GATE 2025

Computer Science & IT
Shift-2

Questions & Solutions

Exam held on
01/02/2025 (Afternoon Session)

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SECTION - A GENERAL APTITUDE

Q.1 Despite his initial hesitation, Rehman's _____ to contribute to the success of the project never wavered.
Select the most appropriate option to complete the above sentence.
(a) ambivalence (b) satisfaction
(c) resolve (d) revolve

[2025 (Set-2) : 1 M]

Ans. (c)
"Resolve" refers to a firm determination or decision, which fits the context of unwavering commitment.

End of Solution

Q.2 Bird : Nest :: Bee : _____
Select the correct option to complete the analogy.
(a) Kennel (b) Hammock
(c) Hive (d) Lair

[2025 (Set-2) : 1 M]

Ans. (c)
Just as a bird lives in a nest, a bee lives in a hive.

End of Solution

Q.3 If $Pe^{x} = Qe^{-x}$ for all real values of x, which one of the following statements is true?
(a) $P = Q = 0$ (b) $P = Q = 1$
(c) $P = 1;\ Q = -1$ (d) $\frac{P}{Q} = 0$

[2025 (Set-2) : 1 M]

Ans. (a)

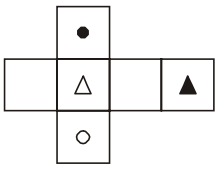
$$Pe^{x} = Qe^{-x}$$
$$\Rightarrow \quad Pe^{2x} = Q$$

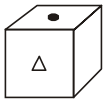
The above equation holds true only when $P = 0$ and $Q = 0$.

End of Solution

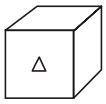
Q.4 The paper as shown in the figure is folded to make a cube where each square corresponds to a particular face of the cube. Which one of the following options correctly represents the cube?

Note: The figures shown are representative.



(a) 

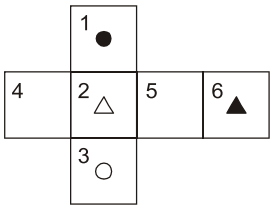
(b) 

(c) 

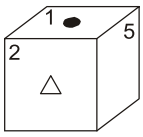
(d) 

[2025 (Set-2) : 1 M]

Ans. (a)



When we fold the given sheet of paper, then the pairs (1 & 3), (4 & 5) and (2 & 6) lie opposite to each other. The cube is represented as below,



Hence, option (a) is correct.

End of Solution

Q.5 Let p_1 and p_2 denote two arbitrary prime numbers. Which one of the following statements is correct for all values of p_1 and p_2?

(a) $p_1 + p_2$ is not a prime number.
(b) $p_1 p_2$ is not a prime number.
(c) $p_1 + p_2 + 1$ is a prime number.
(d) $p_1 p_2 + 1$ is a prime number.

[2025 (Set-2) : 1 M]

Ans. (b)

The product of two prime numbers is never a prime number, because a prime number has only two divisors: 1 and itself. However, the product of two prime numbers p_1 and p_2 will always have at least four divisors: 1, p_1, p_2 and $p_1 p_2$.

Hence, $p_1 p_2$ cannot be prime, therefore, option (b) is correct.

End of Solution

Q.6 Based only on the conversation below, identify the logically correct inference:
"Even if I had known that you were in the hospital, I would not have gone there to see you", Ramya told Josephine.
(a) Ramya knew that Josephine was in the hospital.
(b) Ramya did not know that Josephine was in the hospital.
(c) Ramya and Josephine were once close friends; but now, they are not.
(d) Josephine was in the hospital due to an injury to her leg.

[2025 (Set-2) : 2 M]

Ans. (b)

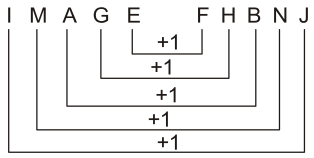
Ramya's statement define a hypothetical scenario, wherein, if she had known Josephine was in the hospital, she still wouldn't have visited. Thus, Ramya was not aware whether the Josephine was in the hospital. Hence, option (b) is correct.

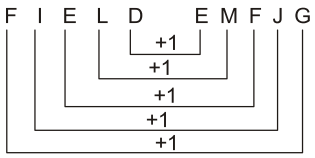
End of Solution

Q.7 If IMAGE and FIELD are coded as FHBNJ and EMFJG respectively then, which one among the given options is the most appropriate code for BEACH ?
(a) CEADP (b) IDBFC
(c) JGIBC (d) IBCEC

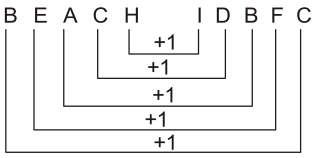
[2025 (Set-2) : 2 M]

Ans. (b)





Using above, the code for BEACH can be obtained as



End of Solution

Q.8 Which one of the following options is correct for the given data in the table?

Iteration (i)	0	1	2	3
Input (I)	20	–4	10	15
Output (X)	20	16	26	41
Output (Y)	20	–80	–800	–12000

(a) $X(i) = X(i-1) + I(i);\ Y(i) = Y(i-1)I(i);\ i > 0$
(b) $X(i) = X(i-1)I(i);\ Y(i) = Y(i-1) + I(i);\ i > 0$
(c) $X(i) = X(i-1)I(i);\ Y(i) = Y(i-1)I(i);\ i > 0$
(d) $X(i) = X(i-1) + I(i);\ Y(i) = Y(i-1)\ I(i-1);\ i > 0$

[2025 (Set-2) : 2 M]

Ans. (a)

Consider $i = 1$. Then, we have

$$X(i) = X(1) = 16$$
$$X(i-1) = X(0) = 20$$
$$I(i) = I(1) = -4$$
$$Y(i) = Y(1) = -80$$
$$Y(i-1) = Y(0) = 20$$

From the above values, we can write, for $i > 0$,

$$X(i) = X(i-1) + I(i)$$

and $$Y(i) = Y(i-1) \cdot I(i)$$

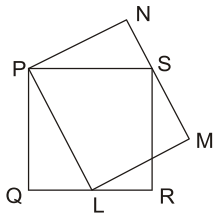
Hence, option (a) is correct.

End of Solution

Q.9 In the given figure, PQRS is a square of side 2 cm and PLMN is a rectangle. The corner L of the rectangle is on the side QR. Side MN of the rectangle passes through the corner S of the square.

What is the area (in cm^2) of the rectangle PLMN?

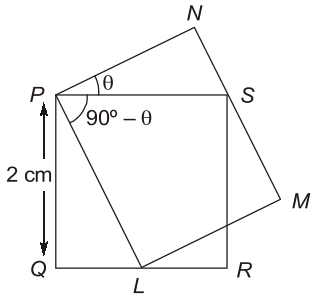
Note: The figure shown is representative



(a) $2\sqrt{2}$
(b) 2
(c) 8
(d) 4

[2025 (Set-2) : 2 M]

Ans. (d)



Assume $\angle QPL = \theta$. Since $PQRS$ is a square, $\angle QPS = 90°$.
Therefore, $\angle LPS = 90° - \theta$.
Since the sides of a rectangle are also perpendicular to each other therefore, $\angle LPN = 90°$ which gives $\angle SPN = 90° - (90° - \theta) = \theta$
In ΔQPL,

$$\cos\theta = \frac{PQ}{PL} = \frac{2}{PL}$$

$$\Rightarrow \quad PL = \frac{2}{\cos\theta} \qquad \ldots(i)$$

In ΔSPN,

$$\cos\theta = \frac{PN}{PS} = \frac{PN}{2}$$

$$\Rightarrow \quad PN = 2\cos\theta \qquad \ldots(ii)$$

From (i) and (ii), the area of rectangle PLMN is given by

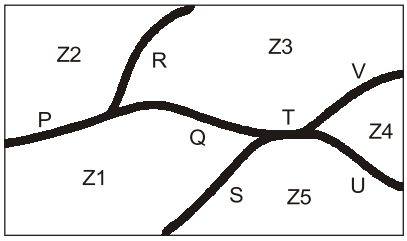
$$A = PL \times PN = \left(\frac{2}{\cos\theta}\right) \times 2\cos\theta$$

$$A = 4 \text{ cm}^2$$

End of Solution

Q.10 The diagram below shows a river system consisting of 7 segments, marked P, Q, R, S, T, U, and V. It splits the land into 5 zones, marked Z1, Z2, Z3, Z4, and Z5. We need to connect these zones using the least number of bridges. Out of the following options, which one is correct?

Note: The figure shown is representative.

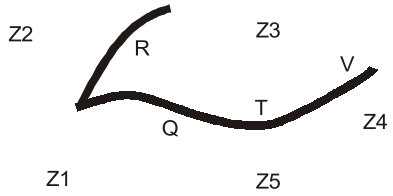


(a) Bridges on P, Q, and T
(b) Bridges on P, Q, S, and T
(c) Bridges on Q, R, T, and V
(d) Bridges on P, Q, S, U, and V

[2025 (Set-2) : 2 M]

Ans. (c)

The bridges on Q, R, T and V connect all the 5 zones Z1, Z2, Z3, Z4 and Z5.



End of Solution

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SECTION - B TECHNICAL

Q.11 If $A = \begin{pmatrix} 1 & 2 \\ 2 & -1 \end{pmatrix}$, then which ONE of the following is A^8 ?

(a) $\begin{pmatrix} 25 & 0 \\ 0 & 25 \end{pmatrix}$ (b) $\begin{pmatrix} 125 & 0 \\ 0 & 125 \end{pmatrix}$

(c) $\begin{pmatrix} 625 & 0 \\ 0 & 625 \end{pmatrix}$ (d) $\begin{pmatrix} 3125 & 0 \\ 0 & 3125 \end{pmatrix}$

[2025 (Set-2) : 1 M]

Ans. (c)

$$A = \begin{bmatrix} 1 & 2 \\ 2 & -1 \end{bmatrix}$$

$$A^2 = \begin{bmatrix} 5 & 0 \\ 0 & 5 \end{bmatrix}$$

$$(A^2)^4 = \begin{bmatrix} 5^4 & 0 \\ 0 & 5^4 \end{bmatrix} = \begin{bmatrix} 625 & 0 \\ 0 & 625 \end{bmatrix}$$

End of Solution

Q.12 The value of x such that $x > 1$, satisfying the equation $\int_1^x t \ln t \, dt = \frac{1}{4}$ is

(a) $\sqrt{e}$ (b) e

(c) e^2 (d) $e - 1$

[2025 (Set-2) : 1 M]

Ans. (a)

$x > 1$, $\int_1^x t \ln t \, dt = \frac{1}{4}$,

$= \int_0^{\ln x} e^u u e^u du = \frac{1}{4}$

$= \int_0^{\ln x} u e^{2u} du = \frac{1}{4}$

$= \frac{ue^{2u}}{2} - 1 \cdot \frac{e^{2u}}{4} \Big]_0^{\ln x} = \frac{1}{4}$

Let $\ln t = u$
$\Rightarrow t = e^u$
$dt = e^u du$
$t = 1 \Rightarrow u = 0$
$t = x \Rightarrow u = \ln x$

$\Rightarrow x^2\left[\frac{\ln x}{2} - \frac{1}{4}\right] = 0 \Rightarrow x = 0$ (or) $t = \pm\sqrt{e}$

$\because x > 0$, $x = \sqrt{e}$

End of Solution

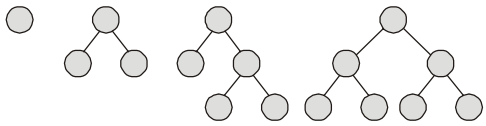
Q.13 Consider a binary tree T in which every node has either zero or two children. Let $n > 0$ be the number of nodes in T.
Which ONE of the following is the number of nodes in T that have exactly two children?

(a) $\frac{n-2}{2}$ (b) $\frac{n-1}{2}$

(c) $\frac{n}{2}$ (d) $\frac{n+1}{2}$

[2025 (Set-2) : 1 M]

Ans. (b)



Number of nodes (n)	Number of nodes of two childs
1	0
3	1
5	2
7	3
n	$\frac{n-1}{2}$

End of Solution

Q.14 Let L, M, and N be non-singular matrices of order 3 satisfying the equations $L^2 = L^{-1}$, $M = L^8$ and $N = L^2$.
Which ONE of the following is the value of the determinant of $(M - N)$?

(a) 0 (b) 1

(c) 2 (d) 3

[2025 (Set-2) : 1 M]

Ans. (a)

$$\begin{aligned} |L^8 - L^2| &= |L^2\ L^2\ L^2\ L^2 - L^2| \\ &= |L^2\ L^2\ L^{-1}\ L^{-1} - L^2| \\ &= |0| = 0 \end{aligned}$$

End of Solution

Q.15 Let $P(x)$ be an arbitrary predicate over the domain of natural numbers.
Which ONE of the following statements is TRUE?

(a) $(P(0) \wedge (\forall x[P(x+1)])) \Rightarrow (\forall x P(x))$

(b) $(P(0) \wedge (\forall x[P(x) \Rightarrow P(x-1)])) \Rightarrow (\forall x P(x))$

(c) $(P(1000) \wedge (\forall x[P(x) \Rightarrow P(x-1)])) \Rightarrow (\forall x P(x))$

(d) $(P(1000) \wedge (\forall x[P(x) \Rightarrow P(x+1)])) \Rightarrow (\forall x P(x))$

[2025 (Set-2) : 1 M]

Ans. (a)

Domain = N

By assignment Method = Consider RHS is false.

$$P(0) \wedge \forall x\,[P(x) \Rightarrow P(x+1)] \Rightarrow \forall x,\ P(x)$$

$$\begin{array}{lll} \mathrm{T} & & \mathrm{T} \\ \mathrm{T} \wedge & P(1) \Rightarrow & P(2) \\ & \wedge & \\ & \mathrm{T} & \mathrm{F} \\ & P(2) \Rightarrow & P(2) \\ & \wedge & \\ & \mathrm{F} & \mathrm{T} \\ & P(3) \Rightarrow & P(4) \\ & \wedge & \\ & \vdots & \vdots \\ & \wedge & \\ & P(n) \Rightarrow & P(n+1) \\ & \wedge & \\ & \vdots & \end{array} \qquad \begin{array}{ll} P(1) & \mathrm{T} \\ \wedge & \\ P(2) & \mathrm{F} \\ \wedge & \\ P(3) & \mathrm{F} \\ \wedge\ \wedge & \\ \vdots\ \vdots & \\ \wedge\ \wedge & \\ P(n) & \mathrm{T} \\ \wedge & \\ \vdots & \end{array}$$

$\forall x,\ P(x) \Rightarrow P(x+1) \equiv F$ $\qquad$ $\forall x,\ P(x) \equiv F$

$\therefore$ $\mathrm{T} \wedge \mathrm{F} \Rightarrow \mathrm{F}$

$\mathrm{F} \Rightarrow \mathrm{F}$ is valid

$\therefore$ Option (a) is true.

End of Solution

Q.16 Consider the following statements:

(i) Address Resolution Protocol (ARP) provides a mapping from an IP address to the corresponding hardware (link-layer) address.

(ii) A single TCP segment from a sender S to a receiver R cannot carry both data from S to R and acknowledgement for a segment from R to S.

Which ONE of the following is CORRECT?

(a) Both (i) and (ii) are TRUE
(b) (i) is TRUE and (ii) is FALSE
(c) (i) is FALSE and (ii) is TRUE
(d) Both (i) and (ii) are FALSE

[2025 (Set-2) : 1 M]

Ans. (b)

ARP is a network protocol used to find the MAC (Media Access Control) address corresponding to a given IP address. So, (i) is true.

TCP uses piggybacking to send an acknowledgment (ACK) along with data in the same segment. So, (ii) is false.

End of Solution

Q.17 Consider the routing protocols given in **List-I** and the names given in **List-II**:

List-I	List-II
(i) Distance vector routing	(a) Bellman-Ford
(ii) Link state routing	(b) Dijkstra

For matching of items in **List-I** with those in **List-II**, which ONE of the following options is CORRECT?

(a) (i) – (a) and (ii) – (b)
(b) (i) – (a) and (ii) – (a)
(c) (i) – (b) and (ii) – (a)
(d) (i) – (b) and (ii) – (b)

[2025 (Set-2) : 1 M]

Ans. (a)

- DVR algorithm uses Bellman-Ford Algorithm to find out the optimal Path.
- Link State Routing algorithm uses Dijkstra's Algorithm to construct the SPT.

End of Solution

Q.18 A machine receives an IPv4 datagram. The protocol field of the IPv4 header has the protocol number of a protocol X.
Which ONE of the following is NOT a possible candidate for X?

(a) Internet Control Message Protocol (ICMP)
(b) Internet Group Management Protocol (IGMP)
(c) Open Shortest Path First (OSPF)
(d) Routing Information Protocol (RIP)

[2025 (Set-2) : 1 M]

Ans. (d)

RIP (Routing Information Protocol) - Uses UDP (Port 520)
RIP is a routing protocol but does NOT have a direct protocol number in the IPv4 header.
Instead, RIP uses UDP as its transport layer protocol (UDP port 520).
Since RIP is encapsulated inside UDP, it does NOT appear directly in the Protocol field of an IPv4 header.
IPv4 Protocol field value = 1 – ICMP
IPv4 Protocol field value = 2 – IGMP
IPv4 Protocol field value = 89 – OSPF

End of Solution

Q.19 Consider the following C program:

```
#include <stdio.h>
void stringcopy(char *, char *);
int main( ) {
        char a[30] = "@#Hello World!";
        stringcopy(a, a + 2);
        printf("%s\n", a);
        return 0;
}
void stringcopy(char *s, char *t) {
        while(*t)
                *s++ = *t++;
}
```

Which ONE of the following will be the output of the program?

(a) @#Hello World!
(b) Hello World!
(c) ello World!
(d) Hello World!d!

[2025 (Set-2) : 1 M]

Ans. (d)

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14
a	@	#	H	e	l	l	o		w	o	r	l	d	!	/◦
	100	101	102	103	104	105	106	107	108	109	110	111	112	113	114

s: ~~100~~ ~~101~~ ~~102~~ ~~103~~ ~~104~~ ~~105~~ ~~106~~ ~~107~~ ~~108~~ ~~109~~ ~~110~~ ~~111~~ 112

t: ~~102~~ ~~103~~ ~~104~~ ~~105~~ ~~106~~ ~~107~~ ~~108~~ ~~109~~ ~~110~~ ~~111~~ ~~112~~ ~~113~~

- Value at location 102 (H) copy into value at location 100.
- Value at location 103 (e) copy into value at location 101.

  ⋮
- The same process continues until it reaches the null character.

End of Solution

Q.20 Consider an unordered list of N distinct integers.
What is the minimum number of element comparisons required to find an integer in the list that is NOT the largest in the list?

(a) 1
(b) $N - 1$
(c) N
(d) $2N - 1$

[2025 (Set-2) : 1 M]

Ans. (a)

Compare any two elements

```
if (a[1] < a[z])
    return(a[1]);
else
    return(a[z]);
```

End of Solution

Q.21 Consider the following statements about the use of backpatching in a compiler for
(I) Backpatching can be used to generate code for Boolean expression in one pass.
(II) Backpatching can be used to generate code for flow-of-control statements in one pass.
Which ONE of the following options is CORRECT?

(a) Only (I) is correct.
(b) Only (II) is correct.
(c) Both (I) and (II) are correct.
(d) Neither (I) nor (II) is correct.

[2025 (Set-2) : 1 M]

Ans. (c)

Both statements are true.

End of Solution

Q.22 Given the following syntax directed translation rules:
Rule 1: $R \rightarrow AB$ $\{B.i = R.i - 1;\ A.i = B.i\ R.i = A.i + 1;\}$
Rule 2: $P \rightarrow CD$ $\{P.i = C.i + D.i;\ D.i = C.i + 2\}$
Rule 3: $Q \rightarrow EF$ $\{Q.i = E.i + F.i;\}$
Which ONE is the CORRECT option among the following?

(a) Rule 1 is S-attributed and L-attributed; Rule 2 is S-attributed and not L-attributed; Rule 3 is neither S-attributed nor L-attributed
(b) Rule 1 is neither S-attributed nor L-attributed: Rule 2 is S-attributed and L-attributed: Rule 3 is S-attributed and L-attributed
(c) Rule 1 is neither S-attributed nor L-attributed; Rule 2 is not S-attributed and is L-attributed; Rule 3 is S-attributed and L-attributed
(d) Rule 1 is S-attributed and not L-attributed; Rule 2 is not S-attributed and is L-attributed: Rule 3 is S-attributed and L-attributed

[2025 (Set-2) : 1 M]

Ans. (c)

According to the definitions of S-attribute and L-attributes correct answer is option (c).

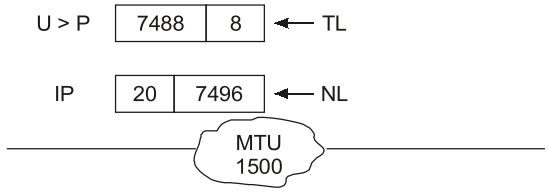
End of Solution

Q.23 Consider a network that uses Ethernet and IPv4. Assume that IPv4 headers do not use any options field. Each Ethernet frame can carry a maximum of 1500 bytes in its data field. A UDP segment is transmitted. The payload (data) in the UDP segment is 7488 bytes. Which ONE of the following choices has the CORRECT total number of fragments transmitted and the size of the last fragment including IPv4 header?

(a) 5 fragments, 1488 bytes
(b) 6 fragments, 88 bytes
(c) 6 fragments, 108 bytes
(d) 6 fragments, 116 bytes

[2025 (Set-2) : 1 M]

Ans. (d)



$$\text{Number of fragments} = \frac{7496}{1480} = 5.06 \approx 6$$

	①	②	③	④	⑤	⑥
DL	1480	1480	1480	1480	1480	96
HL	20	20	20	20	20	20
						⑯

End of Solution

Q.24 Which ONE of the following languages is accepted by a deterministic pushdown automaton?

(a) Any regular language.
(b) Any context-free language.
(c) Any language accepted by a non-deterministic pushdown automaton.
(d) Any decidable language.

[2025 (Set-2) : 1 M]

Ans. (a)

DPDA accepts regular language and DCFL.

End of Solution

Q.25 Let G_1, G_2 be Context Free Grammars (CFGs) and R be a regular expression. For a grammar G, let $L(G)$ denote the language generated by G.
Which ONE among the following questions is decidable?

(a) Is $L(G_1) = L(G_2)$?
(b) Is $L(G_1) \cap L(G_2) = \phi$?
(c) Is $L(G_1) = L(R)$?
(d) Is $L(G_1) = \phi$?

[2025 (Set-2) : 1 M]

Ans. (d)

(a) Equivalence of CFL's is undecidable.
(b) Disjointness of CFL's is undecidable.
(c) Undecidable
(d) Emptiness of CFL is decidable.

End of Solution

Q.26 Processes $P1$, $P2$, $P3$, $P4$ arrive in that order at times 0, 1, 2, and 8 milliseconds respectively, and have execution times of 10, 13, 6, and 9 milliseconds respectively. Shortest Remaining Time First (SRTF) algorithm is used as the CPU scheduling policy. Ignore context switching times.
Which ONE of the following correctly gives the average turnaround time of the four processes in milliseconds?

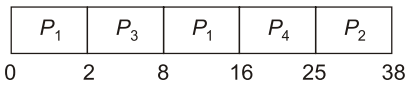
(a) 22 (b) 15
(c) 37 (d) 19

[2025 (Set-2) : 1 M]

Ans. (d)

Process	A.T.	B.T.	C.T.	T.A.T.
P_1	0	10	16	16
P_2	1	13	38	37
P_3	2	6	8	6
P_4	8	9	25	17

Gantt Chart:



Average Turn Around Time $= \frac{16+37+6+17}{4} = \frac{76}{4} = 19$

End of Solution

Q.27 An audit of a banking transactions system has found that on an earlier occasion, two joint holders of account A attempted simultaneous transfers of Rs. 10000 each from account A to account B. Both transactions read the same value, Rs. 11000, as the initial balance in A and were allowed to go through. B was credited Rs. 10000 twice. A was debited only once and ended up with a balance of Rs. 1000.
Which of the following properties is/are certain to have been violated by the system?

(a) Atomicity (b) Consistency
(c) Isolation (d) Durability

[2025 (Set-2) : 1 M]

Ans. (b, c)

Two holders of account A

A = 11000 Rs.

T_1	T_2
$R(A)$	
	$R(A)$
$A = A - 1000$	
	$A = A - 1000$
$R(B)$	
$B = B + 1000$	
$W(B)$	
$W(A)$	
	$R(B)$
	$B = B + 10000$
	$W(B)$
	$W(A)$

Its violation of isolation.

End of Solution

Q.28 Which of the following is/are part of an Instruction Set Architecture of a processor?

(a) The size of the cache memory
(b) The clock frequency of the processor
(c) The number of cache memory levels
(d) The total number of registers

[2025 (Set-2) : 1 M]

Ans. (d)

Instruction Set Architecture defines the set of instructions that a processor can execute including the instruction formats, addressing modes and the operations that the instructions perform.

CLK frequency is the characteristic of the processor's hardware implementation known as micro architecture.

∴ CLK frequency is not comes under the ISA.

End of Solution

Q.29 Which of the following statements regarding Breadth First Search (BFS) and Depth First Search (DFS) on an undirected simple graph G is/are TRUE?

(a) A DFS tree of G is a Shortest Path tree of G.
(b) Every non-tree edge of G with respect to a DFS tree is a forward/back edge.
(c) If (u, v) is a non-tree edge of G with respect to a BFS tree, then the distances from the source vertex s to u and v in the BFS tree are within ± 1 of each other.
(d) Both BFS and DFS can be used to find the connected components of G.

[2025 (Set-2) : 1 M]

Ans. (b, c, d)

- Every non tree edge of G is back/forward edge.
- BFS tree is shortest path tree; so that every tree edge (u, v) with respect to BFS tree of graph G : dist(u) – dist(v) = ±1.
- Both BFS and DFS can used for to test connected components of undirected graph.

End of Solution

Q.30 Consider the two lists **List-I** and **List-II** given below:

List-I	List-II
(i) Context free languages	(a) Closed under union
(ii) Recursive languages	(b) Not closed under complementation
(iii) Regular languages	(c) Closed under intersection

For matching of items in **List-I** with those in **List-II**, which of the following option(s) is/are CORRECT?

(a) (i) - (a), (ii) - (b), and (iii) - (c)
(b) (i) - (b), (ii) - (a), and (iii) - (c)
(c) (i) - (b), (ii) - (c), and (iii) - (a)
(d) (i) - (a), (ii) - (c), and (iii) - (b)

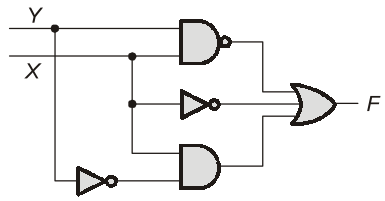
[2025 (Set-2) : 1 M]

Ans. (b, c)

CFL's are not closed under complementation, regular and recursive languages are closed under union and intersection.

End of Solution

Q.31 Consider the following logic circuit diagram.



Which is/are the CORRECT option(s) for the output function?

(a) $\overline{X}\,\overline{Y}$
(b) $\overline{X}+\overline{Y}+X\overline{Y}$
(c) $\overline{X\overline{Y}}+\overline{X}+X\overline{Y}$
(d) $X+\overline{Y}$

[2025 (Set-2) : 1 M]

Ans. (a, b, c)

$$F = \overline{X\overline{Y}}+\overline{X}+X\overline{Y} = \overline{X}+\overline{Y}+\overline{X}+X\overline{Y}$$
$$= \overline{X}+\overline{Y}+X\overline{Y} = \overline{X}+\overline{Y}(1+X)$$
$$= \overline{X}+\overline{Y} = \overline{XY}$$

End of Solution

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Q.32 The following two signed 2's complement numbers (multiplicand M and multiplier Q) are being multiplied using Booth's algorithm:

M : 1100 1101 1110 1101 and Q: 1010 0100 1010 1010

The total number of addition and subtraction operations to be performed is ----------. (Answer in integer)

[2025 (Set-2) : 1 M]

Ans. (13)

Multiplier	Pair with		Recoding
q_0 : 0	q_1 : 0	→	0
1	0	→	–1
0	1	→	+1
1	0	→	–1
0	1	→	+1
1	0	→	–1
0	1	→	+1
1	0	→	–1
0	1	→	+1
0	0	→	0
1	0	→	–1
0	1	→	+1
0	0	→	0
1	0	→	–1
0	1	→	+1
1	0	→	–1

End of Solution

Q.33
```
int x = 126, y = 105;
do {
        if(x > y) x = x – y;
        else y = y – x;
} while(x!=y);
printf("%d", x);
```

The output of the given C code segment is _____. (Answer in integer)

[2025 (Set-2) : 1 M]

Ans. (21)

21

x ~~126~~ y ~~105~~ ~~84~~ ~~63~~ ~~42~~ ~~21~~

When (X = = Y)

(21 = = 21) loop will be stops.

So, GCD of 126 and 105 is 21.

End of Solution

Q.34 In a 4-bit ripple counter, if the period of the waveform at the last flip-flop is 64 microseconds, then the frequency of the ripple counter in kHz is _____. (Answer in integer)

[2025 (Set-2) : 1 M]

Ans. (250)

Note: In the question description, in the last sentence the word clock is missing. Because of the missing of the word clock the question is wrong.

Number of flip-flops in the given Ripple counter, $n = 4$

Time period of the waveform at the last flip-flop (last flip-flop must be MSB flip flop i.e. FF3), $T_3 = 64$ microseconds.

The frequency of the waveform at the last flip-flop $f_{Q3} = \frac{1}{T_3}$

Consider the clock frequency of the ripple counter as f_c.

Where, $f_{Q3} = \frac{f_c}{2^4} = \frac{f_c}{16}$

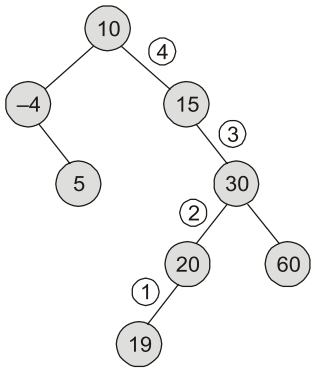
$$f_c = 16 \times f_{Q3} = 16 \times \frac{1}{64 \times 10^{-6}} = \frac{1000}{4} \times 10^3 = 250\,\text{kHz}$$

End of Solution

Q.35 Suppose the values 10, –4,15,30,20,5,60,19 are inserted in that order into an initially empty binary search tree. Let T be the resulting binary search tree. The number of edges in the path from the node containing 19 to the root node of T is _____. (Answer in integer)

[2025 (Set-2) : 1 M]

Ans. (4)



Number of edges from 19 to root node = 4.

End of Solution

Q.36 Suppose we are transmitting frames between two nodes using Stop-and-Wait protocol. The frame size is 3000 bits. The transmission rate of the channel is 2000 bps (bits/second) and the propagation delay between the two nodes is 100 milliseconds. Assume that the processing times at the source and destination are negligible. Also, assume that the size of the acknowledgement packet is negligible. Which ONE of the following most accurately gives the channel utilization for the above scenario in percentage?

(a) 88.23
(b) 93.75
(c) 85.44
(d) 66.67

[2025 (Set-2) : 2 M]

Ans. (a)

$$\text{Frame size} = 3000 \text{ bits}$$
$$\text{Transmission rate} = 2000 \text{ bps}$$
$$\text{Program delay } (T_p) = 100 \text{ millisecond}$$
$$\text{Channel utilization} = \frac{T_{\text{data}}}{T_{\text{data}} + 2T_p} \times 100\%$$
$$T_{\text{data}} = \frac{\text{Frame size}}{\text{Transmission rate}} = \frac{3000 \text{ bits}}{2000 \text{ bps}} = 1.5 \text{ seconds}$$
$$\text{Channel utilization} = \frac{1.5}{1.5 + 2 \times 0.1} \times 100\% = \frac{1.5}{1.7} \times 100\% = 88.23\%$$

End of Solution

Q.37 Let G be an edge-weighted undirected graph with positive edge weights. Suppose a positive constant α is added to the weight of every edge.
Which ONE of the following statements is TRUE about the minimum spanning trees (MSTs) and shortest paths (SPs) in G before and after the edge weight update?

(a) Every MST remains an MST, and every SP remains an SP.
(b) MSTs need not remain MSTs, and every SP remains an SP.
(c) Every MST remains an MST, and SPs need not remain SPs.
(d) MSTs need not remain MSTs, and SPs need not remain SPs.

[2025 (Set-2) : 2 M]

Ans. (c)

For every edge of graph if some positive constant α is added.

- MST of graph remains same.
- SP of graph may not same.

End of Solution

Q.38 A meld operation on two instances of a data structure combines them into one single instance of the same data structure. Consider the following data structures:
P: Unsorted doubly linked list with pointers to the head node and tail node of the list.
Q: Min-heap implemented using an array.
R: Binary Search Tree.
Which ONE of the following options gives the worst-case time complexities for meld operation on instances of size n of these data structures?

(a) P: $\Theta(1)$, Q: $\Theta(n)$, R: $\Theta(n)$
(b) P: $\Theta(1)$, Q: $\Theta(n \log n)$, R: $\Theta(n)$
(c) P: $\Theta(n)$, Q: $\Theta(n \log n)$, R: $\Theta(n^2)$
(d) P: $\Theta(1)$, Q: $\Theta(n)$, R: $\Theta(n \log n)$

[2025 (Set-2) : 2 M]

Ans. (a)

Merging of two unsorted DLL : $\theta(1)$
Merging of two min heaps : $\theta(n)$
Using bottom up
Merging of two Binary Search Trees : $\theta(n)$
[Inorder traversal of both lists : $\theta(n)$ time
Merge two sorted lists : $\theta(n)$ time
Build BST over sorted list : $\theta(n)$ time]

End of Solution

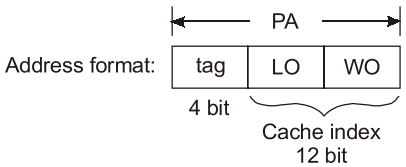
Q.39 For a direct-mapped cache, 4 bits are used for the tag field and 12 bits are used to index into a cache block. The size of each cache block is one byte. Assume that there is no other information stored for each cache block.
Which ONE of the following is the CORRECT option for the sizes of the main memory and the cache memory in this system (byte addressable), respectively?

(a) 64 KB and 4 KB
(b) 128 KB and 16 KB
(c) 64 KB and 8 KB
(d) 128 KB and 6 KB

[2025 (Set-2) : 2 M]

Ans. (a)

- Direct map
- 4 bit tag field
- Cache index = 12 bit



$\therefore$ Cache memory = 2^{12} cells
= 4 K cells = 4 KB

$\therefore$ MM size = 2^{16} cells
= 64 K cells = 64 KB

End of Solution

Q.40 Given a Context-Free Grammar G as follows:

$S \rightarrow Aa \mid bac \mid dc \mid bda$

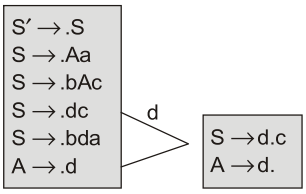
$A \rightarrow d$

Which ONE of the following statements is TRUE?

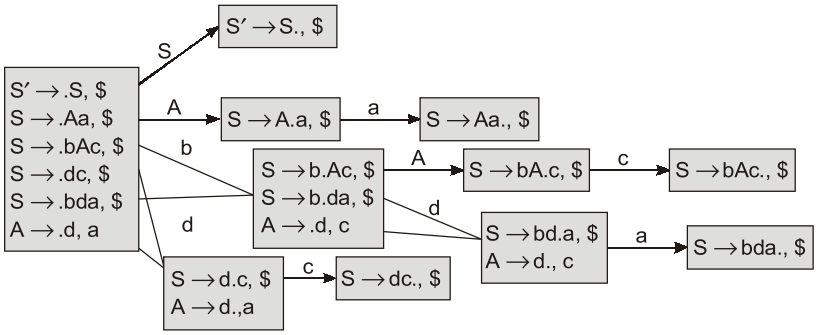
(a) G is neither LALR(1) nor SLR(1)
(b) G is CLR(1), not LALR(1)
(c) G is LALR(1), not SLR(1)
(d) G is LALR(1), also SLR(1)

[2025 (Set-2) : 2 M]

Ans. (c)



$\Rightarrow \{c\} \cap \text{follow (A)}$
$\Rightarrow \{c\} \cap \{a, c\}$
$\Rightarrow \{c\}$
$\neq \phi$
$\Rightarrow$ S/R conflict
$\Rightarrow$ not SLR(1)



No conflicts in CLR(1) and no mergeable states in LALR(1)

$\therefore$ The grammar is CLR(1) and also LALR(1).

End of Solution

Q.41 An array A of length n with distinct elements is said to be bitonic if there is an index $1 = i = n$ such that $A[1..\ i]$ is sorted in the non-decreasing order and $A[i + 1..n]$ is sorted in the non-increasing order.
Which ONE of the following represents the best possible asymptotic bound for the worst-case number of comparisons by an algorithm that searches for an element in a bitonic array A?

(a) $\Theta(n)$ (b) $\Theta(1)$
(c) $\Theta(\log^2 n)$ (d) $\Theta(\log n)$

[2025 (Set-2) : 2 M]

Ans. (d)

	1	2	3	4	5	6	7	8	9	10
a	4	6	8	10	12	15	18	12	8	7

Using Binary Search

```
low = 1; high = n;
while(low ≤ high)
        m = (low + high)/2;
{
   if (a[mid − 1] < a[mid] < a[mid + 1])
        low = mid + 1;
   else if a[mid − 1] > a[mid] > a[mid + 1]
        high = mid − 1;
   else if (a[mid − 1] > a[mid] > a[mid + 1])
        return(mid);
}
   TC: θ(log n)
```

End of Solution

Q.42 Let $\mathcal{F}$ be the set of all functions from $\{1,..., n\}$ to $\{0,1\}$. Define the binary relation $\preccurlyeq$ on $\mathcal{F}$ as follows:
$\forall f.g \in \mathcal{F}$, $f \preccurlyeq g$ if and only if $\forall x \in \{1, ..., n\}$, $f(x) \leq g(x)$, where $0 = 1$.
Which of the following statement(s) is/are TRUE? re TRUE?

(a) $\preccurlyeq$ is a symmetric relation (b) $(\mathcal{F}, \preccurlyeq)$ is a partial order
(c) $(\mathcal{F}, \preccurlyeq)$ is a lattice (d) $\preccurlyeq$ is an equivalence relation

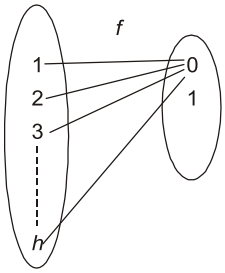
[2025 (Set-2) : 2 M]

Ans. (b, c)

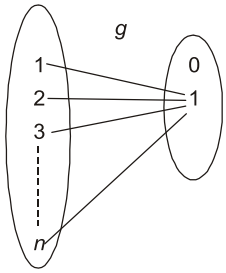
$\mathcal{F}$: Set of all function from {1, 2, 3 ..... n} to {0, 1} and R = "$\leq$"

$\mathcal{F} \leq g$ iff $f(x) \leq g(x)$, $\forall x, \in$ {1, 2, 3 ..... n}

Let,



$f(x) = 0$



$g(x) = 1$

Here $f(x) \leq g(x)$

But $g(x) \not\leq f(x)$

$\therefore$ It cannot be a symmetric.

$\Rightarrow$ It cannot be equivalence reaction.

But here, If $f(x) \leq g(x)$ and $g(x) \leq f(x)$

Then, $f(x) = g(x)$

$(0 = 0)$

$(1 = 1)$

$\therefore$ It is antisymmetric.

Reflexive:

$\because$ $f(x) \leq f(x)$, $\forall x, \in$ {1, 2, ... n}

$0 \leq 0$

$1 \leq 0$

$\therefore$ It is reflexive.

Transitive:

Let, $0 \leq 1$

$1 \not\leq 0$

Let $0 \leq 0$ and $0 \leq 1$ then $0 \leq 1$

If

$\therefore$ $f(x) \leq g(x)$ and $g(x) \leq h(x)$

Then $f(x) \leq h(x)$

$\therefore$ It is transitive.

Hence it is poset.

We know that,

glb (f, g) wrt '$\leq$' is f

lub (f, g) wrt $\leq$ is g

$\therefore$ For every two function F $\exists$ a glb and lub also.

$\therefore$ (f, $\leq$) is a lattice.

End of Solution

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Q.43 Given the following Karnaugh Map for a Boolean function $F(w, x, y, z)$:

wx \ yz				
	1	0	0	1
	0	1	1	0
	0	1	1	0
	1	0	0	1

Which one or more of the following Boolean expression(s) represent(s) F?

(a) $\bar{w}\bar{x}\bar{y}\bar{z} + w\bar{x}\bar{y}\bar{z} + \bar{w}\bar{x}y\bar{z} + w\bar{x}y\bar{z} + xz$

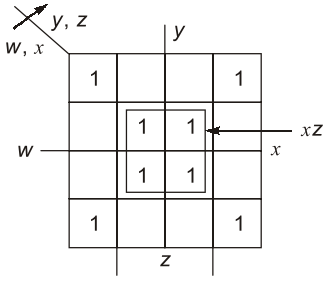
(b) $\bar{w}\bar{x}\bar{y}\bar{z} + \bar{w}\bar{x}y\bar{z} + w\bar{x}yz + xz$

(c) $\bar{w}\bar{x}\bar{y}\bar{z} + w\bar{x}\bar{y}\bar{z} + w\bar{x}\bar{y}z + xz$

(d) $\bar{x}\bar{z} + xz$

[2025 (Set-2) : 2 M]

Ans. (a, d)



$F(w, x, y, z) = \bar{w}\bar{x}\bar{y}\bar{z} + w\bar{x}\bar{y}\bar{z} + \bar{w}\bar{x}y\bar{z} + w\bar{x}y\bar{z} + xz$

$F(w, x, y, z) = \bar{x}\bar{z} + xz$

End of Solution

Q.44 Consider a system of linear equations $PX = Q$ where $P \in \mathbb{R}^{3\times3}$ and $Q \in \mathbb{R}^{3\times3}$. Suppose P has an LU decomposition, $P = LU$, where

$$L = \begin{bmatrix} 1 & 0 & 0 \\ l_{21} & 1 & 0 \\ l_{31} & l_{32} & 1 \end{bmatrix} \quad \text{and} \quad U = \begin{bmatrix} u_{11} & u_{12} & u_{13} \\ 0 & u_{22} & u_{23} \\ 0 & 0 & u_{33} \end{bmatrix}$$

Which of the following statement(s) is/are TRUE?

(a) The system $PX = Q$ can be solved by first solving $LY = Q$ and then $UX = Y$.

(b) If P is invertible, then both L and U are invertible.

(c) If P is singular, then at least one of the diagonal elements of U is zero.

(d) If P is symmetric, then both L and U are symmetric.

[2025 (Set-2) : 2 M]

Ans. **(a, b, c)**

$$P_{3\times 3}\ X = Q_{3\times 1} \quad \ldots(1)$$

and $$P = LU \quad \ldots(2)$$

Sub in (1): $LUX = Q$

Let $UX = Y$ then system is $LY = Q$

Solving $LY = Q$ we get Y then

Sub in $UX = Y$ and save for X

$\therefore$ (a) is true.

(b) $\because$ $P = LU$

$P^{-1} = (LU)^{-1}$

$P^{-1} = U^{-1}L^{-1}$

$\therefore$ If P is invertible then U and L also invertible.

$\therefore$ (b) is true

(c) If $|P| = 0 \Rightarrow |LU| = 0$

$\Rightarrow |L| = 0$ (or) $|U| = 0$

$\because |L| \neq 0$ given

$\Rightarrow |U| = 0$

Then atleast one of the $u_{ii} = 0$

$\therefore$ (c) is true

(d) Given $P = LU$

Let, $P^T = P$

$\Rightarrow (LU)^T = U^TL^T$

If $U^T = U$, $L^T = L$

Then $P^T = (LU)^T = UL \neq LU$

Which is a contradiction

$\therefore$ $U^T \neq U$, $L^T \neq L$

$\therefore$ (d) is false.

End of Solution

Q.45 Consider a stack data structure into which we can PUSH and POP records. Assume that each record pushed in the stack has a positive integer key and that all keys are distinct. We wish to augment the stack data structure with an $O(1)$ time MIN operation that returns a pointer to the record with smallest key present in the stack

1. without deleting the corresponding record, and
2. without increasing the complexities of the standard stack operations.

Which one or more of the following approach(es) can achieve it?

(a) Keep with every record in the stack, a pointer to the record with the smallest key below it.

(b) Keep a pointer to the record with the smallest key in the stack.

(c) Keep an auxiliary array in which the key values of the records in the stack are maintained in sorted order.

(d) Keep a Min-Heap in which the key values of the records in the stack are maintained.

[2025 (Set-2) : 2 M]

Ans. **(a)**

Maintaining a pointer to the smallest key below each element ensures that the MIN operation runs in $O(1)$ time. Push updates this pointer in $O(1)$ time, and pop removes the top element without affecting efficiency. Other approaches require $O(n)$ or $O(\log n)$ updates, making them unsuitable.

End of Solution

Q.46 Consider the following relational schema along with all the functional dependencies that hold on them.

$R1(A, B, C, D, E)$: $\{D \rightarrow E,\ EA \rightarrow B,\ EB \rightarrow C\}$

$R2(A, B, C, D)$: $\{A \rightarrow D,\ A \rightarrow B,\ C \rightarrow A\}$

Which of the following statement(s) is/are TRUE?

(a) $R1$ is in 3NF

(B) $R2$ is in 3NF

(c) $R1$ is NOT in 3NF

(d) $R2$ is NOT in 3NF

[2025 (Set-2) : 2 M]

Ans. **(c, d)**

$R_1(ABCDE)$	$R_2(ABCD)$
$\{D \rightarrow E, EA \rightarrow B, EB \rightarrow C\}$	$\{A \rightarrow D, A \rightarrow B, C \rightarrow A\}$
$(DA)^+ = \{DEABC\}$	$C^+ = CABD$
$\underline{AD}$: Candidate key	$\underline{C}$: Candidate key
R_1 in 1NF but not in 2NF	R_2 in 2NF but not in 3NF

End of Solution

Q.47 Consider a demand paging system with three frames, and the following page reference string: 1 2 3 4 5 4 1 6 4 5 1 3 2. The contents of the frames are as follows initially and after each reference (from left to right):

Initially	after											
-	1*	2*	4*	5*	4	1	6*	4	5	1*	3*	2*
-	1	1	1	1	1	1	6	6	6	6	6	2
-	-	2	2	4	4	4	4	4	4	1	1	1
-	-	-	3	3	5	5	5	5	5	5	3	3

The *-marked references cause page replacements.
Which one or more of the following could be the page replacement policy/policies in use?

(a) Least Recently Used page replacement policy
(b) Least Frequently Used page replacement policy
(c) Most Frequently Used page replacement policy
(d) Optimal page replacement policy

[2025 (Set-2) : 2 M]

Ans. (d)

Reference string 1, 2, 3, 4, 5, 4, 1, 6, 4, 5, 1, 3, 2
Using Optimal page replacement policy

1	2	3	4	5	4	1	6	4	5	3	3	2
		3	3	5	5	5	5	5	5	5	3	3
	2	2	4	4	4	4	4	4	1	1	1	–1
1	1	1	1	1	1	6	6	6	6	6	6	2
H	H	H	H	H		H					H	H

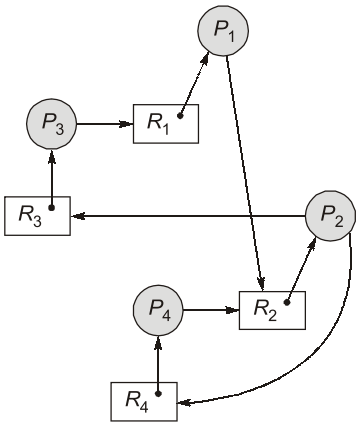
End of Solution

Q.48 $P = \{P_1, P_2, P_3, P_4\}$ consists of all active processes in an operating system.
$R = \{R_1, R_2, R_3, R_4\}$ consists of single instances of distinct types of resources in the system.
The resource allocation graph has the following assignment and claim edges.
Assignment edges: $R_1 \rightarrow P_1$, $R_2 \rightarrow P_2$, $R_3 \rightarrow P_3$, $R_4 \rightarrow P_4$ (the assignment edge $R_1 \rightarrow P_1$ means resource R_1 is assigned to process P_1, and so on for others)
Claim edges: $P_1 \rightarrow R_2$, $P_2 \rightarrow R_3$, $P_3 \rightarrow R_1$, $P_2 \rightarrow R_4$, $P_4 \rightarrow R_2$ (the claim edge $P_1 \rightarrow R_2$ means process P_1 is waiting for resource R_2, and so on for others)
Which of the following statement(s) is/are CORRECT?

(a) Aborting P_1 makes the system deadlock free.
(b) Aborting P_3 makes the system deadlock free.
(c) Aborting P_2 makes the system deadlock free.
(d) Aborting P_1 and P_4 makes the system deadlock free.

[2025 (Set-2) : 2 M]

Ans. (c, d)



Resource Allocation Graph

End of Solution

Q.49 Three floating point numbers X, Y, and Z are stored in three registers R_X, R_Y, and R_Z, respectively in IEEE 754 single precision format as given below in hexadecimal:
R_X = 0xC1100000, R_Y = 0x40C00000, and R_Z = 0x41400000
Which of the following option(s) is/are CORRECT?

(a) $4(X + Y) + Z = 0$
(b) $2Y - Z = 0$
(c) $4X + 3Z = 0$
(d) $X + Y + Z = 0$

[2025 (Set-2) : 2 M]

Ans. (a, b, c)

$R_X = (C1100000)_H$

1	1 0 0 0 0 0 1 0	0 0 1 0 0 0 0 . . . .
S	BE	M

Bias = +127

Value = $(-1)^1 (1.001000 .....) \times 2^{130 - 127}$
$= - 1.001000 ..... \times 2^3$
$= - 9$

$R_Y = (40\,C00000)_H$

0	1 0 0 0 0 0 0 1	1 0 0 0 0 0 . . . .
S	BE	M

Value = $(-1)^0 (1.100 .....) \times 2^{129 - 127}$
$= +(1.100 .....) \times 2^2$
$= +6$

$R_Z = (41400000)_H$

0	1 0 0 0 0 0 1 0	1 0 0 0 0 . . . .
S	BE	M

$$\text{Value} = (-1)^0\ (1.000\ .....) \times 2^{130-127}$$
$$= +\ (1.1000\ .....) \times 2^3$$
$$= +12$$

- $4(-9 \times +6) + 12 = 0 \quad \Rightarrow$ True
- $(2 \times 6) - (+12) = 0 \quad \Rightarrow$ True
- $4 \times (-9) + (3 \times 12) = 0 \quad \Rightarrow$ True
- $-9 + 6 + 12 = 0 \quad \Rightarrow$ False

End of Solution

Q.50 Which of the following Boolean algebraic equation(s) is/are CORRECT?

(a) $\bar{A}BC + A\bar{B}\bar{C} + \bar{A}\bar{B}\bar{C} + A\bar{B}C + ABC = BC + B\bar{C} + \bar{A}\bar{B}$

(b) $AB + \bar{A}C + BC = AB + \bar{A}C$

(c) $(A+C)(\bar{A}+B) = AB + \bar{A}C$

(d) $\overline{(A+\bar{B}+\bar{D})(C+D)(\bar{A}+C+D)(A+B+\bar{D})} = \bar{A}D + \bar{C}\bar{D}$

[2025 (Set-2) : 2 M]

Ans. **(b, c, d)**

(a) $\text{LHS} = \bar{A}BC + A\bar{B}\bar{C} + \bar{A}\bar{B}\bar{C} + A\bar{B}C + ABC$

$= BC + B\bar{C} + AC$

$\neq$ RHS

(b) $\text{LHS} = AB + \bar{A}C + BC$

$= AB + \bar{A}C$ ← using consensus property

$=$ RHS

(c) $\text{LHS} = (A+C)(\bar{A}+B)$

$= AB + \bar{A}C + BC$

$= AB + \bar{A}C$ ← using consensus property

$=$ RHS

(d) $\text{LHS} = \overline{(A+\bar{B}+\bar{D})(C+D)(\bar{A}+C+D)(A+B+\bar{D})}$

$= \bar{A}BD + \bar{C}\bar{D} + A\bar{C}\bar{D} + \bar{A}\bar{B}D$

$= \bar{A}D + \bar{C}\bar{D}$

$=$ RHS

End of Solution

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Q.51 Consider two grammars G_1 and G_2 with the production rules given below:

G_1 : S → if E then S | if E then S else S | a
E → b

G_2 : S → if E then S | M
E → if E then M else S | c
E → b

where if, then, else, a, b, c are the terminals.

Which of the following option(s) is/are CORRECT?

(a) G_1 is not $LL(1)$ and G_2 is $LL(1)$.

(b) G_1 is $LL(1)$ and G_2 is not $LL(1)$.

(c) G_1 and G_2 are not $LL(1)$.

(d) G_1 and G_1 are ambiguous.

[2025 (Set-2) : 2 M]

Ans. **(c, d)**

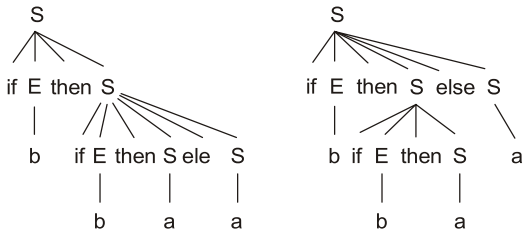
G_1: S → if E then S | if E then S else S | a

⇒ {if} ∩ {if}

⇒ {if}

≠ ϕ

⇒ Not LL(1)



Same string "if b then if b then a else a" is having two different parse trees ⇒ G_1 is ambiguous.

G_2 if E then S | M

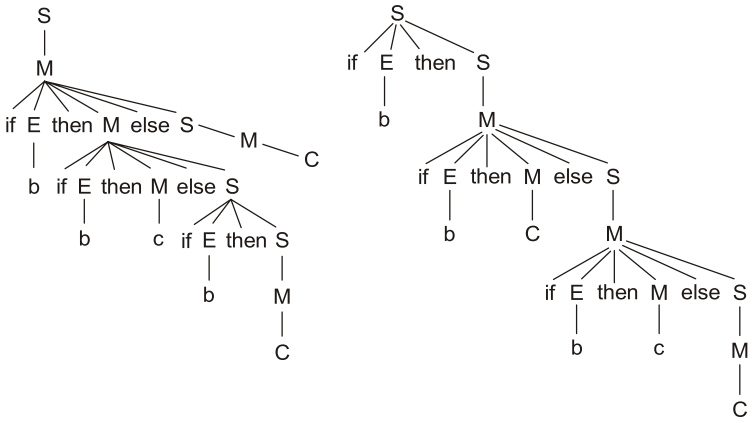
⇒ {if} ∩ First (M)

⇒ {if} ∩ {if, c}

⇒ {if}

≠ ϕ

⇒ Not LL(1)



The string "if b then if b then c else if b then c else c" has two different parse trees
⇒ G_2 is ambiguous.
∴ Answer is (c) and (d).

End of Solution

Q.52 Let $\Sigma = \{a, b, c\}$. For $x \in \Sigma^*$, and $\alpha \in \Sigma$, let $\#_\alpha(x)$ denote the number of occurrences of a in x. Which one or more of the following option(s) define(s) regular language(s)?

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

(b) $\{a, b\}^* \cap \{a^m b^n c^{m-n} \mid m \geq n \geq 0\}$

(c) $\{w \mid w \in \{a, b\}^*, \#_a(w) \equiv 2 \pmod 7$, and $\#_b(w) \equiv 3 \pmod 9\}$

(d) $\{w \mid w \in \{a, b\}^*, \#_a(w) \equiv 2 \pmod 7$, and $\#_a(w) = \#_b(w)\}$

[2025 (Set-2) : 2 M]

Ans. **(a, c)**

A: $\{a^m b^n \mid m, n \geq = 0\}$
Here no comparison between no of a's and b's = regular.

B: $\{a, b\}^* \cap \{a^m b^n c^{m-n} \mid m \geq n \geq = 0\}$
Here in the second set the no of c's must be equal to the difference of no of a's and b's.
⇒ Not regular.

C: Mod functions are always regular

D: Here no of a's and b's must be equal
⇒ Not regular.

End of Solution

Q.53 Consider the database transactions T1 and T2, and data items X and Y. Which of the schedule(s) is/are conflict serializable?

Transaction T1
R1(X)
W1(Y)
R1(X)
W1(X)
COMMIT(T1)

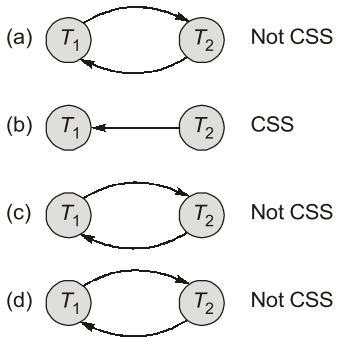
Transaction T2
W1(X)
W2(Y)
COMMIT(T2)

(a) R1(X), W2(X), W1(Y), W2(Y), R1(X), W1(X), COMMIT(T2), COMMIT(T1)
(b) W2(X), R1(X), W2(Y), W1(Y), R1(X), COMMIT(T2), W1(X), COMMIT(T1)
(c) R1(X), W1(Y), W2(X), W2(Y), R1(X), W1(X), COMMIT(T1), COMMIT(T2)
(d) W2(X), R1(X), W1(Y), W2(Y), R1(X), COMMIT(T2), W1(X), COMMIT(T1)

[2025 (Set-2) : 2 M]

Ans. (b)

Precedence graphs of each schedule:



End of Solution

Q.54 Consider the following relational schema:

Students (rollno: integer, name: string, age: integer, cgpa: real)

Courses (courseno: integer, cname: string, credits: integer)

Enrolled (rollno: integer, courseno: integer, grade: string)

Which of the following options is/are correct SQL query/queries to retrieve the names of the students enrolled in course number (i.e., courseno) 1470?

(a)
```
SELECT S.name
FROM Students S
WHERE EXISTS  (SELECT * FROM Enrolled E
               WHERE E.courseno = 1470
               AND E.rollno = S.rollno);
```

(b)
```
SELECT S.name
FROM Students S
WHERE SIZEOF  (SELECT * FROM Enrolled E
                WHERE E.courseno = 1470
                        AND E.rollno = S.rollno) > 0;
```

(c)
```
SELECT S.name
FROM Students  S
               WHERE 0 < (SELECT COUNT(*)
               FROM Enrolled E
               WHERE E.courseno = 1470
                        AND E.rollno = S.rollno);
```

(d)
```
SELECT S.name
FROM Students S NATURAL JOIN Enrolled E
WHERE E.courseno = 1470;
```

[2025 (Set-2) : 2 M]

Ans. (a, c, d)

- EXISTS fun behaves like any/some
  (A correct query)
- Retrieve name his enrolled courses of cid 1470 are more than 0
  (C correct query)
- Using natural join
  (D correct query)

End of Solution

Q.55 Given a computing system with two levels of cache (L1 and L2) and a main memory. The first level (L1) cache access time is 1 nanosecond (ns) and the "hit rate" for L1 cache is 90% while the processor is accessing the data from L1 cache. Whereas, for the second level (L2) cache, the "hit rate" is 80% and the "miss penalty" for transferring data from L2 cache to L1 cache is 10 ns. The "miss penalty" for the data to be transferred from main memory to L2 cache is 100 ns.
Then the average memory access time in this system in nanoseconds is (rounded off to one decimal place)

[2025 (Set-2) : 2 M]

Ans. (4)

$$\begin{aligned} T_{avg} &= H_1T_1 + (1 - H_1)H_2\,(T_2 + T_1) + (1 - H_1)\,(1 - H_2)\,H_3\,(T_3 + T_2 + T_1) \\ &= (0.9 \times 1) + (1 - 0.9)\,0.8\,(10 + 1) + (1 - 0.9)\,(1 - 0.8)\,(100 + 10 + 1) \\ &= 0.9 + 0.88 + 2.22 \\ &= 4 \text{ ns} \end{aligned}$$

End of Solution

Q.56 A 5-stage instruction pipeline has stage delays of 180, 250, 150, 170, and 250, respectively, in nanoseconds. The delay of an inter-stage latch is 10 nanoseconds. Assume that there are no pipeline stalls due to branches and other hazards. The time taken to process 1000 instructions in microseconds is _____ . (Rounded off to two decimal places)

[2025 (Set-2) : 2 M]

Ans. (261.04)

$$\begin{aligned} ET &= (k + n - 1)t_p \\ &= (5 + 1000 - 1)\ 260 \text{ ns} \\ &= 261040 \text{ ns} \\ &= 261.04\ \mu\text{sec} \end{aligned}$$

End of Solution

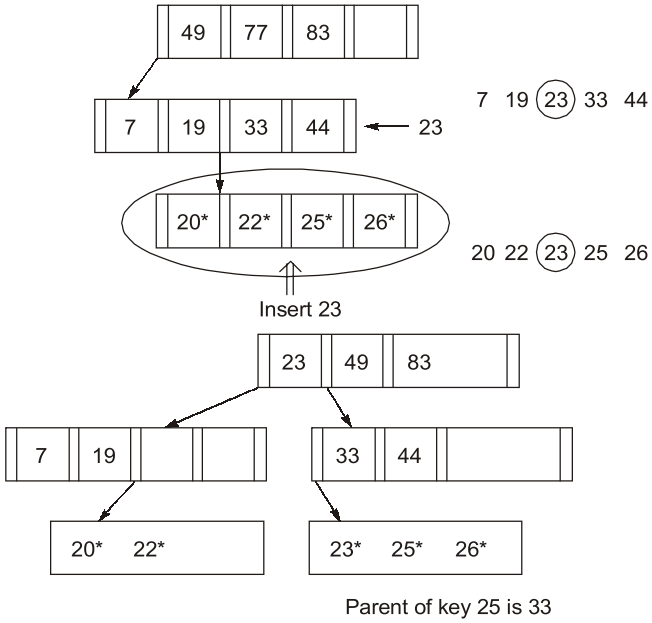
Q.57 In a B^+ - tree where each node can hold at most four key values, a root to leaf path consists of the following nodes:

A = (49, 77, 83, –), B = (7, 19, 33, 44), C = (20*, 22*, 25*, 26*)

The *-marked keys signify that these are data entries in a leaf.
Assume that a pointer between keys k_1 and k_2 points to a subtree containing keys in $[k_1, k_2]$, and that when a leaf is created, the smallest key in it is copied up into
A record with key value 23 is inserted into the B^+ - tree.
The smallest key value in the parent of the leaf that contains 25* is _____.
(Answer in integer)

[2025 (Set-2) : 2 M]

Ans. (33)



Parent of key 25 is 33

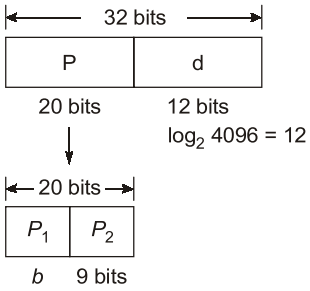
End of Solution

Q.58 A computer system supports a logical address space of 2^{32} bytes. It uses two-level hierarchical paging with a page size of 4096 bytes. A logical address is divided into a *b*-bit index to the outer page table, an offset within the page of the inner page table, and an offset within the desired page. Each entry of the inner page table uses eight bytes. All the pages in the system have the same size.
The value of *b* is _____. (Answer in integer)

[2025 (Set-2) : 2 M]

Ans. (11)

L.A.S. = 2^{32} bits
Page size = 4096 bytes
Two level paging



Each table in the inner page table takes 8 bytes

Number of entries in inner page table = $\frac{4096}{8} = \frac{2^{12}}{2^3} = 2^9$

Out page table index = 20 – 9 = 11 bits.

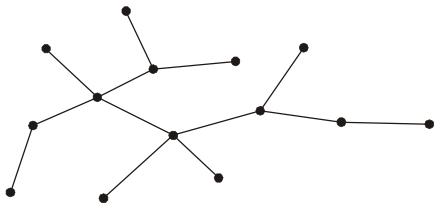
End of Solution

Q.59 Consider the following algorithm someAlgo that takes an undirected graph G as input.

someAlgo (*G*)

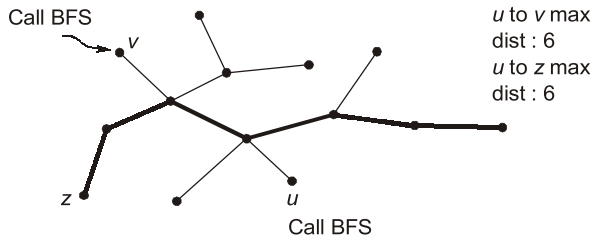
1. Let *v* be any vertex in *G*. Run BFS on *G* starting at *v*. Let *u* be a vertex in *G* at maximum distance from *v* as given by the BFS.
2. Run BFS on *G* again with *u* as the starting vertex. Let *z* be the vertex at maximum distance from *u* as given by the BFS.
3. Output the distance between *u* and *z* in *G*.

The output of someAlgo(*T*) for the tree shown in the given figure is _____. (Answer in integer)



[2025 (Set-2) : 2 M]

Ans. (6)

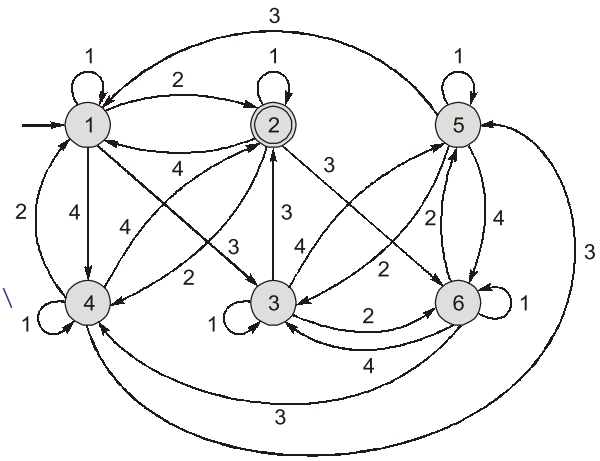


End of Solution

Q.60 Let $\Sigma = \{1, 2, 3, 4\}$ For $x \in \Sigma^*$, let $prod(x)$ be the product of symbols in x modulo 7. We take $prod(\varepsilon) = 1$, where ε is the null string.
For example, $prod(124) = (1 \times 2 \times 4) \bmod 7 = 1$.
Define $L = \{x \in \Sigma^* \mid prod(x) = 2\}$.
The number of states in a minimum state DFA for L is _____. (Answer in integer)

[2025 (Set-2) : 2 M]

Ans. (6)



End of Solution

Q.61 An application executes 6.4×10^8 number of instructions in 6.3 seconds. There are four types of instructions, the details of which are given in the table. The duration of a clock cycle in nanoseconds is _____. (rounded off to one decimal place)

Instruction type	Clock cycles required per instruction (CPI)	Number of Instructions executed
Branch	2	2.25×10^8
Load	5	1.20×10^8
Store	4	1.65×10^8
Arithmetic	3	1.30×10^8

[2025 (Set-2) : 2 M]

Ans. (3)

Program ET = 6.3 sec
(6.4×10^8 instruction)

$$ET = \sum_{i=1}^{n} (IC_i \times CPI) \text{ cycle time}$$

$$= [(2 \times 2.25) + (5 \times 1.2) + (4 \times 1.65) + (3 \times 1.3)]10^8 \text{ cycle}$$

$$= 21 \times 10^8 \text{ cycles}$$

21×10^8 cycles total execution time given as 6.3 sec
So, cycle time is
21×10^8 cycles _____ 6.3 sec
1 cycle _____ ?

$$= \frac{6.3 \text{ sec}}{21 \times 10^8} = 0.3 \times 10^{-8} \text{ sec}$$

$$= 3 \times 10^{-9} \text{ sec} = 3 \text{ ns}$$

End of Solution

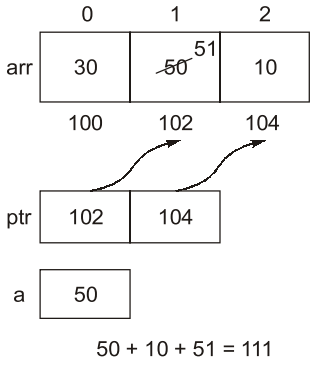
Q.62 Consider the following C program:

```
#include <stdio.h>
int main( ) {
        int a;
        int arr[5] = {30, 50, 10};
        int *ptr;
        ptr = &arr[0] + 1;
        a = *ptr;
        (*ptr)++;
        ptr++;
        printf("%d", a + (*ptr) + arr[1]);
        return 0;
}
```

The output of the above program is _____. (Answer in integer)

[2025 (Set-2) : 2 M]

Ans. (111)



50 + 10 + 51 = 111

End of Solution

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Q.63 Consider the following C program:

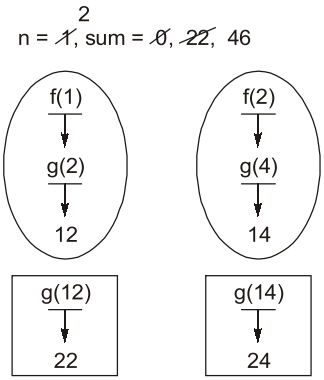
```
#include <stdio.h>
int g(int n) {
    return (n+10);
}
    int f(int n) {
    return g(n*2);
}
int main( ) {
    int sum, n;
    sum=0;
    for (n=1; n<3; n++)
    sum += g(f(n));
    printf("%d", sum);
    return 0;

}
```

The output of the given C program is _____. (Answer in integer)

[2025 (Set-2) : 2 M]

Ans. (46)



End of Solution

Q.64 A quadratic polynomial $(x-\alpha)(x-\beta)$ over complex numbers is said to be square invariant if $(x-\alpha)(x-\beta) = (x-\alpha^2)(x-\beta^2)$. Suppose from the set of all square invariant quadratic polynomials we choose one at random.
The probability that the roots of the chosen polynomial are equal is (rounded off to one decimal place)

[2025 (Set-2) : 2 M]

Ans. (0.5)

Square invariant polynomial, i if

$$(x-\alpha)(x-\beta) = (x-\alpha^2)(x-\beta^2)$$

$\Rightarrow$ Equating we get

$$\alpha + \beta = \alpha^2 + \beta^2 \quad \text{...(i)}$$

and $\alpha\beta = \alpha^2\beta^2$

$\Rightarrow$ $\alpha\beta = 0$ (or) 1

Case (i):

$\alpha\beta = 0$

$\Rightarrow$ $\alpha = 0, \beta = 0$

Let $\alpha = 0$,

Sub in (i),

$\Rightarrow$ $\beta = \beta^2 \Rightarrow \beta = 0$ or 1

$\therefore$ $(\alpha, \beta) = (0, 0)$ or $(0, 1)$ or $(1, 0)$

For $\alpha = 0, \beta = 0$:

Polynomial will be $x^2 = x^2$

Which is square invariant

For $\alpha = 0, \beta = 1$,

Polynomial will be

$$x(x-1) = x(x-1)$$

$\therefore x^2 - x$ is also a square invariant polynomial.

Similarly for $\alpha = 1, \beta = 0$ also.

Case (ii):

$\alpha\beta = 1$

$\Rightarrow$ $\beta = \frac{1}{\alpha}$

Sub in (i),

$\Rightarrow$ $\alpha + \frac{1}{\alpha} = \alpha^2 + \frac{1}{\alpha^2}$

Solving we get,

$\alpha = 1, 1\ \omega, \omega^2$ (cubeth roots of unity)

For $\alpha = 1, \beta = 1$:

Polynomial will be

$$(x-1)^2 = (x-1^2)^2$$

$\therefore (x-1)^2$ is a square invariant polynomial

For $\alpha = \omega$, ω^2 also
We get $x^2 + x + 1$ will be square invariant polynomial
Hence total number of square invariant polynomial = 4
Let, E = Drawing a square invariant polynomial has equal roots
$\therefore$ $n(E) = 2$

Hence, $$P(E) = \frac{n(E)}{n(S)} = \frac{2}{4} = \frac{1}{2} = 0.5$$

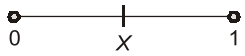
End of Solution

Q.65 The unit interval (0,1) is divided at a point chosen uniformly distributed over (0,1) in $\mathbb{R}$ into two disjoint subintervals.
The expected length of the subinterval that contains 0.4 is _____.
(rounded off to two decimal places)

[2025 (Set-2) : 2 M]

Ans. (0.75)

- Let X be a random variable that represents the point where the unit integral (0, 1) is divided into disjoint subintervals.
- X is uniformly distributed over (0, 1)
  Then, subintervals are (0, X) and (X, 1)



- Condition is 0.4 lies interval,
  So, if $X < 0.4$, 0.4 will be in (X, 1)
  and if $X > 0.4$, 0.4 will be in (0, X)
  Define now R.V. Y = as length of interval containing 0.4
  $\therefore$ $Y = \max(X, 1 - X)$ and $\times$ uniformly distribution over (0, 1)

There,
$$E(y) = \int_0^1 Y f_X(X)dx = \int_0^1 \max(X, 1-x)\frac{1}{1-0}dx$$
$$= \int_0^{0.5} (1-x)dx + \int_{0.5}^1 x dx$$
$$= \left(x - \frac{x^2}{2}\right)_0^{0.5} + \left(\frac{x^2}{2}\right)_{0.5}^1$$
$$= \left(\frac{1}{2} - \frac{1}{8}\right) + \left(\frac{1}{2} - \frac{1}{8}\right) = 0.75$$

End of Solution

■■■■