | 1     |
| 0     | 1     | 1       | 0       | 1     | 1     |
| 1     | 0     | 1       | 1       | 0     | 1     |
| 1     | 1     | 1       | 1       | 0     | 0     |

$$T_1 = \overline{Q_1} Q_0$$

$$T_0 = \overline{Q_1} + \overline{Q_0}$$



43. Consider the set of processes with arrival time (in milliseconds). CPU burst time (in milliseconds), and priority (0 is the highest priority) shown below. None of the processes have I/O burst time.

| Process        | Arrival Time | Burst Time | Priority |
|----------------|--------------|------------|----------|
| P <sub>1</sub> | 0            | 11         | 2        |
| P <sub>2</sub> | 5            | 28         | 0        |
| P <sub>3</sub> | 12           | 2          | 3        |
| P <sub>4</sub> | 2            | 10         | 1        |
| P <sub>5</sub> | 9            | 16         | 4        |

The average waiting time (in milliseconds) of all the processes using preemptive priority scheduling algorithm is \_\_\_\_\_

**Key: (29)**

**Exp:**

| PID            | AT | BT | Priority | CT | TAT | Waiting Time |
|----------------|----|----|----------|----|-----|--------------|
| P <sub>1</sub> | 0  | 11 | 2        | 49 | 49  | 38           |
| P <sub>2</sub> | 5  | 28 | 0        | 33 | 28  | 0            |
| P <sub>3</sub> | 12 | 2  | 3        | 51 | 39  | 37           |
| P <sub>4</sub> | 2  | 10 | 1        | 40 | 38  | 28           |
| P <sub>5</sub> | 9  | 16 | 4        | 67 | 58  | 42           |

**Gantt Chart:**

|                |                |                |                |                |                |                |
|----------------|----------------|----------------|----------------|----------------|----------------|----------------|
| P <sub>1</sub> | P <sub>4</sub> | P <sub>2</sub> | P <sub>4</sub> | P <sub>1</sub> | P <sub>3</sub> | P <sub>5</sub> |
|----------------|----------------|----------------|----------------|----------------|----------------|----------------|

0    2    5    33    40    49    51    67

$$\text{Therefore Average waiting time} = \frac{(38 + 0 + 37 + 28 + 42)}{5} = \frac{145}{5} = 29 \text{ ms}$$

44. For any discrete random variable X, with probability mass function

$$P(X = j) = p_j, p_j \geq 0, j \in \{0, \dots, N\} \text{ and } \sum_{j=0}^N p_j = 1, \text{ define the polynomial function}$$

$$g_x(z) = \sum_{j=0}^N p_j z^j \text{ For a certain discrete random variable Y, there exists a scalar } \beta \in [0, 1] \text{ such}$$

that  $g_Y(z) = (1 - \beta + \beta z)^N$ . The expectation of Y is

- (A)  $N\beta(1 - \beta)$
- (B)  $N\beta$
- (C)  $N(1 - \beta)$
- (D) Not expressible in terms of N and  $\beta$  alone

**Key: (B)**

45. The read access times and the hit ratios for different caches in a memory hierarchy are as given below.

| Cache    | Read access time<br>(in nanoseconds) | Hit ratio |
|----------|--------------------------------------|-----------|
| I-cache  | 2                                    | 0.8       |
| D-cache  | 2                                    | 0.9       |
| L2-cache | 8                                    | 0.9       |

The read access time of main memory is 90 nanoseconds. Assume that the caches use the referred word-first read policy and the write back policy. Assume that all the caches are direct mapped caches. Assume that the dirty bit is always 0 for all the blocks in the caches. In execution of a program, 60% of memory reads are for instruction fetch and 40% are for memory operand fetch. The average read access time in nanoseconds (up to 2 decimal places) is \_\_\_\_\_.

**Key:** (4.72)

**Exp:** Given,

| Cache                       | I-Cache | D-Cache | L <sub>2</sub> -Cache | Main Memory |
|-----------------------------|---------|---------|-----------------------|-------------|
| Read Access Time<br>(in ns) | 2       | 2       | 8                     | 90          |
| Hit Ratio                   | 0.8     | 0.9     | 0.9                   | 1.0         |

And in execution of program 60% of memory reads are for instruction fetch and 40% are for memory operand fetch.

Now,

Average instruction fetch time = I-cache access time + I-cache miss ratio \* L<sub>2</sub>-cache access time + I-cache miss rate \* L<sub>2</sub>-cache miss ratio \* main memory access time

$$= 2 + (1 - 0.8) \times 8 + (1 - 0.8) \times (1 - 0.9) \times 90 = 5.4 \text{ n sec}$$

And average data fetch time = D-cache access time + D-cache miss ratio \* L<sub>2</sub>-cache access time + D-cache miss ratio \* L<sub>2</sub>-cache miss ratio \* main memory access time

$$2 + (1 - 0.9) \times 8 + (1 - 0.9) \times (1 - 0.9) \times 90 = 3.7 \text{ n sec}$$

Therefore, average memory access time = Fraction of instruction fetch \* average instruction fetch time + fraction of data fetch \* Average data fetch time  
 $= 0.6 \times 5.4 + 0.4 \times 3.7 = 4.72 \text{ (in n sec)}$

46. If the ordinary generating function of a sequence  $\{a_n\}_{n=0}^{\infty}$  is  $\frac{1+z}{(1-z)^3}$ , then  $a_3 - a_0$  is equal to \_\_\_\_\_.

**Key:** (15)

**Exp:**  $f(z) = \frac{1}{1-z} = 1 + z + z^2 + \dots$

$$f'(z) = \frac{1}{(1-z)^2} = 1 + 2z + 3z^2 + \dots$$

$$\text{Consider } \frac{1+z}{(1-z)^3} = \frac{1}{(1-z)^2} + \frac{2z}{(1-z)^3}$$

$$\frac{1}{(1-z)^2} = 1 + 2z + 3z^2 + 4z^3 \dots$$

$$f''(z) = \frac{2}{(1-z)^3} = +2 + 6z + 12z^2 \dots$$

$$\frac{1}{(1-z)^2} + \frac{2z}{(1-z)^3} = (1 + 2z + 3z^2 + 4z^3 - \dots) + (2z + 6z^2 + 12z^3 \dots)$$

$$= 1 + 4z + 9z^2 + 16z^3 \dots$$

$$= a_0 + a_1z + a_2z^2 + a_3z^3 \dots$$

$$a_0 = 1$$

$$a_3 = 16$$

$$a_3 - a_0 = 16 - 1 = 15$$

47. Consider the following snippet of a C program. Assume that swap (&x, &y) exchanges the contents of x and y.

```
int main () {
int array[]={3,5,1,4,6,2};
int done =0 ;
int i ;
while (done == 0) {
 done = 1;
 for (i = 0; i <=4; i++) {
 if (array [i] < array [i+1]) {
 swap (& array [i], &array [i+1]);
 done = 0;
 }
 }
}
for (i = 5 ; i > =1; i--) {
 if (array [i] > array [i-1]) {
 swap (& array [i] , &array [i-1]);
 done = 0;
 }
}
```

```

}
printf (“ %d “ , array [3]);
}

```

The output of the program is \_\_\_\_\_.

**Key: (3)**

**Exp:** The final contents of the array is

|   |   |   |   |   |   |
|---|---|---|---|---|---|
| 6 | 5 | 4 | 3 | 2 | 1 |
|---|---|---|---|---|---|

$\therefore a[3] = 3$  will be printed

48. Consider the following C program.

```

#include <stdio.h>
int main () {
 int m = 10;
 int n, n1;
 n = ++m;
 n1 = m++;
 n--;
 --n1;
 n - = n1;
 printf (“%d”, n) ;
 return 0;
}

```

The output of the program is \_\_\_\_\_.

**Key: (0)**

**Exp:**  $m = 10$

$n = ++m$  will increment  $m$  & assign it to  $n \Rightarrow n = 11$  &  $m = 1$

$n_1 = m++$  will assign  $m$  to  $n_1$  and then increment  $m$  by 1

$\Rightarrow n_1 = 11, m = 12$

$n--$ ; decrement  $n$  by 1  $\Rightarrow n = 10$

$--n_1$ ; decrement  $n_1$  by 1  $\Rightarrow n_1 = 10$

$n - = n_1$ ; [same as  $n = n - n = 10 - 10 = 0$ ]

$\therefore '0'$  is printed

49. Consider the following database table named *top\_scorer*.

*top\_scorer.*

| Player   | Country | Goals |
|----------|---------|-------|
| Klose    | Germany | 16    |
| Ronald   | Brazil  | 15    |
| G Muller | Germany | 14    |

|           |           |    |
|-----------|-----------|----|
| Fontaine  | France    | 13 |
| Pele      | Brazil    | 12 |
| Klinsmann | Germany   | 11 |
| Kocsis    | Hungary   | 11 |
| Batistuta | Argentina | 10 |
| Cubillas  | Peru      | 10 |
| Lato      | Poland    | 10 |
| Lineker   | England   | 10 |
| T Miller  | Germany   | 10 |
| Rahn      | Germany   | 10 |

Consider the following SQL query:

```
SELECT ta.player FROM top_scorer AS ta
WHERE ta.goals > ALL (SELECT tb.goals
 FROM top_scorer AS tb
 WHERE tb.country = 'Spain')
AND ta.goals > ANY (SELECT tc.goals
 FROM top_scorer AS tc
 WHERE tc.country = 'Germany')
```

The number of tuples returned by the above SQL query is \_\_\_\_\_.

**Key:** (7)

**Exp:** Player

|           |
|-----------|
| Klose     |
| Ronaldo   |
| G Muller  |
| Fontaine  |
| Pele      |
| Klinsmann |
| Kocsis    |

50. Given  $f(w,x,y,z) = \sum_m (0,1,2,3,7,8,10) + \sum_d (5,6,11,15)$ , where  $d$  represents the don't care condition in Karnaugh maps. Which of the following is a minimum product-of-sums (POS) form of  $f(w,x,y,z)$  ?

(A)  $f = (\bar{w} + \bar{z})(\bar{x} + z)$

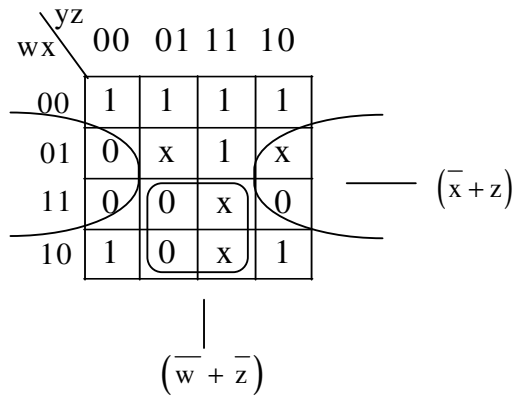
(B)  $f = (\bar{w} + z)(x + z)$

(C)  $f = (w + z)(\bar{x} + z)$

(D)  $f = (w + \bar{z})(\bar{x} + z)$

**Key:** (A)

**Exp:**



$$= (\bar{w} + \bar{z})(\bar{x} + z)$$

51. In a  $B^+$  tree, if the search –key value is 8 bytes long, the block size is 512 bytes and the block pointer size is 2 bytes, then maximum order of the  $B^+$  tree is \_\_\_\_\_.

**Key: (52)**

**Exp:** Let 'K' be the order

$$K(2) + (K - 1)(8) \leq 512$$

$$\Rightarrow 2K + 8k - 8 \leq 512$$

$$\Rightarrow 10K \leq 520 \Rightarrow K \leq \frac{520}{10}$$

$$\therefore K \leq 52$$

52. Let  $L(R)$  be the language represented by regular expression  $R$ . Let  $L(G)$  be the language generated by a context free grammar  $G$ . Let  $L(M)$  be the language accepted by a Turing machine  $M$ . Which of the following decision problems are undecidable ?

I. Given a regular expression  $R$  and a string  $w$ , is  $w \in L(R)$ ?

II. Given a context-free grammar  $G$ ,  $L(G) = \emptyset$ ?

III. Given a context-free grammar  $G$ , is  $L(G) = \Sigma^*$  for some alphabet  $\Sigma$ ?

IV. Given a Turing machine  $M$  and a string  $w$ , is  $w \in L(M)$ ?

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

**Key: (D)**

**Exp:**  $L(R)$  is the language represented by regular expression

$L(G)$  is the language generated by context free grammar

$L(M)$  is the language accepted by Turing Machine

I. The problem a given regular expression  $R$  and a string  $w$ , is  $w \in L(R)$ ?, is a membership problem. Membership problem is decidable for Finite state machine and regular expression.

II. Given Context free grammar  $G$ , is  $L(G) = \emptyset$ ?, is emptiness problem for context free grammar. Emptiness problem is decidable for CFG by checking usefulness of start symbol.

III. A given context free grammar  $G$ , is  $L(G)$  is  $\Sigma^*$  for some alphabet  $\Sigma$ ?, is undecidable problem. We can't check whether  $L(G) = \Sigma^*$  or not but rather we can check complement of  $L(G)$  is  $\phi$ . Since context free language are not closed under complement operation  $\overline{L(G)}$  may be language accepted by Turing Machine and we can't check emptiness for Turing machine.

IV. Given a Turing Machine  $M$  and a string  $w$ , is  $w \in L(M)$ ?, is a membership problem for TM. Membership problem is not a decidable problem for TM.

53. Consider a machine with a byte addressable main memory of  $2^{32}$  bytes divided into blocks of size 32 bytes. Assume that a direct mapped cache having 512 cache lines is used with this machine. The size of the tag field in bits is \_\_\_\_\_.

**Key: (18)**

**Exp:**

$$32 - (5 + 9) = 18$$

$\downarrow$        $\downarrow$        $\swarrow$   
 Total block    block  
           size      identifier

54. Let  $\delta$  denote that transition function and  $\hat{\delta}$  denote the extended transition function of the  $\epsilon$ -NFA whose transition table is given below:

| $\delta$          | $\epsilon$  | a           | b           |
|-------------------|-------------|-------------|-------------|
| $\rightarrow q_0$ | $\{q_2\}$   | $\{q_1\}$   | $\{q_0\}$   |
| $q_1$             | $\{q_2\}$   | $\{q_2\}$   | $\{q_3\}$   |
| $q_2$             | $\{q_0\}$   | $\emptyset$ | $\emptyset$ |
| $q_3$             | $\emptyset$ | $\emptyset$ | $\{q_2\}$   |

Then  $\hat{\delta}(q_2, aba)$  is

- (A)  $\emptyset$                       (B)  $\{q_0, q_1, q_3\}$                       (C)  $\{q_0, q_1, q_2\}$                       (D)  $\{q_0, q_2, q_3\}$

**Key: (C)**

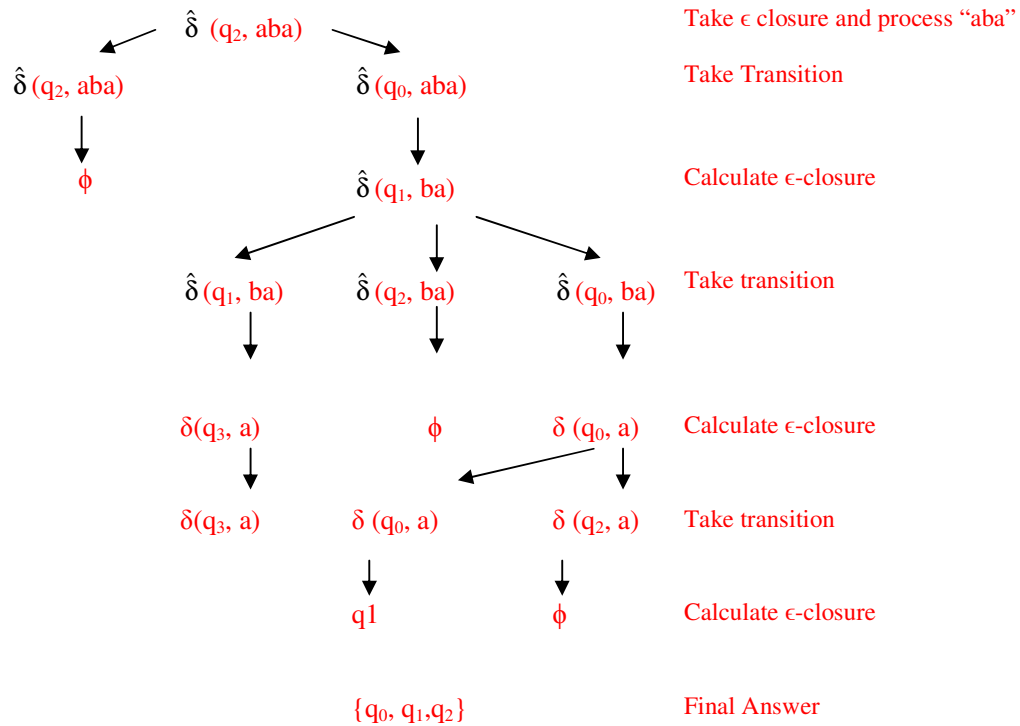
**Exp:**

The given table for NFA- $\epsilon$  Transition is

| $\delta$          | $\epsilon$ | a         | b         |
|-------------------|------------|-----------|-----------|
| $\rightarrow q_0$ | $\{q_2\}$  | $\{q_1\}$ | $\{q_0\}$ |
| $q_1$             | $\{q_2\}$  | $\{q_2\}$ | $\{q_3\}$ |
| $q_2$             | $\{q_0\}$  | $\Phi$    | $\Phi$    |
| $q_3$             | $\Phi$     | $\Phi$    | $\{q_2\}$ |

The process is we start with  $\epsilon$ -closure of  $q_2$  then for each input first take the transition then calculate  $\epsilon$ -closure

$q_2$  is the start for processing we take  $\epsilon$ -closure which is  $\{q_0, q_2\}$  and process "aba"



55. Consider the following languages.

$$L_1 = \{a^p \mid p \text{ is a prime number}\}$$

$$L_2 = \{a^n b^m c^{2m} \mid n \geq 0, m \geq 0\}$$

$$L_3 = \{a^n b^n c^{2n} \mid n \geq 0\}$$

$$L_4 = \{a^n b^n \mid n \geq 1\}$$

Which of the following are CORRECT ?

I.  $L_1$  is context-free but not regular.

II.  $L_2$  is not context-free.

III.  $L_3$  is not context-free but recursive.

IV.  $L_4$  is deterministic context-free.

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

**Key:** (D)

**Exp:** The given languages are

$$L_1 = \{a^p \mid p \text{ is a prime number}\}$$

$$L_2 = \{a^n b^m c^{2m} \mid n \geq 0, m \geq 0\}$$

$$L_3 = \{a^n b^n c^{2n} \mid n \geq 0\}$$

$$L_4 = \{a^n b^n \mid n \geq 1\}$$

Statements are:

I.  $L_1$  is context free but not regular is **INCORRECT**, It required a Turing machine to accept  $L_1$ .



II.  $L_2$  is not context free is **INCORRECT**; the context free grammar is

$$S \rightarrow XY$$

$$X \rightarrow aX\epsilon$$

$$Y \rightarrow bYc\epsilon$$

III.  $L_3$  is not context free but recursive is **CORRECT**.  $L_3$  is standard context sensitive language.

IV.  $L_4$  is deterministic context free is **CORRECT**; the grammar is

$$S \rightarrow aSblab$$

**General Aptitude**

**Q. No. 1 - 5 Carry One Mark Each**

1. There are 3 red socks, 4 green socks and 3 blue socks, you choose 2 socks. The probability that they are of the same colour is \_\_\_\_\_.

- (A) 1/5                      (B) 7/30                      (C) 1/4                      (D) 4/15

**Key: (D)**

**Exp:** Required probability =  $\frac{{}^3C_2 + {}^4C_2 + {}^3C_2}{{}^{10}C_2} = \frac{4}{15}$

2. Choose the option with words that are not synonyms.

- (A) aversion, dislike                      (B) luminous, radiant  
(C) plunder, loot                      (D) yielding, resistant

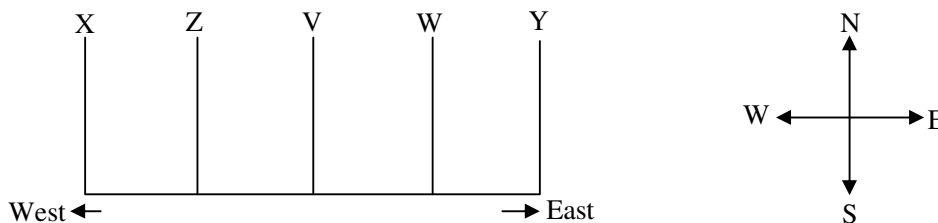
**Key: (D)**

3. There are five buildings called V, W, X, Y and Z in a row (not necessarily in that order). V is to the west of W. Z is to the East of X and the West of V. W is to the West of Y. Which is the building in the middle ?

- (A) V                      (B) W                      (C) X                      (D) Y

**Key: (A)**

**Exp:** From the given data, the following is formed



**∴ The building 'V' is in the middle**

4. A test has twenty questions worth 100 marks in total. There are two types of questions, multiple choice questions are worth 3 marks each and essay questions are worth 11 marks each. How many multiple choice questions does the exam have?

- (A) 12                      (B) 15                      (C) 18                      (D) 19

**Key:** (B)

**Exp:**  $x + y = 20$  (  $x = \text{MCQ}, y = \text{Essay type}$  )

$$3x + 11y = 100$$

$$\Rightarrow x = 15, y = 5$$

5. Saturn is \_\_\_\_ to be seen on a clear night with the naked eye.

- (A) enough bright (B) bright enough  
(C) as enough bright (D) bright as enough

**Key:** (B)

**Q. No. 6 – 10 Carry Two Marks Each**

6. "We lived in a culture that denied any merit to literary works, considering them important only when they were handmaidens to something seemingly more urgent - namely ideology. This was a country where all gestures, even the most private, were interpreted in political terms."

The author's belief that ideology is not as important as literature is revealed by the word:

- (A) 'culture' (B) 'seemingly' (C) 'urgent' (D) 'political'

**Key:** (B)

7. X is a 30 digit number starting with the digit 4 followed by the digit 7, then the number  $X^3$  will have

- (A) 90 digits (B) 91 digits (C) 92 digits (D) 93 digits

**Key:** (A)

**Exp:**  $X = (47\text{.....})_{30 \text{ digits}}$

$$\text{Suppose } (47)_{30 \text{ digits}}^3 = (2 + 2 + 2) \text{ digits in } (47)^3$$

$$\text{Similarly } (47)_{30 \text{ digits}}^3 = \text{contains } (30 + 30 + 30) \text{ digits} = 90 \text{ digits.}$$

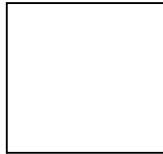
8. There are three boxes, one contains apples, another contains oranges and the last one contains both apples and oranges. All three are known to be incorrectly labelled. If you are permitted to open just one box and then pull out and inspect only one fruit, which box would you open to determine the contents of all three boxes?

- (A) The box labelled 'Apples' (B) The box labelled 'Apples and Oranges'  
(C) The box labelled 'Oranges' (D) Cannot be determined

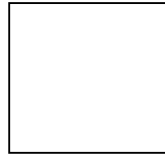
**Key:** (B)

**Exp:** The person who is opening the boxes, he knew that all 3 are marked wrong.

Suppose if 3 boxes are labelled as below.



(1) Apples



(2) Oranges



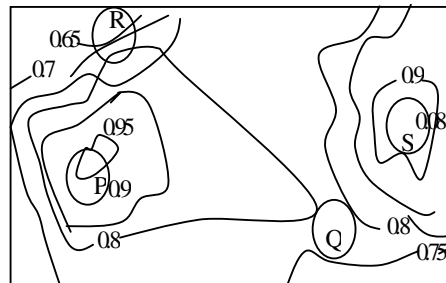
(3) Apples & Oranges

If he inspected from Box(1), picked one fruit, found orange, then he don't know whether box contains oranges (or) both apples and oranges.

Similarly, if he picked one fruit from box(2), found apple then he don't know whether box contain apples (or) both apples and oranges.

But if he picked one fruit from box(3), i.e., labelled is "apples and oranges", if he found apple then he can decide compulsorily that box(3) contains apples and as he knew all boxes are labelled as incorrect, he can tell box(2) contains both apples and oranges, box(1) contain remaining oranges. So, he should open box labelled 'Apples and Oranges' to determine contents of all the three boxes.

9. An air pressure contour line joins locations in a region having the same atmospheric pressure . The following is an air contour plot of a geographical region . Contour lines are shown at 0.05 bar intervals in this plot.



If the possibility of a thunderstorm is given by how fast air pressure rises or drops over a region, which of the following regions is most likely to have a thunderstorm?

- (A) P                      (B) Q                      (C) R                      (D) S

**Key:** (C)

**Exp:**

| Region | Air pressure difference |
|--------|-------------------------|
| P      | $0.95 - 0.90 = 0.05$    |
| Q      | $0.80 - 0.75 = 0.05$    |
| R      | $0.85 - 0.65 = 0.20$    |
| S      | $0.95 - 0.90 = 0.05$    |

In general thunder storms are occurred in a region where suddenly air pressure changes (i.e.,) sudden rise (or) sudden fall of air pressure. From the given contour map in 'R' region only more changes in air pressure. So, the possibility of a thunder storms in this region.

So option (C) is correct.

10. The number of roots of  $e^x + 0.5x^2 - 2 = 0$  in the range  $[-5, 5]$  is  
(A) 0                      (B) 1                      (C) 2                      (D) 3

**Key:** (A)

**Exp:**  $f(x) = e^x + 0.5x^2 - 2$

$$f(-5) = 10.50; f(-4) = 6.01, f(-2) = 0.135; f(-1) = -1.13;$$

$$f(0) = -1, f(1) = 1.21, f(2) = 7.38, f(3), f(4), f(5) \text{ also } +ve.$$

$\therefore$  As there are 2 sign changes from +ve to -ve and -ve to +ve, two roots will be there in the range  $[-5, 5]$ .

**GATE Previous Year  
Solved Paper  
Computer Science**

**2018**

**Q. 1 – Q. 5 carry one mark each.**

Q.1 “From where are they bringing their books? \_\_\_\_\_ bringing \_\_\_\_\_ books from \_\_\_\_\_.”

The words that best fill the blanks in the above sentence are

- (A) Their, they're, there
- (B) They're, their, there
- (C) There, their, they're
- (D) They're, there, there

Q.2 “A \_\_\_\_\_ investigation can sometimes yield new facts, but typically organized ones are more successful.”

The word that best fills the blank in the above sentence is

- (A) meandering
- (B) timely
- (C) consistent
- (D) systematic

Q.3 The area of a square is  $d$ . What is the area of the circle which has the diagonal of the square as its diameter?

- (A)  $\pi d$
- (B)  $\pi d^2$
- (C)  $\frac{1}{4} \pi d^2$
- (D)  $\frac{1}{2} \pi d$

Q.4 What would be the smallest natural number which when divided either by 20 or by 42 or by 76 leaves a remainder of 7 in each case?

- (A) 3047
- (B) 6047
- (C) 7987
- (D) 63847

Q.5 What is the missing number in the following sequence?

2, 12, 60, 240, 720, 1440, \_\_\_\_\_, 0

- (A) 2880
- (B) 1440
- (C) 720
- (D) 0

Q. 6 – Q. 10 carry two marks each.

Q.6 In appreciation of the social improvements completed in a town, a wealthy philanthropist decided to gift Rs 750 to each male senior citizen in the town and Rs 1000 to each female senior citizen. Altogether, there were 300 senior citizens eligible for this gift. However, only  $\frac{8}{9}$ th of the eligible men and  $\frac{2}{3}$ rd of the eligible women claimed the gift. How much money (in Rupees) did the philanthropist give away in total?

- (A) 1,50,000 (B) 2,00,000  
(C) 1,75,000 (D) 1,51,000

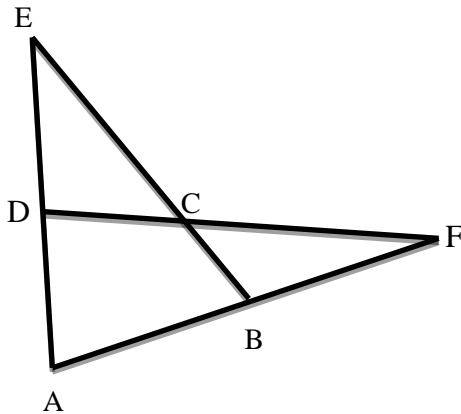
Q.7 If  $pqr \neq 0$  and  $p^{-x} = \frac{1}{q}$ ,  $q^{-y} = \frac{1}{r}$ ,  $r^{-z} = \frac{1}{p}$ , what is the value of the product  $xyz$ ?

- (A)  $-1$  (B)  $\frac{1}{pqr}$  (C)  $1$  (D)  $pqr$

Q.8 In a party, 60% of the invited guests are male and 40% are female. If 80% of the invited guests attended the party and if all the invited female guests attended, what would be the ratio of males to females among the attendees in the party?

- (A) 2:3 (B) 1:1 (C) 3:2 (D) 2:1

Q.9 In the figure below,  $\angle DEC + \angle BFC$  is equal to \_\_\_\_\_ .



- (A)  $\angle BCD - \angle BAD$  (B)  $\angle BAD + \angle BCF$   
(C)  $\angle BAD + \angle BCD$  (D)  $\angle CBA + \angle ADC$

- Q.10 A six sided unbiased die with four green faces and two red faces is rolled seven times. Which of the following combinations is the most likely outcome of the experiment?
- (A) Three green faces and four red faces.
  - (B) Four green faces and three red faces.
  - (C) Five green faces and two red faces.
  - (D) Six green faces and one red face.

**END OF THE QUESTION PAPER**



**Q. 1 – Q. 25 carry one mark each.**

Q.1 Which one of the following is a closed form expression for the generating function of the sequence  $\{a_n\}$ , where  $a_n = 2n + 3$  for all  $n = 0, 1, 2, \dots$  ?

- (A)  $\frac{3}{(1-x)^2}$       (B)  $\frac{3x}{(1-x)^2}$       (C)  $\frac{2-x}{(1-x)^2}$       (D)  $\frac{3-x}{(1-x)^2}$

Q.2 Consider the following C program.

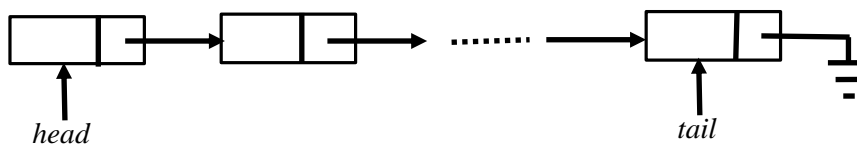
```
#include<stdio.h>
struct Ournode{
 char x,y,z;
};

int main(){
 struct Ournode p = {'1', '0', 'a'+2};
 struct Ournode *q = &p;
 printf ("%c, %c", *((char*)q+1), *((char*)q+2));
 return 0;
}
```

The output of this program is:

- (A) 0, c      (B) 0, a+2      (C) '0', 'a+2'      (D) '0', 'c'

Q.3 A queue is implemented using a non-circular singly linked list. The queue has a head pointer and a tail pointer, as shown in the figure. Let  $n$  denote the number of nodes in the queue. Let enqueue be implemented by inserting a new node at the head, and dequeue be implemented by deletion of a node from the tail.



Which one of the following is the time complexity of the most time-efficient implementation of enqueue and dequeue, respectively, for this data structure?

- (A)  $\theta(1), \theta(1)$       (B)  $\theta(1), \theta(n)$       (C)  $\theta(n), \theta(1)$       (D)  $\theta(n), \theta(n)$

Q.4 Let  $\oplus$  and  $\odot$  denote the Exclusive OR and Exclusive NOR operations, respectively. Which one of the following is NOT CORRECT?

- (A)  $\overline{P \oplus Q} = P \odot Q$   
 (B)  $\overline{P} \oplus Q = P \odot Q$   
 (C)  $\overline{P} \oplus \overline{Q} = P \oplus Q$   
 (D)  $(P \oplus \overline{P}) \oplus Q = (P \odot \overline{P}) \odot \overline{Q}$

Q.5 Consider the following processor design characteristics.

- I. Register-to-register arithmetic operations only  
 II. Fixed-length instruction format  
 III. Hardwired control unit

Which of the characteristics above are used in the design of a RISC processor?

- (A) I and II only      (B) II and III only      (C) I and III only      (D) I, II and III

Q.6 Let  $N$  be an NFA with  $n$  states. Let  $k$  be the number of states of a minimal DFA which is equivalent to  $N$ . Which one of the following is necessarily true?

- (A)  $k \geq 2^n$       (B)  $k \geq n$       (C)  $k \leq n^2$       (D)  $k \leq 2^n$

Q.7 The set of all recursively enumerable languages is

- (A) closed under complementation.  
 (B) closed under intersection.  
 (C) a subset of the set of all recursive languages.  
 (D) an uncountable set.

Q.8 Which one of the following statements is FALSE?

- (A) Context-free grammar can be used to specify both lexical and syntax rules.  
 (B) Type checking is done before parsing.  
 (C) High-level language programs can be translated to different Intermediate Representations.  
 (D) Arguments to a function can be passed using the program stack.



Q.12 Consider the following two tables and four queries in SQL.

Book (isbn, bname), Stock (isbn, copies)

- Query 1:      SELECT B.isbn, S.copies  
                  FROM Book B INNER JOIN Stock S  
                  ON B.isbn = S.isbn;
- Query 2:      SELECT B.isbn, S.copies  
                  FROM Book B LEFT OUTER JOIN Stock S  
                  ON B.isbn = S.isbn;
- Query 3:      SELECT B.isbn, S.copies  
                  FROM Book B RIGHT OUTER JOIN Stock S  
                  ON B.isbn = S.isbn;
- Query 4:      SELECT B.isbn, S.copies  
                  FROM Book B FULL OUTER JOIN Stock S  
                  ON B.isbn = S.isbn;

Which one of the queries above is certain to have an output that is a superset of the outputs of the other three queries?

- (A) Query 1      (B) Query 2      (C) Query 3      (D) Query 4

Q.13 Match the following:

| <u>Field</u>                    | <u>Length in bits</u> |
|---------------------------------|-----------------------|
| P. UDP Header's Port Number     | I. 48                 |
| Q. Ethernet MAC Address         | II. 8                 |
| R. IPv6 Next Header             | III. 32               |
| S. TCP Header's Sequence Number | IV. 16                |

- (A) P-III, Q-IV, R-II, S-I      (B) P-II, Q-I, R-IV, S-III  
(C) P-IV, Q-I, R-II, S-III      (D) P-IV, Q-I, R-III, S-II

Q.14 Consider the following statements regarding the slow start phase of the TCP congestion control algorithm. Note that  $cwnd$  stands for the TCP congestion window and MSS denotes the Maximum Segment Size.

- (i) The  $cwnd$  increases by 2 MSS on every successful acknowledgment.
- (ii) The  $cwnd$  approximately doubles on every successful acknowledgement.
- (iii) The  $cwnd$  increases by 1 MSS every round trip time.
- (iv) The  $cwnd$  approximately doubles every round trip time.

Which one of the following is correct?

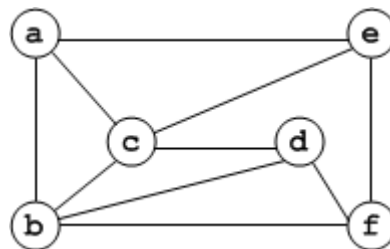
- (A) Only (ii) and (iii) are true
- (B) Only (i) and (iii) are true
- (C) Only (iv) is true
- (D) Only (i) and (iv) are true

Q.15 Two people, P and Q, decide to independently roll two identical dice, each with 6 faces, numbered 1 to 6. The person with the lower number wins. In case of a tie, they roll the dice repeatedly until there is no tie. Define a trial as a throw of the dice by P and Q. Assume that all 6 numbers on each dice are equi-probable and that all trials are independent. The probability (rounded to 3 decimal places) that one of them wins on the third trial is \_\_\_\_\_.

Q.16 The value of  $\int_0^{\pi/4} x \cos(x^2) dx$  correct to three decimal places (assuming that  $\pi = 3.14$ ) is \_\_\_\_\_.

Q.17 Consider a matrix  $A = uv^T$  where  $u = \begin{pmatrix} 1 \\ 2 \end{pmatrix}$ ,  $v = \begin{pmatrix} 1 \\ 1 \end{pmatrix}$ . Note that  $v^T$  denotes the transpose of  $v$ . The largest eigenvalue of  $A$  is \_\_\_\_\_.

Q.18 The chromatic number of the following graph is \_\_\_\_\_.



Q.19 Let  $G$  be a finite group on 84 elements. The size of a largest possible proper subgroup of  $G$  is \_\_\_\_\_.

Q.20 The postorder traversal of a binary tree is 8,9,6,7,4,5,2,3,1. The inorder traversal of the same tree is 8,6,9,4,7,2,5,1,3. The height of a tree is the length of the longest path from the root to any leaf. The height of the binary tree above is \_\_\_\_\_.

Q.21 Consider the following C program:

```
#include <stdio.h>

int counter = 0;

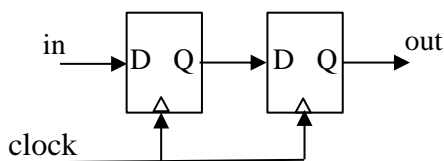
int calc (int a, int b) {
 int c;

 counter++;
 if (b==3) return (a*a*a);
 else {
 c = calc(a, b/3);
 return (c*c*c);
 }
}

int main (){
 calc(4, 81);
 printf ("%d", counter);
}
```

The output of this program is \_\_\_\_\_.

Q.22 Consider the sequential circuit shown in the figure, where both flip-flops used are positive edge-triggered D flip-flops.



The number of states in the state transition diagram of this circuit that have a transition back to the same state on some value of “in” is \_\_\_\_\_.

- Q.23 A 32-bit wide main memory unit with a capacity of 1 GB is built using  $256\text{M} \times 4\text{-bit}$  DRAM chips. The number of rows of memory cells in the DRAM chip is  $2^{14}$ . The time taken to perform one refresh operation is 50 nanoseconds. The refresh period is 2 milliseconds. The percentage (rounded to the closest integer) of the time available for performing the memory read/write operations in the main memory unit is \_\_\_\_\_.
- Q.24 Consider a system with 3 processes that share 4 instances of the same resource type. Each process can request a maximum of  $K$  instances. Resource instances can be requested and released only one at a time. The largest value of  $K$  that will always avoid deadlock is \_\_\_\_\_.
- Q.25 Consider a long-lived TCP session with an end-to-end bandwidth of 1 Gbps ( $= 10^9$  bits-per-second). The session starts with a sequence number of 1234. The minimum time (in seconds, rounded to the closest integer) before this sequence number can be used again is \_\_\_\_\_.

**Q. 26 – Q. 55 carry two marks each.**

- Q.26 Consider a matrix  $P$  whose only eigenvectors are the multiples of  $\begin{bmatrix} 1 \\ 4 \end{bmatrix}$ .
- Consider the following statements.
- (I)  $P$  does not have an inverse
  - (II)  $P$  has a repeated eigenvalue
  - (III)  $P$  cannot be diagonalized

Which one of the following options is correct?

- (A) Only I and III are necessarily true
- (B) Only II is necessarily true
- (C) Only I and II are necessarily true
- (D) Only II and III are necessarily true

Q.27 Let  $N$  be the set of natural numbers. Consider the following sets.

- $P$ : Set of Rational numbers (positive and negative)
- $Q$ : Set of functions from  $\{0, 1\}$  to  $N$
- $R$ : Set of functions from  $N$  to  $\{0, 1\}$
- $S$ : Set of finite subsets of  $N$ .

Which of the sets above are countable?

- (A)  $Q$  and  $S$  only      (B)  $P$  and  $S$  only      (C)  $P$  and  $R$  only      (D)  $P$ ,  $Q$  and  $S$  only

Q.28 Consider the first-order logic sentence

$$\varphi \equiv \exists s \exists t \exists u \forall v \forall w \forall x \forall y \psi(s, t, u, v, w, x, y)$$

where  $\psi(s, t, u, v, w, x, y)$  is a quantifier-free first-order logic formula using only predicate symbols, and possibly equality, but no function symbols. Suppose  $\varphi$  has a model with a universe containing 7 elements.

Which one of the following statements is necessarily true?

- (A) There exists at least one model of  $\varphi$  with universe of size less than or equal to 3.
- (B) There exists no model of  $\varphi$  with universe of size less than or equal to 3.
- (C) There exists no model of  $\varphi$  with universe of size greater than 7.
- (D) Every model of  $\varphi$  has a universe of size equal to 7.



Q.29 Consider the following C program:

```
#include<stdio.h>

void fun1(char *s1, char *s2){
 char *tmp;
 tmp = s1;
 s1 = s2;
 s2 = tmp;
}

void fun2(char **s1, char **s2){
 char *tmp;
 tmp = *s1;
 *s1 = *s2;
 *s2 = tmp;
}

int main(){
 char *str1 = "Hi", *str2 = "Bye";
 fun1(str1, str2); printf("%s %s ", str1, str2);
 fun2(&str1, &str2); printf("%s %s", str1, str2);
 return 0;
}
```

The output of the program above is

- |                   |                   |
|-------------------|-------------------|
| (A) Hi Bye Bye Hi | (B) Hi Bye Hi Bye |
| (C) Bye Hi Hi Bye | (D) Bye Hi Bye Hi |

Q.30 Let  $G$  be a simple undirected graph. Let  $T_D$  be a depth first search tree of  $G$ . Let  $T_B$  be a breadth first search tree of  $G$ . Consider the following statements.

- (I) No edge of  $G$  is a cross edge with respect to  $T_D$ . (A cross edge in  $G$  is between two nodes neither of which is an ancestor of the other in  $T_D$ .)
- (II) For every edge  $(u,v)$  of  $G$ , if  $u$  is at depth  $i$  and  $v$  is at depth  $j$  in  $T_B$ , then  $|i - j| = 1$ .

Which of the statements above must necessarily be true?

- |                   |                      |
|-------------------|----------------------|
| (A) I only        | (B) II only          |
| (C) Both I and II | (D) Neither I nor II |

- Q.31 Assume that multiplying a matrix  $G_1$  of dimension  $p \times q$  with another matrix  $G_2$  of dimension  $q \times r$  requires  $pqr$  scalar multiplications. Computing the product of  $n$  matrices  $G_1G_2G_3\dots G_n$  can be done by parenthesizing in different ways. Define  $G_i G_{i+1}$  as an **explicitly computed pair** for a given paranthesization if they are directly multiplied. For example, in the matrix multiplication chain  $G_1G_2G_3G_4G_5G_6$  using parenthesization  $(G_1(G_2G_3))(G_4(G_5G_6))$ ,  $G_2G_3$  and  $G_5G_6$  are the only explicitly computed pairs.

Consider a matrix multiplication chain  $F_1F_2F_3F_4F_5$ , where matrices  $F_1, F_2, F_3, F_4$  and  $F_5$  are of dimensions  $2 \times 25, 25 \times 3, 3 \times 16, 16 \times 1$  and  $1 \times 1000$ , respectively. In the parenthesization of  $F_1F_2F_3F_4F_5$  that minimizes the total number of scalar multiplications, the explicitly computed pairs is/are

- (A)  $F_1F_2$  and  $F_3F_4$  only  
 (B)  $F_2F_3$  only  
 (C)  $F_3F_4$  only  
 (D)  $F_1F_2$  and  $F_4F_5$  only
- Q.32 Consider the following C code. Assume that unsigned long int type length is 64 bits.

```
unsigned long int fun(unsigned long int n){
 unsigned long int i, j = 0, sum = 0;
 for (i = n; i > 1; i = i/2) j++;
 for (; j > 1; j = j/2) sum++;
 return(sum);
}
```

The value returned when we call fun with the input  $2^{40}$  is

- (A) 4  
 (B) 5  
 (C) 6  
 (D) 40
- Q.33 Consider the unsigned 8-bit fixed point binary number representation below,

$$b_7 \ b_6 \ b_5 \ b_4 \ b_3 \ . \ b_2 \ b_1 \ b_0$$

where the position of the binary point is between  $b_3$  and  $b_2$ . Assume  $b_7$  is the most significant bit. Some of the decimal numbers listed below **cannot** be represented **exactly** in the above representation:

(i) 31.500    (ii) 0.875    (iii) 12.100    (iv) 3.001

Which one of the following statements is true?

- (A) None of (i), (ii), (iii), (iv) can be exactly represented  
 (B) Only (ii) cannot be exactly represented  
 (C) Only (iii) and (iv) cannot be exactly represented  
 (D) Only (i) and (ii) cannot be exactly represented

Q.34 The size of the physical address space of a processor is  $2^P$  bytes. The word length is  $2^W$  bytes. The capacity of cache memory is  $2^N$  bytes. The size of each cache block is  $2^M$  words. For a  $K$ -way set-associative cache memory, the length (in number of bits) of the tag field is

- (A)  $P - N - \log_2 K$  (B)  $P - N + \log_2 K$   
 (C)  $P - N - M - W - \log_2 K$  (D)  $P - N - M - W + \log_2 K$

Q.35 Consider the following languages:

- I.  $\{a^m b^n c^p d^q \mid m + p = n + q, \text{ where } m, n, p, q \geq 0\}$   
 II.  $\{a^m b^n c^p d^q \mid m = n \text{ and } p = q, \text{ where } m, n, p, q \geq 0\}$   
 III.  $\{a^m b^n c^p d^q \mid m = n = p \text{ and } p \neq q, \text{ where } m, n, p, q \geq 0\}$   
 IV.  $\{a^m b^n c^p d^q \mid mn = p + q, \text{ where } m, n, p, q \geq 0\}$

Which of the languages above are context-free?

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

Q.36 Consider the following problems.  $L(G)$  denotes the language generated by a grammar  $G$ .  $L(M)$  denotes the language accepted by a machine  $M$ .

- (I) For an unrestricted grammar  $G$  and a string  $w$ , whether  $w \in L(G)$   
 (II) Given a Turing machine  $M$ , whether  $L(M)$  is regular  
 (III) Given two grammars  $G_1$  and  $G_2$ , whether  $L(G_1) = L(G_2)$   
 (IV) Given an NFA  $N$ , whether there is a deterministic PDA  $P$  such that  $N$  and  $P$  accept the same language.

Which one of the following statements is correct?

- (A) Only I and II are undecidable (B) Only III is undecidable  
 (C) Only II and IV are undecidable (D) Only I, II and III are undecidable

Q.37 A lexical analyzer uses the following patterns to recognize three tokens  $T_1$ ,  $T_2$ , and  $T_3$  over the alphabet  $\{a,b,c\}$ .

$$T_1: a?(b|c)^*a$$

$$T_2: b?(a|c)^*b$$

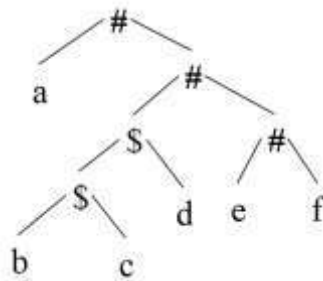
$$T_3: c?(b|a)^*c$$

Note that ' $x?$ ' means 0 or 1 occurrence of the symbol  $x$ . Note also that the analyzer outputs the token that matches the longest possible prefix.

If the string  $bbaacabc$  is processed by the analyzer, which one of the following is the sequence of tokens it outputs?

- (A)  $T_1T_2T_3$       (B)  $T_1T_1T_3$       (C)  $T_2T_1T_3$       (D)  $T_3T_3$

Q.38 Consider the following parse tree for the expression  $a\#b\$c\$d\#e\#f$ , involving two binary operators  $\$$  and  $\#$ .



Which one of the following is correct for the given parse tree?

- (A)  $\$$  has higher precedence and is left associative;  $\#$  is right associative  
 (B)  $\#$  has higher precedence and is left associative;  $\$$  is right associative  
 (C)  $\$$  has higher precedence and is left associative;  $\#$  is left associative  
 (D)  $\#$  has higher precedence and is right associative;  $\$$  is left associative

- Q.39 In a system, there are three types of resources:  $E$ ,  $F$  and  $G$ . Four processes  $P_0$ ,  $P_1$ ,  $P_2$  and  $P_3$  execute concurrently. At the outset, the processes have declared their maximum resource requirements using a matrix named Max as given below. For example,  $\text{Max}[P_2, F]$  is the maximum number of instances of  $F$  that  $P_2$  would require. The number of instances of the resources allocated to the various processes at any given state is given by a matrix named Allocation.

Consider a state of the system with the Allocation matrix as shown below, and in which 3 instances of  $E$  and 3 instances of  $F$  are the only resources available.

| Allocation |     |     |     |
|------------|-----|-----|-----|
|            | $E$ | $F$ | $G$ |
| $P_0$      | 1   | 0   | 1   |
| $P_1$      | 1   | 1   | 2   |
| $P_2$      | 1   | 0   | 3   |
| $P_3$      | 2   | 0   | 0   |

| Max   |     |     |     |
|-------|-----|-----|-----|
|       | $E$ | $F$ | $G$ |
| $P_0$ | 4   | 3   | 1   |
| $P_1$ | 2   | 1   | 4   |
| $P_2$ | 1   | 3   | 3   |
| $P_3$ | 5   | 4   | 1   |

From the perspective of deadlock avoidance, which one of the following is true?

- (A) The system is in *safe* state.
- (B) The system is not in *safe* state, but would be *safe* if one more instance of  $E$  were available
- (C) The system is not in *safe* state, but would be *safe* if one more instance of  $F$  were available
- (D) The system is not in *safe* state, but would be *safe* if one more instance of  $G$  were available

- Q.40 Consider the following solution to the producer-consumer synchronization problem. The shared buffer size is  $N$ . Three semaphores *empty*, *full* and *mutex* are defined with respective initial values of 0,  $N$  and 1. Semaphore *empty* denotes the number of available slots in the buffer, for the consumer to read from. Semaphore *full* denotes the number of available slots in the buffer, for the producer to write to. The placeholder variables, denoted by  $P$ ,  $Q$ ,  $R$ , and  $S$ , in the code below can be assigned either *empty* or *full*. The valid semaphore operations are: `wait()` and `signal()`.

| Producer:                                                                                                          | Consumer:                                                                                                                |
|--------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------|
| <pre>do{     wait(P);     wait(mutex);     //Add item to buffer     signal(mutex);     signal(Q); }while(1);</pre> | <pre>do{     wait(R);     wait(mutex);     //Consume item from buffer     signal(mutex);     signal(S); }while(1);</pre> |

Which one of the following assignments to  $P$ ,  $Q$ ,  $R$  and  $S$  will yield the correct solution?

- (A)  $P: full, Q: full, R: empty, S: empty$   
 (B)  $P: empty, Q: empty, R: full, S: full$   
 (C)  $P: full, Q: empty, R: empty, S: full$   
 (D)  $P: empty, Q: full, R: full, S: empty$
- Q.41 Consider the relations  $r(A, B)$  and  $s(B, C)$ , where  $s.B$  is a primary key and  $r.B$  is a foreign key referencing  $s.B$ . Consider the query

$$Q: r \bowtie (\sigma_{B < 5}(s))$$

Let *LOJ* denote the natural left outer-join operation. Assume that  $r$  and  $s$  contain no null values.

Which one of the following queries is NOT equivalent to  $Q$ ?

- (A)  $\sigma_{B < 5}(r \bowtie s)$                       (B)  $\sigma_{B < 5}(r \text{ LOJ } s)$   
 (C)  $r \text{ LOJ } (\sigma_{B < 5}(s))$                       (D)  $\sigma_{B < 5}(r) \text{ LOJ } s$

Q.42 Consider the following four relational schemas. For each schema, all non-trivial functional dependencies are listed. The underlined attributes are the respective primary keys.

Schema I: *Registration* (*rollno*, *courses*)

Field '*courses*' is a set-valued attribute containing the set of courses a student has registered for.

Non-trivial functional dependency:

*rollno* → *courses*

Schema II: *Registration* (*rollno*, *courseid*, *email*)

Non-trivial functional dependencies:

*rollno*, *courseid* → *email*

*email* → *rollno*

Schema III: *Registration* (*rollno*, *courseid*, *marks*, *grade*)

Non-trivial functional dependencies:

*rollno*, *courseid* → *marks*, *grade*

*marks* → *grade*

Schema IV: *Registration* (*rollno*, *courseid*, *credit*)

Non-trivial functional dependencies:

*rollno*, *courseid* → *credit*

*courseid* → *credit*

Which one of the relational schemas above is in 3NF but not in BCNF?

(A) Schema I

(B) Schema II

(C) Schema III

(D) Schema IV

Q.43 Let  $G$  be a graph with  $100!$  vertices, with each vertex labelled by a distinct permutation of the numbers  $1, 2, \dots, 100$ . There is an edge between vertices  $u$  and  $v$  if and only if the label of  $u$  can be obtained by swapping two adjacent numbers in the label of  $v$ . Let  $y$  denote the degree of a vertex in  $G$ , and  $z$  denote the number of connected components in  $G$ . Then,  $y + 10z = \underline{\hspace{2cm}}$ .

- Q.44 Consider Guwahati (G) and Delhi (D) whose temperatures can be classified as high ( $H$ ), medium ( $M$ ) and low ( $L$ ). Let  $P(H_G)$  denote the probability that Guwahati has high temperature. Similarly,  $P(M_G)$  and  $P(L_G)$  denotes the probability of Guwahati having medium and low temperatures respectively. Similarly, we use  $P(H_D)$ ,  $P(M_D)$  and  $P(L_D)$  for Delhi.

The following table gives the conditional probabilities for Delhi's temperature given Guwahati's temperature.

|       | $H_D$ | $M_D$ | $L_D$ |
|-------|-------|-------|-------|
| $H_G$ | 0.40  | 0.48  | 0.12  |
| $M_G$ | 0.10  | 0.65  | 0.25  |
| $L_G$ | 0.01  | 0.50  | 0.49  |

Consider the first row in the table above. The first entry denotes that if Guwahati has high temperature ( $H_G$ ) then the probability of Delhi also having a high temperature ( $H_D$ ) is 0.40; i.e.,  $P(H_D|H_G) = 0.40$ . Similarly, the next two entries are  $P(M_D|H_G) = 0.48$  and  $P(L_D|H_G) = 0.12$ . Similarly for the other rows.

If it is known that  $P(H_G) = 0.2$ ,  $P(M_G) = 0.5$ , and  $P(L_G) = 0.3$ , then the probability (correct to two decimal places) that Guwahati has high temperature given that Delhi has high temperature is \_\_\_\_\_.

- Q.45 Consider the following program written in pseudo-code. Assume that  $x$  and  $y$  are integers.

```

Count(x, y) {
 if (y != 1) {
 if (x != 1) {
 print("*");
 Count(x/2, y);
 }
 else {
 y = y-1;
 Count(1024, y);
 }
 }
}

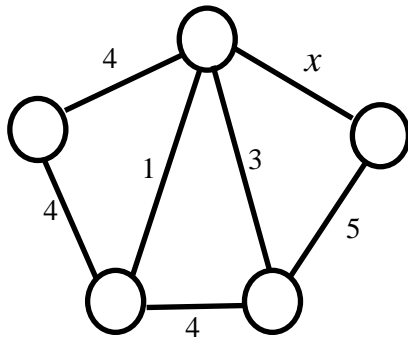
```

The number of times that the print statement is executed by the call  $\text{Count}(1024, 1024)$  is \_\_\_\_\_.

- Q.46 The number of possible min-heaps containing each value from  $\{1, 2, 3, 4, 5, 6, 7\}$  exactly once is \_\_\_\_\_.



Q.47 Consider the following undirected graph G:



Choose a value for  $x$  that will maximize the number of minimum weight spanning trees (MWSTs) of G. The number of MWSTs of G for this value of  $x$  is \_\_\_\_\_.

Q.48 Consider the weights and values of items listed below. Note that there is only one unit of each item.

| Item number | Weight (in Kgs) | Value (in Rupees) |
|-------------|-----------------|-------------------|
| 1           | 10              | 60                |
| 2           | 7               | 28                |
| 3           | 4               | 20                |
| 4           | 2               | 24                |

The task is to pick a subset of these items such that their total weight is no more than 11 Kgs and their total value is maximized. Moreover, no item may be split. The total value of items picked by an optimal algorithm is denoted by  $V_{opt}$ . A greedy algorithm sorts the items by their value-to-weight ratios in descending order and packs them greedily, starting from the first item in the ordered list. The total value of items picked by the greedy algorithm is denoted by  $V_{greedy}$ .

The value of  $V_{opt} - V_{greedy}$  is \_\_\_\_\_.

Q.49 Consider the minterm list form of a Boolean function  $F$  given below.

$$F(P, Q, R, S) = \sum m(0, 2, 5, 7, 9, 11) + d(3, 8, 10, 12, 14)$$

Here,  $m$  denotes a minterm and  $d$  denotes a don't care term. The number of essential prime implicants of the function  $F$  is \_\_\_\_\_.

- Q.50 The instruction pipeline of a RISC processor has the following stages: Instruction Fetch (IF), Instruction Decode (ID), Operand Fetch (OF), Perform Operation (PO) and Writeback (WB). The IF, ID, OF and WB stages take 1 clock cycle each for every instruction. Consider a sequence of 100 instructions. In the PO stage, 40 instructions take 3 clock cycles each, 35 instructions take 2 clock cycles each, and the remaining 25 instructions take 1 clock cycle each. Assume that there are no data hazards and no control hazards.

The number of clock cycles required for completion of execution of the sequence of instructions is \_\_\_\_\_.

- Q.51 A processor has 16 integer registers (R0, R1, .. , R15) and 64 floating point registers (F0, F1, ... , F63). It uses a 2-byte instruction format. There are four categories of instructions: Type-1, Type-2, Type-3, and Type-4. Type-1 category consists of four instructions, each with 3 integer register operands (3Rs). Type-2 category consists of eight instructions, each with 2 floating point register operands (2Fs). Type-3 category consists of fourteen instructions, each with one integer register operand and one floating point register operand (1R+1F). Type-4 category consists of N instructions, each with a floating point register operand (1F).

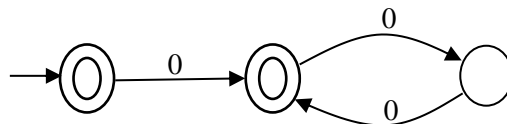
The maximum value of N is \_\_\_\_\_.

- Q.52 Given a language  $L$ , define  $L^i$  as follows:

$$L^0 = \{\varepsilon\}$$

$$L^i = L^{i-1} \cdot L \text{ for all } i > 0$$

The order of a language  $L$  is defined as the smallest  $k$  such that  $L^k = L^{k+1}$ . Consider the language  $L_1$  (over alphabet 0) accepted by the following automaton.



The order of  $L_1$  is \_\_\_\_\_.

- Q.53 Consider a storage disk with 4 platters (numbered as 0, 1, 2 and 3), 200 cylinders (numbered as 0, 1, ... , 199), and 256 sectors per track (numbered as 0, 1, ... , 255). The following 6 disk requests of the form [sector number, cylinder number, platter number] are received by the disk controller at the same time:

[120, 72, 2] , [180, 134, 1] , [60, 20, 0] , [212, 86, 3] , [56, 116, 2] , [118, 16, 1]

Currently the head is positioned at sector number 100 of cylinder 80, and is moving towards higher cylinder numbers. The average power dissipation in moving the head over 100 cylinders is 20 milliwatts and for reversing the direction of the head movement once is 15 milliwatts. Power dissipation associated with rotational latency and switching of head between different platters is negligible.

The total power consumption in milliwatts to satisfy all of the above disk requests using the Shortest Seek Time First disk scheduling algorithm is \_\_\_\_\_.

- Q.54 Consider an IP packet with a length of 4,500 bytes that includes a 20-byte IPv4 header and a 40-byte TCP header. The packet is forwarded to an IPv4 router that supports a Maximum Transmission Unit (MTU) of 600 bytes. Assume that the length of the IP header in all the outgoing fragments of this packet is 20 bytes. Assume that the fragmentation offset value stored in the first fragment is 0.

The fragmentation offset value stored in the third fragment is \_\_\_\_\_.

- Q.55 Consider a simple communication system where multiple nodes are connected by a shared broadcast medium (like Ethernet or wireless). The nodes in the system use the following carrier-sense based medium access protocol. A node that receives a packet to transmit will carrier-sense the medium for 5 units of time. If the node does not detect any other transmission in this duration, it starts transmitting its packet in the next time unit. If the node detects another transmission, it waits until this other transmission finishes, and then begins to carrier-sense for 5 time units again. Once they start to transmit, nodes do not perform any collision detection and continue transmission even if a collision occurs. All transmissions last for 20 units of time. Assume that the transmission signal travels at the speed of 10 meters per unit time in the medium.

Assume that the system has two nodes P and Q, located at a distance  $d$  meters from each other. P starts transmitting a packet at time  $t=0$  after successfully completing its carrier-sense phase. Node Q has a packet to transmit at time  $t=0$  and begins to carrier-sense the medium.

The maximum distance  $d$  (in meters, rounded to the closest integer) that allows Q to successfully avoid a collision between its proposed transmission and P's ongoing transmission is \_\_\_\_\_.

**END OF THE QUESTION PAPER**

# GATE Solved Paper 2018

Q1.

What is the missing number in the following sequence? 2, 12, 60, 240, 720, 1440, ....

0

- A 2880
- B 1440
- C 720
- D 0

Sol: **Answer: (B)**

The series starts with 2. We multiply first term with 6 to get second term 12. Then we multiply second term with 5 to get third term 60. Then we multiply third term with 4 to get fourth term 240. Then we multiply fourth term with 3 to get fifth term 720. Then we multiply fifth term with 2 to get sixth term 1440. Then we need to multiply with 1 and we get 1440 again.

Q2.

What would be the smallest natural number which when divided either by 20 or by 42 or by 76 leaves a remainder '7' in each case is\_

- A 3047
- B 6047
- C 7987
- D 63847

Sol: **Answer: (C)**

We need a number that can be written as  $20x + 7$ ,  $42y + 7$ ,  $76z + 7$  for three integers  $x$ ,  $y$  and  $z$ .

We basically need to find least common multiple of 20 ( $2 * 2 * 5$ ), 42 ( $2 * 3 * 7$ ) and 76 ( $2 * 2 * 19$ ) which is

$$2 * 2 * 5 * 3 * 7 * 19 = 20 * 21 * 19 = 420 * 19 = 7980$$

So our number is  $7980 + 7 = 7987$ .

Q3.

"From where are they bringing their books? \_\_\_\_\_ bringing \_\_\_\_\_ books from \_\_\_\_\_." The words that best fill the blanks in the above sentence are

- A** Their, they're, there
- B** They're, their, there
- C** There, their, they're
- D** They're, there, there

**Answer: (B)**

**Explanation:** "From where are they bringing their books? **Who** bringing **Whose** books from **Where**."

**Who** – A group as subject = They are

**Whose** – of that group = their

**Where** – from a place = there

"From where are they bringing their books? **They are** bringing **their** books from **there**."

Q4.

A \_\_\_\_\_ investigation can sometimes yield new facts, but typically organized once are more successful.

- A** Meandering
- B** Timely
- C** Consistent
- D** Systematic

**Answer: (A)**

**Explanation:** Meandering (as adjective) = proceeding in a convoluted or **undirected fashion**.

Q5.

The area of a square is 'd'. What is the area of the circle which has the diagonal of the square as its diameter?

- A**  $\pi d$
- B**  $\pi d^2$
- C**  $(1/4) \pi d^2$
- D**  $(1/2) \pi d$

**Answer: (D)**

One important observation to solve the question :

Diagonal of Square = Diameter of Circle.

Let side of square be  $x$ .

From Pythagorouous theorem.

$$\text{Diagonal} = \sqrt{2*x*x}$$

We know **area of square** =  $x * x = d$

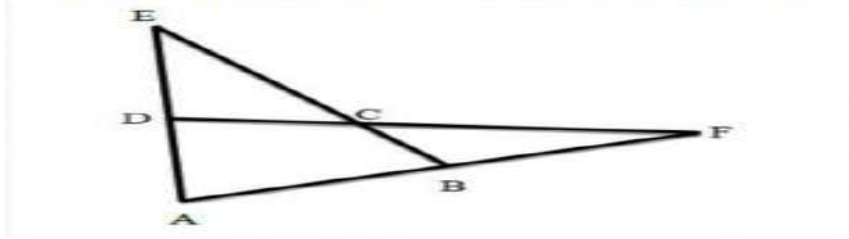
$$\text{Diameter} = \text{Diagonal} = \sqrt{2*d}$$

$$\text{Radius} = \sqrt{d/2}$$

$$\text{Area of Circle} = \pi * \sqrt{d/2} * \sqrt{d/2} = 1/2 * \pi * d$$

Q6.

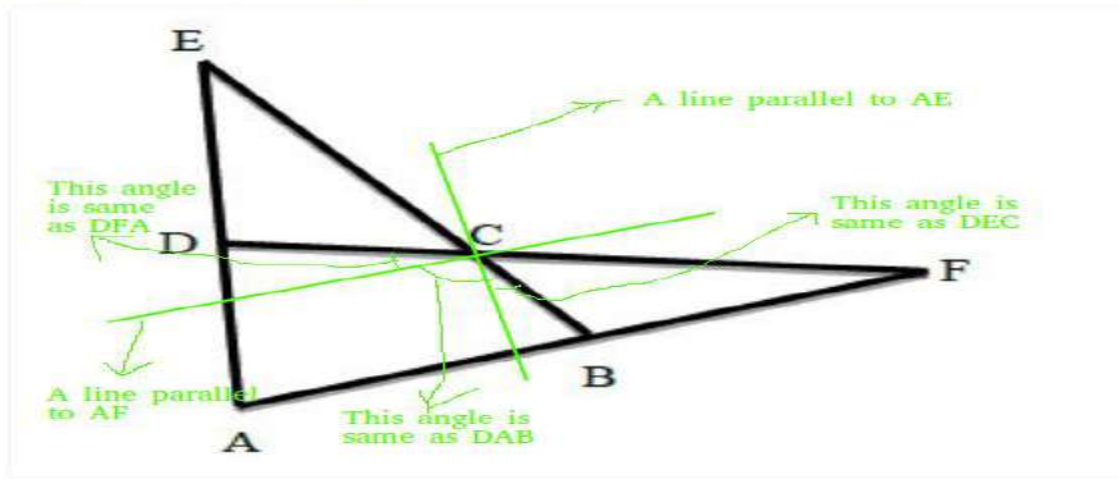
In the figure below,  $\angle DEC + \angle BFC$  is equal to \_\_\_\_\_.



- A**  $\angle BCD - \angle BAD$
- B**  $\angle BAD + \angle BCF$
- C**  $\angle BAD + \angle BCD$
- D**  $\angle CBA + \angle ADC$

Answer: (A)

Explanation: Option (A) is correct.



Q7.

In a party, 60% of the invited guests are male and 40% are female. If 80% of the invited guests attended the party and if all the invited female guests attended, what would be the ratio of males to females among the attendees in the party?

- A 2:3
- B 1:1
- C 3:2
- D 2:1

Answer: (B)

Explanation:

Let total males and females be  $60x$  and  $40x$  respectively.

Total number of people =  $(60x + 40x)$

Total number of people who attended :

$$0.8(60x + 40x) = 80x$$

Let  $y$  males attended. It is given all



1 females attended

$$40x + y = 80x$$

$$y = 40x \text{ which is same as females.}$$

Q8.

A six sided unbiased die with four green faces and two red faces is rolled seven times. Which of the following combinations is the most likely outcome of the experiment?

- A Three green faces and four red faces.
- B Four green faces and three red faces.
- C Five green faces and two red faces.
- D Six green faces and one red face

**Answer: (C)**

**Explanation:** Considering uniformly distributed outcomes, we get 4 greens and 2 reds in six throws. Then in one more throw, green is more likely.

Q9.

If  $pqr \neq 0$  and  $p^{-x} = \frac{1}{q}$ ,  $q^{-y} = \frac{1}{r}$ ,  $r^{-z} = \frac{1}{p}$ , what is the value of the product  $xyz$  ?

- A -1
- B  $1 / pqr$
- C 1
- D  $pqr$

**Answer: (C)**

**Explanation:** Taking logs of given three values, we get

$$1/q = p^{-x} \text{ -----(1)}$$

$$1/r = q^{-y} \text{ -----(2)}$$

$$1/p = r^{-z} \text{ -----(3)}$$

$$1/q = p^{-x}$$

$$\begin{aligned}
 &= r^{-xz} \text{ [Putting value of } p \text{ from (3)]} \\
 &= q^{-xyz} \text{ [Putting value of } r \text{ from (2)]} \\
 &= 1 / q^{xyz}
 \end{aligned}$$

On comparing power of  $q$  both sides, we get  $xyz = 1$

Q10.

In appreciation of social improvement completed in a town, a wealthy philanthropist decided to give gift of Rs. 750 to each male senior citizen and Rs. 1000 for female senior citizens. There are total 300 senior citizens and  $\frac{8}{9}$ th of total men and  $\frac{2}{3}$ rd of total women claimed the gift. What is amount of money philanthropist paid?

- A** 15000
- B** 200000
- C** 115000
- D** 151000

**Answer: (B)**

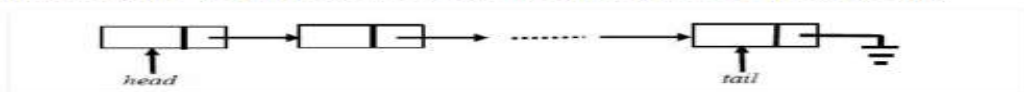
**Explanation:**

Let there be  $x$  total men.

$$\begin{aligned}
 \text{Total amount paid} &= x * 750 * \frac{8}{9} + (300 - x) * 1000 * \frac{2}{3} \\
 &= x * \frac{2000}{3} + 300 * 1000 * \frac{2}{3} - x * \frac{2000}{3} \\
 &= 200000
 \end{aligned}$$

Q11.

A queue is implemented using a non-circular singly linked list. The queue has a head pointer and a tail pointer, as shown in the figure. Let  $n$  denote the number of nodes in the queue. Let 'enqueue' be implemented by inserting a new node at the head, and 'dequeue' be implemented by deletion of a node from the tail.



Which one of the following is the time complexity of the most time-efficient implementation of 'enqueue' and 'dequeue', respectively, for this data structure?

- A**  $\Theta(1), \Theta(1)$
- B**  $\Theta(1), \Theta(n)$
- C**  $\Theta(n), \Theta(1)$
- D**  $\Theta(n), \Theta(n)$

**Answer: (B)**

**Explanation:** For Enqueue operation, performs in constant amount of time (i.e.,  $\Theta(1)$ ), because it modifies only two pointers, i.e.,

Create a Node P.

P-->Data = Data

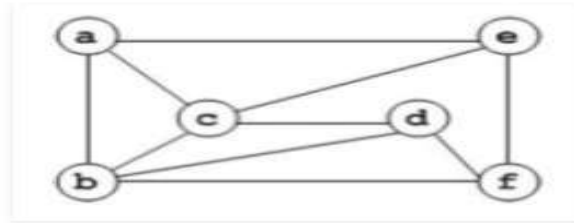
P-->Next = Head

Head = P

For Dequeue operation, we need address of second last node of single linked list to make NULL of its next pointer. Since we can not access its previous node in singly linked list, so need to traverse entire linked list to get second last node of linked list.

Q12.

The chromatic number of the following graph is \_\_\_\_\_. **Note** - This was Numerical Type question.



- A 2
- B 4
- C 3
- D 5

**Answer: (C)**

**Explanation:** Chromatic number of given graph is **3**. Note that graph is Planar so Chromatic number should be less than or equal to 4 and can not be less than 3 because of odd length cycle.

Q13.

Consider a matrix  $A = uv^T$  where  $u = \begin{pmatrix} 1 \\ 2 \end{pmatrix}$ ,  $v = \begin{pmatrix} 1 \\ 1 \end{pmatrix}$ . Note that  $v^T$  denotes the transpose of  $v$ . The largest eigenvalue of  $A$  is \_\_\_\_\_. **Note** -This was Numerical Type question.

- A** 0
- B** 1
- C** 2
- D** 3

**Answer: (D)**

Q14.

Consider the following C program:

```
#include <stdio.h>

int counter = 0;

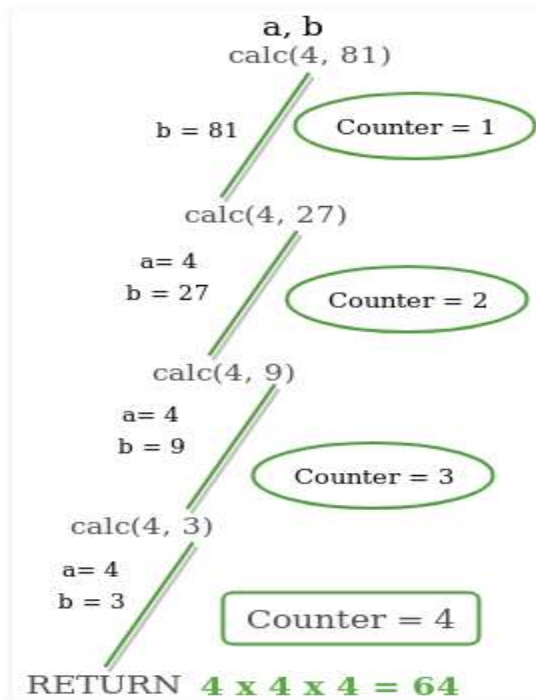
int calc(int a, int b) {
 int c;

 counter++;
 if (b == 3)
 return (a * a * a);
 else {
 c = calc(a, b / 3);
 return (c * c * c);
 }
}

int main() {
 calc(4, 81);
 printf("%d", counter);
}
```

The output of this program is 4

**Explanation:**



Q15.

A 32-bit wide main memory unit with a capacity of 1 GB is built using 256M X 4-bit DRAM chips. The number of rows of memory cells in the DRAM chip is  $2^{14}$ . The time taken to perform one refresh operation is 50 nanoseconds. The refresh period is 2 milliseconds. The percentage (rounded to the closest integer) of the time available for performing the memory read/write operations in the main memory unit is \_\_\_\_\_.

**Note** - This was Numerical Type question.

- A 59
- B 40
- C 99
- D None of these

**Answer: (A)**

**Explanation:** Given, total number of rows is  $2^{14}$  and time taken to perform one refresh operation is 50 nanoseconds.

So, total time taken to perform refresh operation =  $2^{14} \times 50$  nanoseconds = 819200 nanoseconds = 0.819200 milliseconds.

But refresh period is 2 milliseconds.

So, time spent in refresh period in percentage =  $(0.819200 \text{ milliseconds}) / (2 \text{ milliseconds}) = 0.4096 = 40.96\%$

Hence, time spent in read/write operation =  $100\% - 40.96\% = 59.04\% = 59$  (in percentage and rounded to the closet integer).

So, answer is **59**.

Q16.

Let G be a finite group on 84 elements. The size of a largest possible proper subgroup of G is \_\_\_\_\_. **Note** - This was Numerical Type question.

- A** 42
- B** 84
- C** 1
- D** 28

**Answer: (A)**

**Explanation:** According to Lagrange's theorem, states that for any finite group G, the order (number of elements) of every subgroup H of G **divides** the order of G. Therefore, possible subgroups of group on 84 elements are : 1, 2, 3, 4, 6, 7, 12, 14, 21, 28, 42, 84.

Subgroups with element 1 and 84 are trivial groups.

The size of a largest possible **proper** subgroup of G is **42**.

Q17.

Consider a process executing on an operating system that uses demand paging. The average time for a memory access in the system is M units if the corresponding memory page is available in memory, and D units if the memory access causes a page fault. It has been experimental measured that the average time taken for a memory access in the process is X units. Which one of the following is the correct expression for the page fault rate experienced by the process?

- A**  $(D - M) / (X - M)$
- B**  $(X - M) / (D - M)$
- C**  $(D - X) / (D - M)$
- D**  $(X - M) / (D - X)$

**Answer: (B)**

**Explanation:** Given, average time for a memory access = M units if page hits, and average time for a memory access = M units if page fault occurred.  
And total/experimental average time taken for a memory access = X units.

Let page fault rate is p. Therefore,

Average memory access time = ( 1 – page fault rate) \* memory access time when no page fault + Page fault rate \* Memory access time when page fault

Q18.

Which one the following is a closed form expression for the generating function of the sequence  $\{a_n\}$ , where  $a_n = 2n + 3$  for all  $n = 0, 1, 2, \dots$ ?

(A)  $\frac{3}{(1-x)^2}$       (B)  $\frac{3x}{(1-x)^2}$       (C)  $\frac{2-x}{(1-x)^2}$       (D)  $\frac{3-x}{(1-x)^2}$

- A
- B
- C
- D

**Answer: (D)**

page fault + Page fault rate \* Memory access time when page fault

Q19.

Which one of the following statements is FALSE?

- A Context-free grammar can be used to specify both lexical and syntax rules.
- B Type checking is done before parsing.
- C High-level language programs can be translated to different Intermediate Representations.
- D Arguments to a function can be passed using the program stack.

**Answer: (B)**

**Explanation:** Type checking is done at semantic analysis phase and parsing is done at syntax analysis phase. And we know Syntax analysis phase comes before semantic analysis. So Option **(B)** is **False**.

Q20.

The postorder traversal of a binary tree is 8, 9, 6, 7, 4, 5, 2, 3, 1. The inorder traversal of the same tree is 8, 6, 9, 4, 7, 2, 5, 1, 3. The height of a tree is the length of the longest path from the root to any leaf. The height of the binary tree above is \_\_\_\_\_. **Note** -This was Numerical Type question.

- A 2
- B 3
- C 4
- D 5

]

**Answer: (C)**

**Explanation:** Given, post-order – 8, 9, 6, 7, 4, 5, 2, 3, 1  
and in-order – 8, 6, 9, 4, 7, 2, 5, 1, 3

The height of the binary tree above is **4**.



