GATE 2026

Computer Science-2

Afternoon Session

Detailed Solutions

Exam held on 08-02-2026

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SECTION - A GENERAL APTITUDE

Q.1 Expedite, Hasten, Hurry, _____.

Fill the blank by choosing a word with a meaning similar to that of the words given above.

(a) Accelerate (b) Retard

(c) Provide (d) Disable

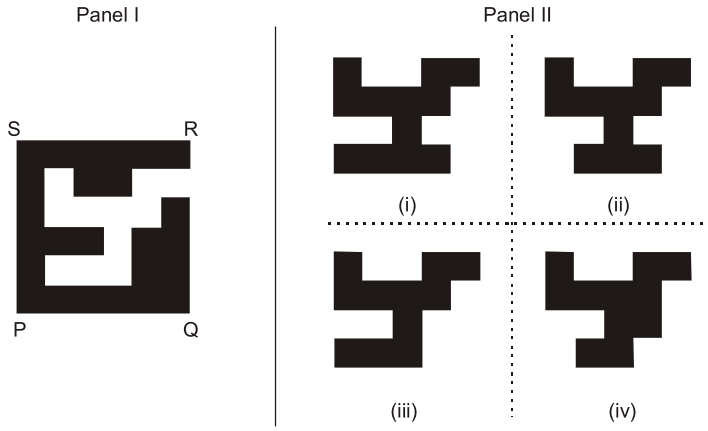
Ans. (a)

All three words given Expedite, Hasten, Hurry, mean to make something happen faster:

- Accelerate → Means to speed up
- Retard → Means to delay
- Provide → Means to give
- Disable → Means to make unable

End of Solution

Q.2 A black square PQRS has been cut into two parts. One part of it is shown in Panel I. Which one of the shapes in Panel II is the other part?



(a) (i) (b) (ii)

(c) (iii) (d) (iv)

Ans. (c)

End of Solution

Q.3 A day can only be cloudy or sunny. The probability of a day being cloudy is 0.5, independent of the condition on other days. What is the probability that in any given four days, there will be three cloudy days and one sunny day?

(a) $\frac{1}{4}$ (b) $\frac{3}{4}$

(c) $\frac{2}{3}$ (d) $\frac{3}{8}$

Ans. **(a)**

Probability of cloudy (C) = 0.5

Probability of sunny (S) = 0.5

Need probability of exactly 3 cloudy and 1 sunny in 4 days.

This is a binomial probability

$$P = {}^4C_3 (0.5)^3 (0.5)^1$$

$$= 4 \times (0.5)^4 = \frac{1}{4}$$

End of Solution

Q.4 The values of Stock A and Stock B on a particular day are Rs. 50 and Rs. 80, respectively. An investor invests Rs. 100 in Stock A and Rs. 80 in Stock B. He sells all the stocks the next day when the value of Stock A is Rs. 55 and Stock B is Rs. 70. The profit made by the investor is Rs. _____.

(a) 0 (b) 5

(c) 10 (d) 20

Ans. **(a)**

A is value = 50

B is value = 80

Stock of A

$$\frac{100}{50} = 2 \text{ stocks}$$

Stock of B

$$\frac{80}{8} = 1 \text{ stock}$$

Total cost price = 180

Total selling price (S.P) = $2 \times 55 + 70 + 1$

$= 110 + 70 = 180$

Profit = S.P − C.P

$= 180 - 180 = 0$

End of Solution

Q.5 'When it is raining, peacocks dance.'

Based only on this sentence, which one of the following options is necessarily true?

(a) Peacocks dance only when it is raining.
(b) When peacocks dance, it is raining.
(c) When peacocks are not dancing, it is not raining.
(d) When it is not raining, peacocks do not dance.

Ans. **(c)**

Given statement:
'When it is raining, peacocks dance.'
This is a conditional statement.
Then contra positive is always true:
So, if peacocks are not dancing, then it is not raining.

End of Solution

Q.6 Water : P :: Food : Q

Choose the P and Q combination from the options below to form a meaningful analogy.

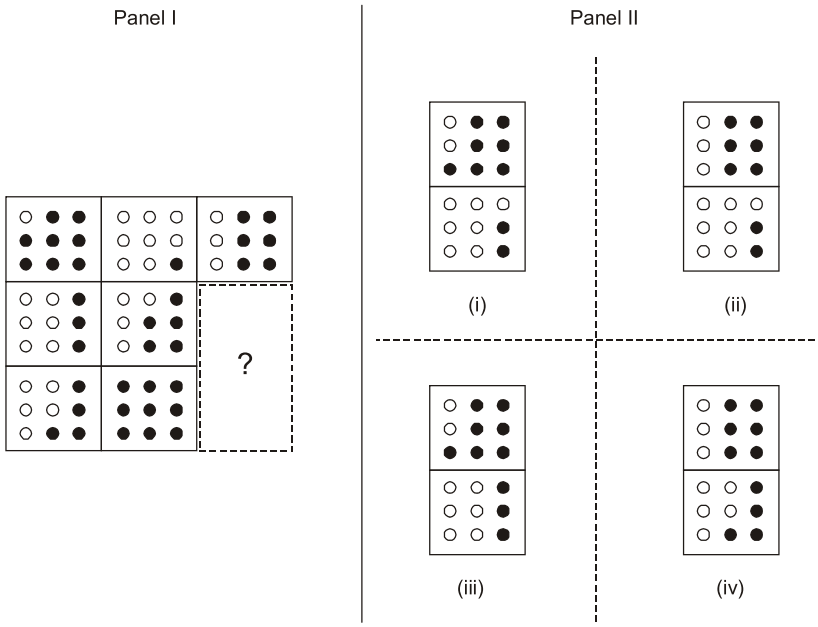
(a) P = Thirst; Q = Hunger
(b) P = Drink; Q = Hunger
(c) P = Thirst; Q = Satiated
(d) P = Wet; Q = Critic

Ans. **(a)**

- Water satisfies thirst.
- Food satisfies hunger.

End of Solution

Q.7 Two tiles are missing in Panel I. Which one of the options in Panel II is the appropriate choice for the missing tiles?



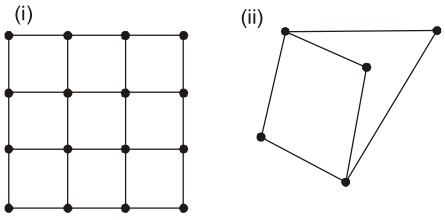
(a) (i)
(b) (ii)
(c) (iii)
(d) (iv)

Ans. (a)

End of Solution

Q.8 Figures (i) and (ii) represent intercity highway systems. The black dots represent cities and the line segments between them represent intercity highways. A salesperson needs to make a trip. She needs to start from a city, visit each of the remaining cities exactly once, and finally return to the same city from which she started.

Which one of the following options is then true?



(a) Such a trip is possible for (i), but not for (ii).
(b) Such a trip is possible for (ii), but not for (i).
(c) Such a trip is possible for both (i) and (ii).
(d) Such a trip is possible neither for (i) nor for (ii).

Ans. (a)

Figure (i) is a Hamiltonian cycle.

She must, start at a city, visit every other city exactly once, return to the starting city.

A rectangular grid with at least 2 rows and 2 columns always has Hamiltonian cycle.

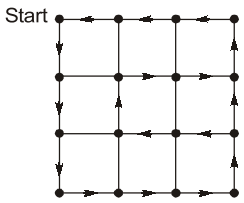
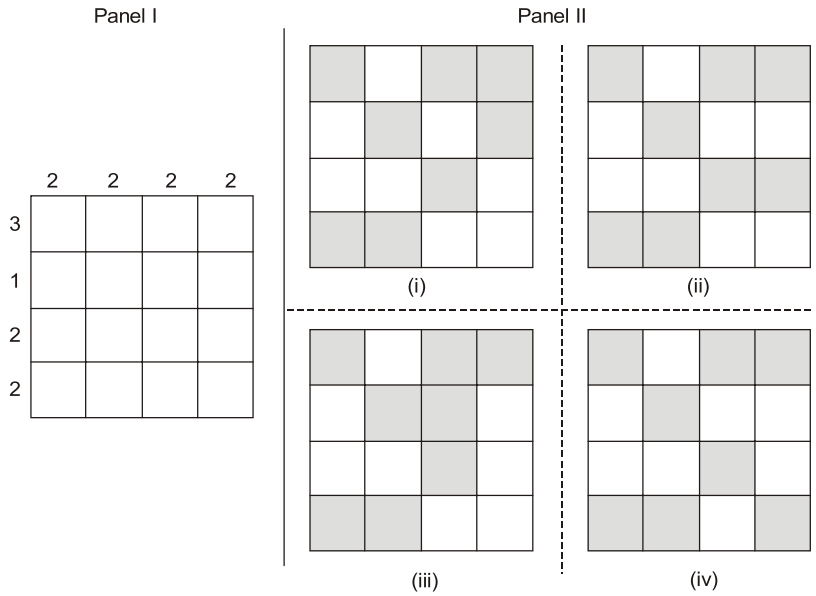


Figure (ii) such a trip is possible for (i), but not for (ii).

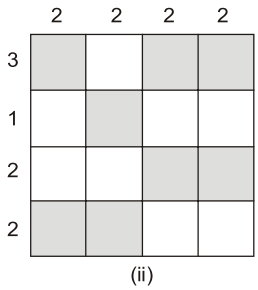
End of Solution

Q.9 The figure in Panel I below is a grid of cells with four rows and four columns. The numbers on the top and on the left represent the number of cells that are to be shaded in that column and row, respectively. Which one of the options shown in Panel II below represents the grid shaded correctly?



(a) (i)
(b) (ii)
(c) (iii)
(d) (iv)

Ans. (b)



(ii)

All conditions satisfied.

End of Solution

Q.10 An unbiased six-faced dice whose faces are marked with numbers 1, 2, 3, 4, 5, and 6 is rolled twice in succession and the number on the top face is recorded each time. The probability that the sum of the two recorded numbers is a prime number is _____.

(a) $\frac{3}{36}$ (b) $\frac{13}{36}$

(c) $\frac{15}{36}$ (d) $\frac{19}{36}$

Ans. (c)

Total outcomes when a die is rolled twice = $6 \times 6 = 36$

Possible sums range from 2 to 12

Prime numbers between 2 and 12

2, 3, 5, 7, 11

Sum = 2

(1, 1) → 1 outcome

Sum = 3

(1, 2), (2, 1) → 2 outcomes

Sum = 5

(1, 4), (2, 3), (3, 2), (4, 1) → 4

Sum = 7

(1, 6), (2, 5), (3, 4), (4, 3), (5, 2) (6, 1) → 6 outcomes

Sum = 11

(5, 6), (6, 5) → 2 outcomes

Total favourable outcomes = 1 + 2 + 4 + 6 + 2 = 15

Probability = $\frac{15}{36}$

End of Solution

■■■■

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SECTION - B TECHNICAL

Q.11 For two different persons x and y, the predicate $M(x, y)$ denotes that x knows y. Consider the following statement.

There is a person who does not know anyone else, but that person is known by everyone else.

Which one of the following expressions represents the above statement?

(a) $(\exists y)(\forall x)((x \neq y)) \rightarrow (M(x, y) \wedge \neg M(y, x))$

(b) $(\forall y)(\exists x)((x \neq y)) \rightarrow (M(x, y) \wedge \neg M(y, x))$

(c) $(\exists y)(\exists x)((x \neq y)) \rightarrow (M(x, y) \wedge \neg M(y, x))$

(d) $(\forall y)(\forall x)((x \neq y)) \rightarrow (M(x, y) \wedge \neg M(y, x))$

Ans. (a)

End of Solution

Q.12 The set T represents various traversals over binary tree. The set S represents the order of visiting nodes during a traversal.

T		S	
I:	Inorder	L:	left subtree, node, right subtree
II:	Preorder	M:	node, left subtree, right subtree
III:	Postorder	N:	left subtree, right subtree, node

Which one of the following is the correct match from T to S?

(a) I – L, II – M, III – N (b) I – M, II – L, III – N

(c) I – N, II – M, III – L (d) I – L, II – N, III – M

Ans. (a)

Inorder: Left subtree, node, right subtree

Preorder : Node, left subtree, right subtree

Postorder: Left subtree, right subtree, node

End of Solution

Q.13 Which one of the following statements is equivalent to the following assertion?

Turing machine M decides the language $L \subseteq \{0,1\}$.

(a) Turing machine M halts on all input strings in $\{0,1\}^*$

(b) Turing machine M accepts all input strings in L

(c) Turing machine M rejects all input strings in $\{0,1\}^* - L$

(d) Turing machine M accepts all input strings in L and rejects all input strings in $\{0,1\}^* - L$

Ans. (d)

Given that the TM decides the language $L \subseteq \{0, 1\}^*$

$\Rightarrow$ TM accepts all strings in L and rejects all strings that are not in L.

$\therefore$ Option (d) is correct.

End of Solution

Q.14 The probability density function $f(x)$ of a random variable X which takes real values is

$$f(x) = \frac{1}{3\sqrt{2\pi}} \exp\left(-\frac{x^2}{18}\right), \quad x \in (-\infty, +\infty)$$

Which one of the following statements is correct about the random variable .. ?

(a) X is an exponential random variable

(b) X is a normal random variable

(c) X is a Poisson random variable

(d) X is a uniform random variable

Ans. (b)

$f(x)$ is p.d.f. of normal distribution.

$\therefore$ Random variable x follows normal distribution.

End of Solution

Q.15 In the context of DBMS, consider the two sets **T** and **S** given below.

T	**S**
I: Logical schema	**L:** Views
II: Physical schema	**M:** File organization and indexes
III: External schema	**N:** Relations

Which one of the following is the correct match from T to S?

(a) I – L, II – M, III – N (b) I – M, II – L, III – N

(c) I – N, II – M, III – L (d) I – N, II – L, III – M

Ans. (c)

- Logical scheme → Relations
- Physical scheme → File organization and indexes
- External scheme → Views

End of Solution

Q.16 Which one of the following options is **not** a property of Boolean Algebra?

Note: + is OR operation, · is AND operation, and ′ is NOT operation

(a) $a + b = b + a$ (b) $a \cdot a' = 1$

(c) $a + a' = 1$ (d) $a \times b = b \cdot a$

Ans. (b)

$\#a \cdot a' = 0$ not 1

End of Solution

Q.17 In C runtime environment, which one of the following is stored in heap?

(a) A static variable declared inside a function

(b) An array of integers declared inside a function

(c) A dynamically allocated array of integers created using malloc() function call

(d) Return address of a function

Ans. (c)

Memory allocated using malloc is created at runtime and its stored in the heap. This memory remains allocated until it is explicitly released using tree( ).

End of Solution

Q.18 Consider the following two statements about interrupt handling mechanisms in a CPU.

S1: In non-vectored interrupt mechanism, it usually takes more time to start the Interrupt Service Routine (ISR) when compared to that in a vectored interrupt mechanism.

S2: In daisy-chain interrupt mechanism, the CPU polls all the input devices individually to determine the source of the interrupt.

Which one of the following options is correct with respect to S1 and S2?

(a) Both S1 and S2 are true (b) Both S1 and S2 are false

(c) S1 is true and S2 is false (d) S1 is false and S2 is true

Ans. (c)

- In non vectored INT, CPU send the $\overline{\text{INTA}}$ signal and waiting until the INT source supplies the vector address, to service the INT. So it takes more time to service the INT compared with vectored INT.
- In Daisy-chain mechanism, CPU receive the INT signal from all the devices because all devices connected to single INTR Pin, later CPU enables the $\overline{\text{INTA}}$ signal in a sequential order from one device to another.

End of Solution

Q.19 Consider the following three ANSI-C programs, P1, P2 and P3

P1	P2	P3

#include <stdio.h>
int a=5;
int main(){
  int a=7;
  return(θ);
}
	#include <stdio.h>
	int main(){
	  int a=5;
	  int a=7;
	  return(θ);
	}
		#include <stdio.h>
		int main(){
		  int a=5;
		  float a=7;
		  return(θ);
		}

Which one of the following statements is true?

(a) Only P1 will compile without any error
(b) Only P2 will compile without any error
(c) Only P3 will compile without any error
(d) All three programs P1, P2, and P3 will compile without any error

Ans. (a)

The programs P2 and P3 will have compilation error since P2 and P3 are redefining the same variable in the same lexical scope which gives semantic error. There is no compiler error in P1.

End of Solution

Q.20 Consider concurrent execution of two transactions *T*1 and *T*2 in a DBMS, both of which access a data object *A*. For these two transactions to not conflict on *A*, which one of the following statements must be true?

(a) Both *T*1 and *T*2 only read *A*
(b) *T*1 reads *A* and *T*2 writes *A*
(c) *T*1 writes *A* and *T*2 reads *A*
(d) Both *T*1 and *T*2 write *A*

Ans. (a)

T_1, T_2 both transactions are reads 'A' is not conflict on A.

End of Solution

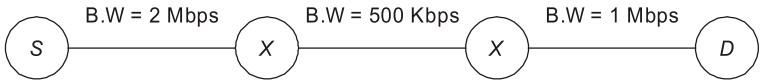
Q.21 Consider a file of size 4 million bytes being transferred between two hosts connected via a path consisting of three consecutive links of bandwidth 2 Mbps, 500 kbps, and 1 Mbps, respectively. All processing delays and propagation delays are negligible. Assume that there is no other background traffic over the path and no other additional overhead to transfer the file.

Which one of the following is the total time (in seconds) to transfer the file?

Note: 1M = 10^6, 1k = 10^3

(a) 731
(b) 64
(c) 8
(d) 16

Ans. (b)



File size = $4 \times 10^6 \times 8$ bits

$$T \cdot T_{L_1} = \frac{4 \times 10^6 \times 8}{2 \times 10^6} = 1 \text{ sec}$$

$$T \cdot T_{L_2} = \frac{4 \times 10^6 \times 8}{500 \times 10^3} = \frac{320}{5} = 64 \text{ sec}$$

$$T \cdot T_{L_3} = \frac{4 \times 10^6 \times 8}{10^6} = 32 \text{ sec}$$

Bottleneck BW = Min (2 Mbps, 500 kbps, 1 Mbps)

$$\Rightarrow \quad T \cdot T_{L_2} = \frac{4 \times 10^6 \times 8}{500 \times 10^2} = \frac{320}{5} = 64 \text{ sec}$$

End of Solution

Q.22 Which one of the following protocols may need to broadcast some of its messages?

(a) SMTP
(b) FTP
(c) DHCP
(d) HTTP

Ans. (c)

DHCP protocol purpose is used to assign IP addresses to all clients. It uses broadcast address 255.255.255.255 to tell about server address to all clients.

End of Solution

Q.23 Which one of the following CPU scheduling algorithms cannot be preemptive?

(a) Shortest Remaining Time First (SRTF) Scheduling
(b) First Come First Serve (FCFS) Scheduling
(c) Round Robin Scheduling
(d) Priority Scheduling

Ans. (b)

Non-preemptive Algorithm – First Come First Serve

Processes are executed in the order of Arrival time, once a process starts, it cannot be preempted until it finishes.

End of Solution

Q.24 Consider the following functions, where n is a positive integer.

$$n^{1/3}, \log(n), \log(n!), 2^{\log(n)}$$

Which one of the following options lists the functions in increasing order of asymptotic growth rate?

Note: Assume the base of log to be 2.

(a) $\log(n)$, $n^{1/3}$, $2^{\log(n)}$, $\log(n!)$
(b) $n^{1/3}$, $\log(n)$, $\log(n!)$, $2^{\log(n)}$
(c) $\log(n)$, $n^{1/3}$, $\log(n!)$, $2^{\log(n)}$
(d) $2^{\log(n)}$, $n^{1/3}$, $\log(n)$, $\log(n!)$

Ans. (a)

$n^{1/3}$, $\log_2(n)$, $\log_2(n!)$, $2^{\log_2 n}$

$n^{1/3}$: Polynomial

$\log_2(n)$: logarithmic

$\log_2(n!)$: $n \log_2 n$: Polynomial

$2^{\log_2 n}$: n : Polynomial

Asymptotic increasing order,

$\log_2 n$, $n^{1/3}$, $2^{\log_2 n}$, $\log_2 n!$

End of Solution

Q.25 Which of the following can be recurrence relation(s) corresponding to an algorithm with time complexity $\Theta(n)$?

(a) $T(n) = T(n-1) + 1, \quad T(1) = 1$

(b) $T(n) = 2T\left(\frac{n}{2}\right) + 1, \quad T(1) = 1$

(c) $T(n) = 2T\left(\frac{n}{2}\right) + n, \quad T(1) = 1$

(d) $T(n) = T(n-1) + n, \quad T(1) = 1$

Ans. (a, b)

(a) $T(n) = T(n-1) + 1$

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

$= T(n-k) + k \qquad [n - k = 1,\ k = n-1]$

$= T(1) + n - 1$

$T(n) = n$

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

$f(n) = 1, \quad n^{\log_b^a} = n$

Master theorems case (i)

$T(n) = \theta(n)$

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

$f(n) = n, \quad n^{\log_b^a} = n$

Master theorems case (ii) applicable

$T(n) = \theta(n.\log n)$

(d) $T(n) = T(n-1) + n$

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

$= T(n-3) + (n-2) + (n-1) + n$

$= T(1) + 2 + 3 + \ldots\ldots + (n-1) + n$

$T(n) = \frac{n(n+1)}{2} = \theta(n^2)$

End of Solution

Q.26 Let R be a binary relation on the set {1, 2, ..., 10}, where $(x, y) \in R$ if the product of x and y is square of an integer. Which of the following properties is/are satisfied by R?

(a) Reflexive
(b) Symmetric
(c) Transitive
(d) Antisymmetric

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

R defined on $A = \{1, 2, 3, 4, ... 10\}$

xRy iff $xy = k^2$, $k \in Z$, $x, y \in A$

(1) $\forall x \in A$

$$x \cdot x = x^2 \in Z^2$$

$\therefore$ xRx, $\forall x \in A$

it is reflexive.

(2) $\forall x, y \in A$

Let xRy

$\Rightarrow$ $xy = k^2$, $k \in Z$

$\Rightarrow$ $yx = k^2$, $k \in Z$

$\Rightarrow$ yRx

$\therefore$ R is symmetric

(3) $\forall x, y, z \in A$

Let xRy and yRz

$\Rightarrow$ $xy = k_1^2$ and $yz = k_2^2$, $k_1, k_2 \in Z$

$A = \{1, 2, 3, 4, 5, 6, 7, 8, 9, 10\}$

For example:

$x = 4$, $y = 9$

$\Rightarrow$ $xy = 6^2$ and $y = 9$, $z = 9$

$yz = 9^2$

$xz = 4 \times 9 = 36 = 6^2 \Rightarrow xRz$

$\because$ A is finite set,

R is a transitive.

(4) $\forall x, y \in A$

Let xRy and yRx

$\Rightarrow$ $xy = k_1^2$ and $yz = k_1^2$ there $x \neq y$

$A = \{1, 2, 3, 4, 5, 6, 7, 8, 9, 10\}$

For example:

$x = 4$, $y = 9$

$\Rightarrow$ $xy = 36 = 6^2$ and $yx = 6^2$

But $x \neq y$

$\therefore$ It is not antisymmetric.

End of Solution

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Q.27 For a real number a, let $I(a) = \int_{-1}^{1} (3x^2 - ax + 1)dx$. Which of the following statements is/are true?

(a) The value of $I(a)$ is independent of the value of a
(b) The value of $I(a)$ can vary with the value of a
(c) There exists $a \in (-\infty, +\infty)$ such that $I(a)$ is a positive real number
(d) There exists $a \in (-\infty, +\infty)$ such that $I(a)$ is a negative real number

Ans. (a, c)

End of Solution

Q.28 In a system, numbers are represented using 4-bit two's complement form. Consider four numbers $N1 = 1011$, $N2 = 1101$, $N3 = 1010$ and $N4 = 1001$ in the system.
Which of the following operations will result in arithmetic overflow?

(a) $N1 + N2$ (b) $N2 + N3$
(c) $N3 - N4$ (d) $N1 + N4$

Ans. (b, d)

2s complement data given

$N_1 : 1011 \rightarrow (-5)_{10}$
$N_2 : 1101 \rightarrow (-3)_{10}$
$N_3 : 1010 \rightarrow (-6)_{10}$
$N_4 : 1001 \rightarrow (-7)_{10}$
4-bit 2s complement range : {–8 to + 7}
$N_1 + N_2 \rightarrow (-5) + (-3) = -8$
$N_2 + N_3 \rightarrow (-3) + (-6) = -9$ (over flow)
$N_3 + N_4 \rightarrow (-6) - (-7) = +1$
$N_1 + N_4 \rightarrow (-5) + (-7) = -12$ (over flow)

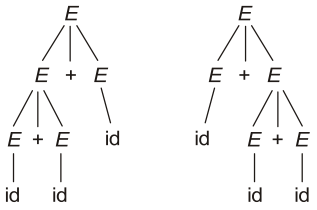
End of Solution

Q.29 Which of the following grammars is/are ambiguous?

(a) $S \rightarrow aSb \mid \in$ (b) $E \rightarrow E + E \mid E * E \mid \text{id}$
(c) $S \rightarrow aS \mid Sa \mid \in$ (d) $S \rightarrow aS \mid \in$

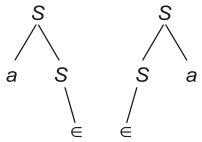
Ans. (b, c)

(a) $S \rightarrow aSb \mid \in$ in unambiguous.
(b) $E \rightarrow E + E \mid E * E \mid \text{id}$ is ambiguous.



The same string id + id + id is having 2 different parse trees, so the grammar is ambiguous.

(c) $S \rightarrow aS \mid Sa \mid \in$ is ambiguous.



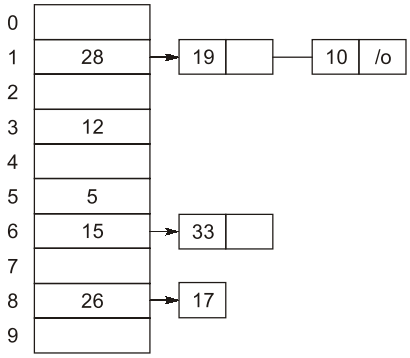
(d) $S \rightarrow aS \mid \in$ is unambiguous.

End of Solution

Q.30 The keys 5, 28, 19, 15, 26, 33, 12, 17, 10 are inserted into a hash table using the hash function $h(k) = k \ mod \ 9$. The collisions are resolved by chaining. After all the keys are inserted, the length of the longest chain is _____. (answer in integer)

Ans. (3)

5 mod 9 = 5
28 mod 9 = 1
19 mod 9 = 1
15 mod 9 = 6
26 mod 9 = 8
33 mod 9 = 6
12 mod 9 = 3
17 mod 9 = 8
10 mod 9 = 1



Longest chain length = 3

End of Solution

Q.31 Consider the system of linear equations given below.

$$ax + y = b$$
$$16x + ay = 24$$

Suppose the values of a and b are chosen such that the system of linear equations produce multiple solutions. Then the product of a and b is _____. (answer in integer)

Ans. **(24)**

$(a = -4,\ b = -6)$

$$ax + y = b \quad \text{...(i)}$$
$$16x + ay = 24 \quad \text{...(ii)}$$

has infinite solution

$$\therefore \quad |A| = 0$$

$$\Rightarrow \quad \begin{vmatrix} a & 1 \\ 16 & a \end{vmatrix} = 0 \Rightarrow a = \pm 4$$

For $a = 4$:

(i) $\Rightarrow$ $4x + y = b$

(ii) $\Rightarrow$ $16x + 4y = 24 = 4[4x + y = 6]$

$\because$ $\rho(A) = 1$

$\Rightarrow$ $b = 6$

For $a = -4$:

(i) $\Rightarrow$ $-4x + y = b \Rightarrow 4x - y = -b$

(ii) $\Rightarrow$ $16x - 4y = 24 \Rightarrow 4[4x - y = 6]$

$\because$ $\rho(A) = 1$

$\Rightarrow$ $-b = 6$

$\therefore$ $a = -4,\ b = -6$

$a \cdot b = -4 \times -6 = 24$

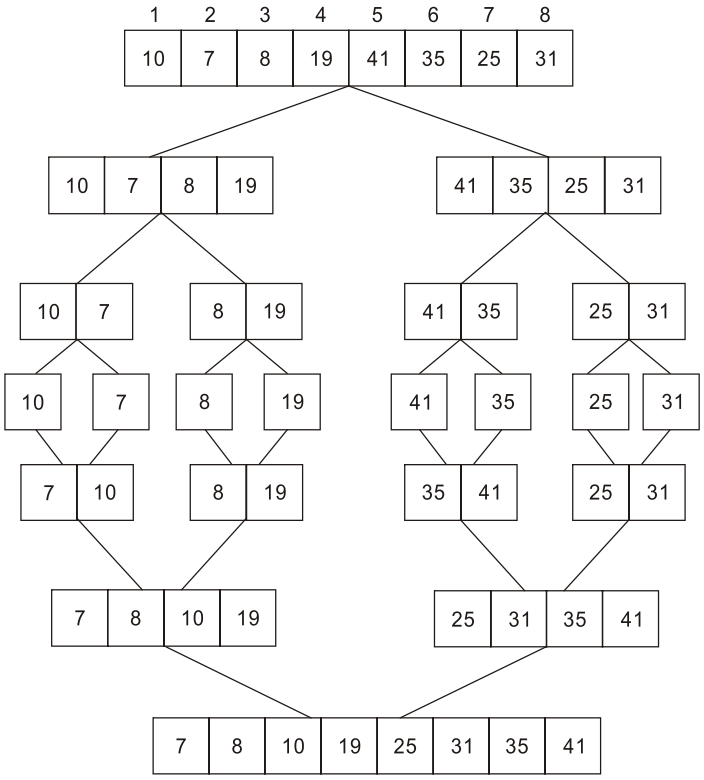
End of Solution

Q.32 Consider an array $A = [10, 7, 8, 19, 41, 35, 25, 31]$. Suppose the merge sort algorithm is executed on array A to sort it in increasing order. The merge sort algorithm will carry out a total of 7 merge operations.

A merge operation on sorted left array L and sorted right array R is said to be void if the output of the merge operation is the elements of array L followed by the elements of array R.

The number of void merge operations among these 7 merge operations is _____. (answer in integer)

Ans. (3)



End of Solution

Q.33 If an IP network uses a subnet mask of 255.255.240.0, the maximum number of IP addresses that can be assigned to network interfaces is _____. (answer in integer)

Ans. (4094)

Given subnet mask is 255.255.240.0

[Prefix + suffix] bits

$$\underbrace{11111111\ 11111111\ 1111}_{\text{Prefix}}\ \underbrace{0000\ 00000000}_{\text{Suffix bits}}$$

Suffix bits = 12 bits

Number of address that can be assigned to network interfaces

$= 2^{12} - 2 = 4094$

End of Solution

Q.34 The 32-bit IEEE 754 single precision representation of a number is 0xC2710000. The number in decimal representation is _____. (rounded off to two decimal places)

Ans. **(–60.25)**

(C2710000)H

1	1000010 0	111 0001000 .....
S	BE	M

Value: $(-1)^1 (1.1110001000 ....) \times 2^{132-127}$

$-(1.1110001000 ....) \times 2^5$

$-111100.01000 .... \rightarrow -60.25$

End of Solution

Q.35 A lexical analyzer uses the following token definitions

- letter → [*A* – *Za* – *z*]
- digit → [0 – 9]
- id → letter (letter | digit)*
- number → digit+
- ws → (blank | tab | newline)+

For the string given below,

*x*1 23 mm 78 y 7z zz5 14A 8H AaYcD

the number of tokens (excluding ws) that will be produced by the lexical analyzer is _____. (answer in integer)

Ans. **(13)**

*x*1 23 *mm* 78 *y* 7*z* *zz*5 14*A* 8*H* *AaYcD*

Total 13 tokens.

End of Solution

Q.36 Consider a complete graph K_n with n vertices ($n > 4$). Note that multiple spanning trees can be constructed over K_n. Each of these spanning trees is represented as a set of edges. The Jaccard coefficient between any two sets is defined as the ratio of the size of the intersection of the two sets to the size of the union of the two sets.
Which one of the following options gives the lowest possible value for the Jaccard coefficient between any two spanning trees of K_n?

(a) $\frac{1}{n}$ (b) $\frac{1}{2n-3}$

(c) 0 (d) $\frac{1}{n-1}$

Ans. (c)

Each spanning tree of k_n has $(n-1)$ edges Jaccard coefficient $J = \frac{|T_1 \cap T_2|}{|T_1 \cup T_2|}$.

Ratio of the size of the intersection of the two sets to the size of the union of the two sets.

Lowest possible value of Jaccard Coefficient : 0

Because $T_1 \cap T_2 = 0$ if T_1 T_2 are Edge disjoint ST's of k_n.

End of Solution

Q.37 Let G be a weighted directed acyclic graph with m edges and n vertices. Given G and a source vertex s in G, which one of the following options gives the worst case time complexity of the fastest algorithm to find the lengths of shortest paths from s to all vertices that are reachable from s in G?

(a) $\theta(m + n)$ (b) $\theta(m + n \log(n))$
(c) $\theta(nm)$ (d) $\theta(n^3)$

Ans. (a)

G be a weighted directed acyclic graph with m edges and n vertices.

Worst cone time complexity of the fastest algorithm to find the lengths of shortest paths from S to all vertices that are reachable from S in G is by using Topological sorting with time complexity $\theta(n + m)$.

End of Solution

Q.38 Consider an array A of integers of size n. The indices of A run from 1 to n. An algorithm is to be designed to check whether A satisfies the condition given below.

$\forall i, j \in \{1, \ldots, n-1\}$ such that $i > j$, $(A[i + 1] - A[i]) > (A[j + 1] - A[j])$

Which one of the following gives the worst case time complexity of the fastest algorithm that can be designed for the problem?

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

Ans. (a)

Array of size n with indices 1 to n. An algorithm is to be designed to check whether satisfies the condition:

$\forall i, j \in \{1, 2, \ldots, n-1\}$ such that

$i > j$, $(A[i + 1] - A[i]) > (A[j + 1] - A[j])$

Let, $D[k] = A[k + 1] - A[k]$

Then condition of difference array

$D[1] < D[2] < D[3] < .... < D[n-1]$
difference array must be strictly increasing.
Step (i) : Compute difference array in linear time.
Step (ii) : Difference array must be strictly increasing order.

End of Solution

Q.39 Consider a table T, where the elements $T[i][j]$, $0 \le i, j \le n$, represent the cost of the optimal solutions of different subproblems of a problem that is being solved using a dynamic programming algorithm. The recursive formulation to compute the table entries is as follows:

$$T[0][k] = T[k][0] = 1 \qquad \text{for } k = 0,1,2, \ldots, n$$
$$T[i][j] = 2T[i-1][j] + 3T[i][j-1] \qquad \text{for } 1 \le i, j \le n$$

Consider the following two algorithms to compute entries of T. Assume that for both the algorithms, for all $0 \le i, j \le n$, $T[i][j]$ has been initialized to 1.

Algorithm B_1: For $i = 1, 2, \ldots, n$
  For $j = 1, 2, \ldots, n$
    $T[i][j] = 2T[i-1][j] + 3T[i][j-1]$

Algorithm B_2: For $s = 2,3, \ldots, 2n$
  For $i = 1, 2, \ldots, n$
    For $j = 1, 2, \ldots, n$
      If $(i + j == s)$
        $T[i][j] = 2T[i-1][j] + 3T[i][j-1]$

Algorithm B_k, $k \in \{1,2\}$ is said to be correct if and only if it calculates the correct values of $T[i][j]$, for all $0 \le i, j \le n$, (as per the recursive formulation) at the end of the execution of the algorithm B_k.

Which one of the following statements is true?

(a) Both algorithms B_1 and B_2 are correct
(b) Algorithm B_1 is correct, but algorithm B_2 is incorrect
(c) Algorithm B_2 is correct, but algorithm B_1 is incorrect
(d) Both algorithms B_1 and B_2 are incorrect

Ans. (a)

Table T, where the elements $T[i][j]$,
$0 \le i, j \le n$
Recursive formulation

$$T[0][k] = T[k][0] = 1 \text{ for } k = 0, 1, 2, \ldots, n$$
$$T[i][j] = 2T[i-1][j] + 3T[i][j-1]$$

Both given algorithms correct for given recursive solution.

End of Solution

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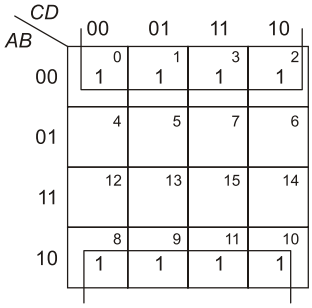
Q.40 Consider the following 4-variable Boolean function
$F(A, B, C, D) = \Sigma m(0, 1, 2, 3, 8, 9, 10, 11)$
Consider A as MSB, D as LSB. Which one of the following options represents the minimal sum of products form for the above function?
Note: + is OR operation, · is AND operation, ′ is NOT operation
(a) $A' + B' + C' + D'$ (b) B'
(c) $A'.B' + A.B$ (d) A'

Ans. (b)

$$F(A, B, C, D) = \Sigma m(0, 1, 2, 3, 8, 9, 10, 11)$$



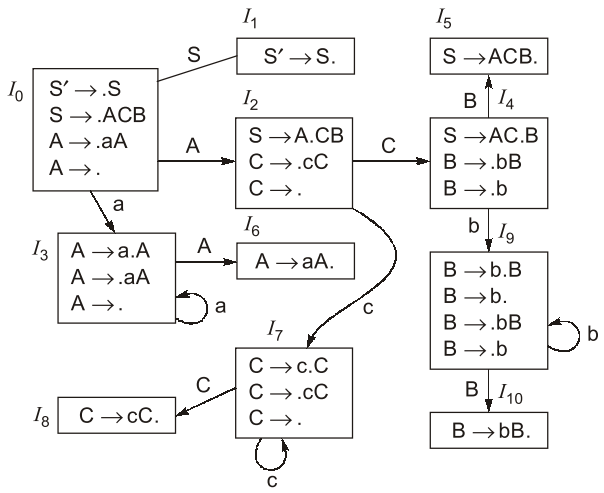
$$F = \bar{B}$$

End of Solution

Q.41 Consider the canonical $LR(0)$ parsing of the grammar below using terminals $\{a, b, c\}$ and non-terminals $\{A, B, C, S\}$ with S as the start symbol.
$S \rightarrow ACB$
$A \rightarrow \alpha A \mid \in$
$C \rightarrow cC \mid \in$
$B \rightarrow bB \mid b$
Which one of the following options gives the number of shift-reduce conflicts that will occur in the $LR(0)$ ACTION table?
(a) 2 (b) 3
(c) 4 (d) 5

Ans. (d)

$G = \{S \to ACB,\ A \to aA \mid \in,\ C \to cC \mid \in,\ B \to bB \mid b\}$



I_0, I_2, I_3, I_7 and I_9 are having S/R conflict.

End of Solution

Q.42 In the context of schema normalization in relational DBMS, consider a set F of functional dependencies. The set of all functional dependencies implied by F is called the closure of F. To compute the closure of F, Armstrong's Axioms can be applied. Consider X, Y, and Z as sets of attributes over a relational schema. The three rules of Armstrong's Axioms are described as follows.

Reflexivity: If $Y \subseteq X$, then $X \to Y$

Augmentation: If $X \to Y$, then $XZ \to YZ$ for any Z

Transitivity: If $X \to Y$ and $Y \to Z$, then $X \to Z$

The additional rule of Union is defined as follows.

Union: If $X \to Y$ and $X \to Z$, then $X \to YZ$

It can be proved that the additional rule of Union is also implied by the three rules of Armstrong's Axioms. Listed below are four combinations of these three rules. Which one of these combinations is both necessary and sufficient for the proof?

(a) Reflexivity, Augmentation, and Transitivity
(b) Reflexivity and Augmentation
(c) Transitivity
(d) Augmentation and Transitivity

Ans. (d)

Reflexivity, if $Y \subseteq X$ then $X \to Y$

Augmentation, if $X \to Y$ then $XZ \to YZ$

Transitivity, if $X \to Y$, $Y \to Z$ then $X \to Z$

The additional union rule

If $X \to Y$, $X \to Z$ then $X \to YZ$

To derive union rule required Augmentation or transitivity.
If $X \rightarrow Y$ then $X \rightarrow XY$: Augmentation
If $X \rightarrow Z$ then $XY \rightarrow YZ$: Augmentation
If $X \rightarrow XY$, $XY \rightarrow YZ$ then $X \rightarrow YZ$: Transitivity.

End of Solution

Q.43 Consider the transmission of data bits 110001011 over a link that uses Cyclic Redundancy Check (CRC) code for error detection. If the generator bit pattern is given to be 1001, which one of the following options shows the remainder bit pattern appended to the data bits before transmission?

(a) 011 (b) 101
(c) 000 (d) 100

Ans. (d)

Data bits transmission = 110001011
Generator = 1001

```
1001 ) 110001011000 (110111100
       1001
       1010
       1001
        0111
        0000
         1110
         1001
          1111
          1001
           1101
           1001
            1000
            1001
             0010
             0000
              0100
              0000
               100
```

End of Solution

Q.44 Consider a processor that has 16 general purpose registers and it uses 2-byte instruction format for all its instructions. Variable-sized opcodes are permitted. There are three different types of instructions; M-type, R-type, and C-type. Each M-type instruction has 2 register operands and a 6-bit immediate operand. Each R-type instruction has 3 register operands. Each C-type instruction has a register operand and a 6-bit offset value. If there are 2 unique M-type opcodes and 7 unique R-type opcodes, which one of the following options gives the maximum number of unique opcodes possible for C-type instructions?

(a) 8 (b) 4
(c) 64 (d) 16

Ans. (b)

Instruction size = 16 bit

M-Type:	OPcode	reg	reg	6 bit immediate
	2	4	4	6

R-Type:	OPcode	reg	reg	reg
	4	4	4	4

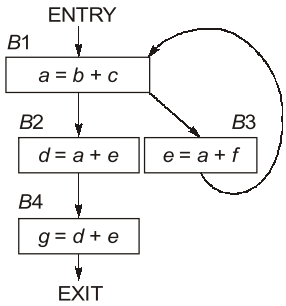
C-Type:	OPcode	reg	6 bit off set
	2	4	6

Take from CDR

1. Primitive OPcode size = 2 bit
2. Number of instructions = $2^2 = 4$
3. Number of free OPcodes after M-Type = $(4 - 2) = 2$
4. Number of R-Type instruction = $2 \times 2^2 = 8$
5. Number of free OPcodes after R-Type = $(8 - 7) = 1$
6. Number of C-Type instruction = $1 \times 2^2 = 4$

End of Solution

Q.45 Consider the control flow graph given below.



Which one of the following options is the set of live variables at the exit point of each basic block?

(a) B1: {a, b, c, e, f}, B2: {d, e}, B3: {b, c, e, f}, B4: ϕ

(b) B1: ϕ, B2: {d, e}, B3: {a, c, f}, B4: ϕ

(c) B1: {a, b, c, e, f}, B2: {d, e}, B3: {c, e, f}, B4: ϕ

(d) B1: ϕ, B2: {d, e, f}, B3: {a, b, c, e, f}, B4: ϕ

Ans. (a)

The variables that are live in each block are

	a	b	c	d	e	f	g
B1	×	✓	✓	×	✓	✓	×
B2	✓	×	×	×	✓	×	×
B3	✓	✓	✓	×	×	✓	×
B4	×	×	×	✓	✓	×	×

$$\begin{aligned}\text{Exit of } B1 &= \text{IN(B2)} \cup \text{IN(B3)}\\ &= \{a, b, c, e, f\}\\ \text{Out } (B2) &= \text{IN}(B4)\\ &= \{d, e\}\\ \text{Out } (B3) &= \text{IN(B1)}\\ &= \{b, c, e, f\}\\ \text{Out } (B4) &= \text{Empty since no successor node for B4}\\ &= \phi\end{aligned}$$

End of Solution

Q.46 An index in a DBMS is said to be dense if an index entry appears for every search-key value in the indexed file. Otherwise it is called a sparse index. Consider the following two statements.

S1: A hash index must be a dense index

S2: A B^+ tree index can be a sparse index

Which one of the following options is correct?

(a) Both S1 and S2 are true

(b) Both S1 and S2 are false

(c) S1 is true and S2 is false

(d) S1 is false and S2 is true

Ans. (a)

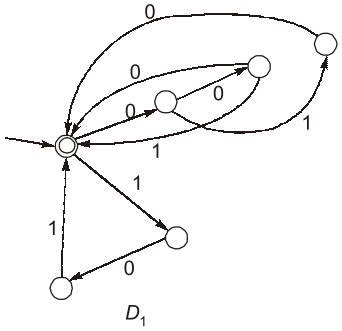
S1 : A has index must be a dense index [True]

S2 : B^+ Tree can be a sparse index [True]

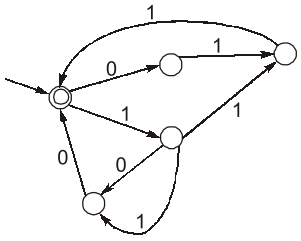
B or B^+Tree index can be dense or sparse.

End of Solution

Q.47 Consider the following two finite automata D_1 and D_2.



D_1



D_2

Which of the following statements is/are true?

(a) $L(D_1) = L(D_2)$

(b) $L(D_1)$ is a proper subset of $L(D_2)$

(c) $L(D_1) \cap L(D_2) = \{\in\}$

(d) $(L(D_1) \cup L(D_2))^*$ consists of all strings in $\{0,1\}^*$ whose length is divisible by 3.

Ans. (c, d)

Both finite automates D_1 and D_2 accepts individually they accept.
'$\in$' and some strings having length multiple of 3,

$$L(D_1) \cap L(D_2) = \{\in\}$$

The strings of length 3 accepted by D1 are 000, 001, 010, 101
The strings of length 3 accepted by D_2 are 011, 100, 110, 111
i.e. together D_1 and D_2 accepts all strings of length 3.

Hence, $[L(D_1) \cup L(D_2)]^*$ contains all strings of length divisible by 3.

End of Solution

Q.48 Let $\Sigma = \{a, b, c, d\}$ and let $L = \{a^i b^j c^k d^l \mid i, j, k, l \geq 0\}$.
Which of the following constraints ensure(s) that the language L is context-free?

(a) $i + k = j + l$
(b) $i = k$ and $j = l$
(c) $i = l$ and $j = k$
(d) $i + j = k + l$

Ans. (a, c, d)

$$L = \left\{a^i b^j c^k d^l \middle| i, j, k, l \geq 0\right\}$$

(a) $i + K = j + l$ is CFL
Push all a's when b's comes check for a's in the stack when c's comes if the stack contain b's delete b's then push remaining c's then check with d's

(b) $i = k$ and $j = l$ is not CFL
Alternative comparison is not possible

(c) $i = l$ and $j = k$ is CFL
Push all a's and b's then check the c's with b's and d's with a's.

(d) $i + j = K + l$ is CFL
Push all a's and b's then check with c's and d's

End of Solution

Q.49 Consider a binary search tree (BST) with n leaf nodes ($n > 0$). Given any node V, the key present in the node is denoted as $Val(V)$. All the keys present in the given BST are distinct. The keys belong to the set of real numbers.
For a node V, let $Suc(V)$ denote the node that is its inorder successor. If a node V does not have an inorder successor, then $Suc(V)$ is NULL. As there are no duplicates, if $Suc(V)$ is not NULL, then $Val(V) < Val(Suc(V))$.
Corresponding to every leaf node L_i that has a non-NULL $Suc(L_i)$, a new key k_i with the following property is to be inserted into the BST.
$Val(L_i) < k_i < Val(Suc(L_i))$
Let K represent the list of all such new keys to be inserted into the BST.
Which of the following statements is/are true?

(a) K cannot have any duplicates
(b) K will have at least one element
(c) After inserting all keys from K, the height of the BST can increase at most by one
(d) Number of nodes in the BST will double after inserting all keys from K

Ans. (a, c)

Check duplicates in K

- Each k_i is strictly between a leaf node L_i and its inorder successor $Suc(L_i)$.
- Since all keys in the BST are distinct and the real numbers are dense, you can always pick a unique k_i in each interval.
- Therefore, K cannot have duplicates.

Statement (a) is true.

Will K have at least one element?

- Only leaf nodes L_i with a non-NULL successor generate a new key.
- If the BST has only one node, or the largest leaf has no successor, it may happen that no leaf has a successor.
- So K may be empty in some cases.

Statement (b) is not necessarily true.

Effect on height of BST

- Inserting a key k_i between Li and $Suc(L_i)$ means k_i will always be a child of some leaf L_i (or somewhere along the path to the successor).
- Since each new key is inserted as a new leaf, the height can increase by at most 1.
  - Example: if L_i is at the maximum depth, adding k_i as its child increases height by 1.
  - Other insertions do not increase the height further.

Statement (c) is true.

Number of nodes doubling

- Let's denote:
  - Number of original leaf nodes = n
  - Number of new keys inserted = number of leaves with non-NULL successor = n
- The total number of nodes after insertion = original nodes + n (may be less if some leaves have no successor).
- So the number of nodes does not necessarily double.

Statement (d) is false.

End of Solution

Q.50 Consider a stack S and a queue Q. Both of them are initially empty and have the capacity to store ten elements each. The elements 1, 2, 3, 4, and 5 arrive one by one, in that order. When an element arrives, it is assigned either to S (pushed on S) or to Q (enqueued to Q). Once all the five elements are stored, the output is generated in two steps. First, stack S is emptied by popping all elements. Then queue Q is emptied by dequeueing all elements. The output obtained by following this process is 4 3 1 2 5 .

Given the output, the objective is to predict whether an element was assigned to S or Q. Which of the following options is/are possible valid assignment(s) of the elements?

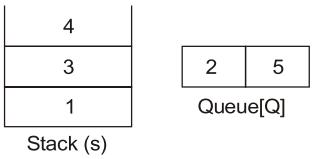
Note: In the options, the notation xS denotes that element x was assigned to S and yQ denotes that element y was assigned to Q.

(a) 1*S*, 2*Q*, 3*S*, 4*S*, 5*Q*
(b) 1*Q*, 2*Q*, 3*S*, 4*S*, 5*Q*
(c) 1*Q*, 2*Q*, 3*Q*, 4*S*, 5*S*
(d) 1*S*, 2*S*, 3*S*, 4*Q*, 5*Q*

Ans. (a, b)

Option (a)

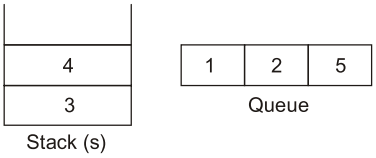
1*S*, 2*Q*, 3*S*, 4*S*, 5*Q*



POP the all elements from stack *S* = 4, 3, 1
Deque the all element from queue *Q* = 2, 5
So, option (a) is correct.

Option (b)

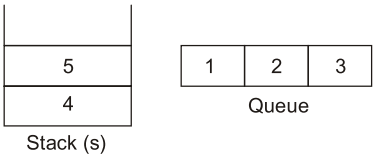
1*Q*, 2*Q*, 3*S*, 4*S*, 5*Q*



POP the all elements from stack *S* = 4, 3
Deque the all element from queue *Q* = 1, 2, 5
Output = 4, 3, 1, 2, 5
So, option (b) is valid.

Option (c)

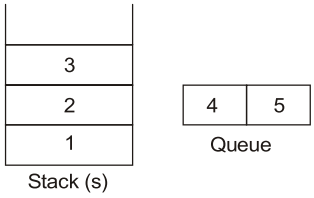
1*Q*, 2*Q*, 3*Q*, 4*S*, 5*S*



POP the all elements from stack *S* = 5, 4
Deque the all element from queue *Q* = 1, 2, 3
Output = 5, 4, 1, 2, 3
Output sequence does not matched.
So, option (c) is invalid.

Option (d)

1S, 2S, 3S, 4Q, 5Q



POP the all elements from stack S = 3, 2, 1
Dequeue the all element from queue Q = 4, 5
Output order = 3, 2, 1, 4, 5,
Output order does not matched.
Option (d) is invalid.

End of Solution

Q.51 Consider three processes P1, P2, and P3 running identical code, as shown in the pseudocode below. A and B are two binary semaphores initialized to 1 and 0, respectively. X is a shared variable initialized to 0. Each line in the pseudocode is executed atomically.
Pseudocode of P1, P2, and P3

```
Wait(A);
    Print(*);
    X = X+1;
    If (X == 2)
        {
            Print($);
            Signal(B);
        }
    Signal(A);
    Wait(B);
    Print(#);
    Signal(B);
```

Assume that any of the three processes can start to execute first and context switching can happen between these processes at any arbitrary time and in any arbitrary order. Which of the following patterns is/are possible to be generated as an outcome of the execution of these three processes?

(a) **$*###
(b) **$#*##
(c) **$*##*#
(d) ***$###

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

Option (d) is not possible to print *** continuously without printing $ after **, all other option are possible.

End of Solution

Q.52 Consider a system with a processor and a 4 KB direct mapped cache with block size of 16 bytes. The system has a 16 MB physical memory. Four words P, Q, R, and S are accessed by the processor in the same order 10 times. That is, there are a total of 40 memory references in the sequence P, Q, R, S, P, Q, R, S,...
Assume that the cache memory is initially empty. The physical addresses of the words are given below (1 word =1 byte).

P: 0x845B32, Q: 0x845B26, R: 0x845B36, S: 0x846B32

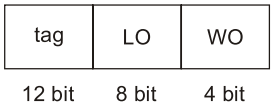
Which of the following statements is/are true?

Note: 1 K = 2^{10} and 1M = 2^{20}

(a) Every access to P results in a cache miss
(b) Every access to R results in a cache hit
(c) Every access to Q results in a cache miss
(d) Except the first access to S, all subsequent accesses to S result in cache hits

Ans. **(a, b)**

Direct Cache Address format:



P :	845	B3	2
Q :	845	B2	6
R :	845	B3	6
S :	846	B3	2

P and R both are in the same block P, R and S both are having different tags but mapped to same line.

∴ P, R block is replaced by Block S.

Accessing:
P — miss
Q — miss
R — hit
S — miss
P — miss
Q — hit
R — hit
S — miss and soon

So, (P, R) block is replaced by block S.

So, S block replaced by block P.

End of Solution

Q.53 To keep track of free blocks in a file system, one of the two approaches is generally used – using bitmaps (bit vectors) or using linked lists. Consider that the linked list approach is used to keep track of free blocks in a file system. Assume that the disk size is 16 GB, block size is 2 KB, and block numbers used are 32-bit long. A single pointer of size 4 bytes is used in each block of the list to point to the next block of the list. The number of blocks required to hold the free disk block numbers is _____. (answer in integer)

Note: $1K = 2^{10}$ and $1G = 2^{30}$

Ans. (16417)

$$\text{Disk size} = 16\ \text{GB}$$
$$\text{Block size} = 2\ \text{KB}$$
$$\text{Block number} = 32\ \text{bit} = 4\ \text{Bytes}$$

Pointer per block : 4 bytes (used to point to next free block)

$$\text{Total number of disk blocks} = \frac{\text{Disk size}}{\text{Block size}}$$
$$= \frac{16\ \text{GB}}{2\ \text{KB}} = \frac{2^4 \times 2^{30}}{2 \times 2^{10}} = \frac{2^{34}}{2^{11}} = 2^{23} = 8388608$$

Each free list block store block numbers + 1 pointer

Usable space for block number per block = 2048 – 4 = 2044 bites

$$\text{Block number usable per block} = \frac{2044}{4} = 511$$

$$\text{Total free list blocks} = \left\lceil \frac{\text{Total disk blocks}}{\text{Block number usable per block}} \right\rceil$$
$$= \left\lceil \frac{8388608}{511} \right\rceil = 16417$$

End of Solution

Q.54 A system has a Translation Lookaside Buffer (TLB) that has a reach of 1 MB. TLB reach is defined as the total amount of physical memory that can be accessed through the TLB entries. The paging system uses pages of size 4 KB. The virtual address space is 64 GB and physical address space is 1 GB. If each TLB entry stores a 4-bit process id, page number, frame number, and a 2-bit control field, then the size of the TLB (in bytes) is _____. (answer in integer)

Note: $1K = 2^{10}$, $1M = 2^{20}$, $1G = 2^{30}$

Ans. (1536)

$$\text{TLB reach} = \text{Number of TLB entries} \times \text{Page size}$$

$$\text{Number of TLB entries} = \frac{\text{TLB reach}}{\text{Page size}} = \frac{1\text{MB}}{4\text{ KB}}$$

$$= \frac{1\times 2^{20}\text{B}}{4\times 2^{10}\text{B}} = \frac{2^{20}}{2^{12}} = 2^8 = 256$$

$$\text{Number of pages} = \frac{\text{Virtual address space}}{\text{Page size}} = \frac{64\text{ GB}}{4\text{ KB}}$$

$$= \frac{2^6\times 2^{30}\text{B}}{2^2\times 2^{10}\text{B}} = \frac{2^{36}}{2^{12}} = 2^{24}$$

$$\text{Page bits} = \log_2^{2^{24}} = 24 \text{ bits}$$

$$\text{Number of frames} = \frac{\text{Physical address space}}{\text{Frame size}} = \frac{2^{30}\text{B}}{2^{12}\text{B}} = 2^{18}$$

$$\text{Frames bits} = \log_2^{2^{18}} = 18 \text{ bits}$$

$$\text{TLB entry bits} = \text{Process ID} + \text{Page number} + \text{Frame number} + \text{Control bit}$$
$$= 4 + 24 + 18 + 2 = 48 \text{ bits}$$

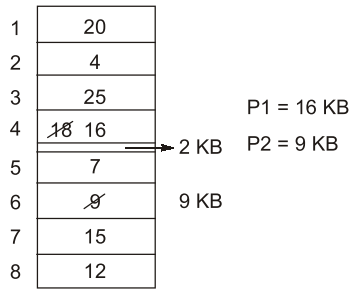
$$\text{TLB size} = \text{TLB entry bits} \times \text{bits per entry}$$
$$= \frac{256\times 48}{8} = 1536 \text{ Bytes}$$

End of Solution

Q.55 Consider contiguous allocation of physical memory to processes using variable partitioning scheme. Suppose there are 8 holes in the memory of sizes 20 KB, 4 KB, 25 KB, 18 KB, 7 KB, 9 KB, 15 KB, and 12 KB. Assume that no two holes are adjacent. Two processes P1 of size 16 KB and P2 of size 9 KB arrive in that order, and they are allocated memory using the best-fit technique. After allocating space to P1 and P2, the number of holes of size less than 8 KB is _____. (answer in integer)

Note: 1K = 2^{10}

Ans. (3)



For P1 = 16 KB
By using Best fit
holes ≥ 16 KB
Smallest suitable hole = 18 KB (hole 4)
For P2 = 9 KB
By using best fit
holes ≥ 9 KB
Smallest suitable hole = 9 KB (hole 6)
Less than 8 KB,
4 KB, 2 KB, 7 KB = 3

End of Solution

Q.56 Consider a system with 1 MB physical memory and a word length of 1 byte. The system uses a direct mapped cache, with block numbers starting from 0. The word with physical address 0xA2C28 is mapped to the cache block number 176_{10}. The maximum possible size of the cache (in KB) for this configuration is _____. (answer in integer)
Note: 1K = 2^{10} and 1M = 2^{20}

Ans. (128)

(A2C28)H : 1010 0010 1100 00 101000
$(176)_{10}$ WO

Here $(176)_{10}$ = 00010110000 (11 bit)
Word offset = 6 bit
∴ Cache address = LO + WO
= 11 + 6 = 17 bit
So, Cache size = 2^{17} B
= 128 KB

End of Solution

Q.57 A non-pipelined instruction execution unit that operates at 1.6 GHz clock takes an average of 5 clock cycles to complete the execution of an instruction. To improve the performance, the system was pipelined with a goal of achieving an average throughput of one instruction per clock cycle. However, it could operate only at 1.2 GHz due to pipeline overheads. While executing a program in the pipelined design, 30% of instructions encountered a stall of 2 cycles due to pipeline hazards. The speed-up obtained by the pipelined design over the non-pipelined one for this program is _____. (rounded off to two decimal places)
Note: 1G = 10^9

Ans. (2.34)

Non pipeline, $ET = CPI \times \text{Cycle time}$

$$= 5 \times \frac{1}{1.6}\text{ns} = 3.125 \text{ ns}$$

$$\text{Pipeline ET} = \left(\frac{1 + \text{Number of stalls}}{\text{Instructions}}\right) t_p$$

$$= \left[1 + (0.3 \times 2)\right] \frac{1}{1.2}\text{ns} = 1.333 \text{ ns}$$

$$S = \frac{\text{ET non-pipe}}{\text{ET pipe}} = \frac{3.125}{1.33} = 2.34$$

End of Solution

Q.58 Consider a new TCP connection between a sender and a receiver. The receiver advertised window is constant at 48 KB, the maximum segment size (MSS) is 2 KB, and the slow start threshold for TCP congestion control is 16 KB. Assume that there are no timeouts or duplicate acknowledgements. The number of rounds of transmission required for the congestion control algorithm of the TCP connection to reach the congestion avoidance phase is _____. (answer in integer)

Note: $1K = 2^{10}$

Ans. (4)

Rwnd = 48 KB
MSS = 2 KB
Slow start threshold = 16 KB

No timeouts and no duplicates

Slow start Algorithm

$$\left.\begin{array}{l} 2\,KB \rightarrow 1RTT \\ 4\,KB \rightarrow 1RTT \\ 8\,KB \rightarrow 1RTT \\ 16\,KB \rightarrow 1RTT \end{array}\right\} \Rightarrow 4\,RTT's$$

End of Solution

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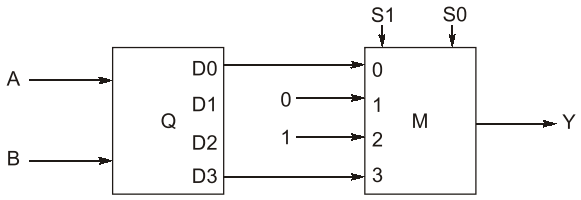
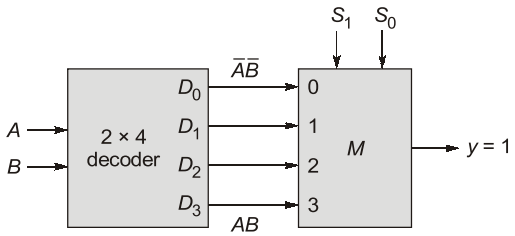
Q.59 Consider the digital circuit shown below with two input lines A and B, two select lines S0 and S1, and an output line Y. The blocks Q and M represent active high 2 : 4 decoder and 4-to-1 multiplexer, respectively. Out of 16 possible input combinations, the number of combinations that produce Y = 1 is _____. (answer in integer)

Note: One input combination is an instance of [A B S1 S0].



Ans. (6)



To provide 4 = 1 ; the set of (A, B, S, S_0) is

A	B	S_1	S_0	y		
X	X	1	0	1	(I_2)	→ 4 possibilities
0	0	0	0	0	I_0 : $\overline{A}\overline{B} \rightarrow 1$	
1	1	1	1	1	I_3 : $AB \rightarrow 1$	→ 2 possibilities

Total possibilities = 6

End of Solution

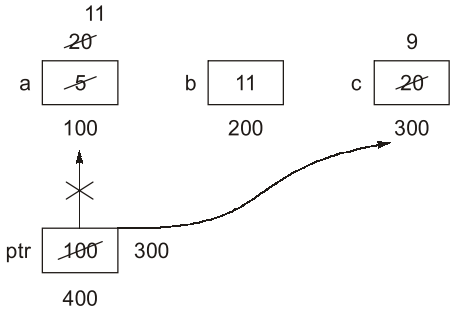
Q.60 Consider the following ANSI-C program.

```
#include <stdio.h>
int main( ) {
   int *ptr, a, b, c;
   a=5; b=11; c=20;
   ptr=&a; *ptr=c; ptr=&c;
   a=*(&b); c=*ptr-a;
   printf("%d",c);
   return(0);
}
```

The output of this program is _____. (answer in integer)

Note: Assume that the program compiles and runs successfully.

Ans. (9)



End of Solution

Q.61 Consider the following ANSI-C function.

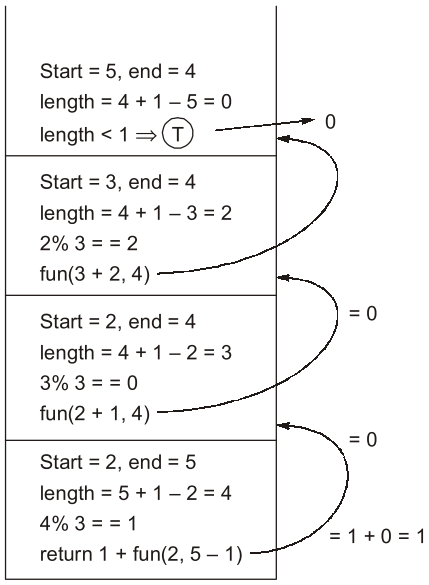
```
int func(int start, int end){
    int length = end + 1 – start;
    if((length<1) || (start < 0) || (end<0)){ return(0); }
    if(length%3 == 0){
        return(func(start+1, end));
    } else if(length%3 == 1){
        return(1 + func(start, end –1));
    } else {
        return(func(start + 2, end));
    }
}
```

The maximum possible value that can be returned from this function is _____. (answer in integer)

Note: Ignore syntax errors (if any) in the function.

Ans. (1)

Assume start = 2, end = 5



We can assume any other values and solve, understand the pattern how it is working.

End of Solution

Q.62 The determinant of a 4 × 4 matrix A is 3. The value of the determinant of $2A$ is _____. (answer in integer)

Ans. (48)

$$|2A_{4\times 4}| = 2^4|A|$$
$$= 16 \times 3 = 48$$

End of Solution

Q.63 Suppose an unbiased coin is tossed 6 times. Each coin toss is independent of all previous coin tosses. Let E_1 be the event that among the second, fourth, and sixth coin tosses, there are at least two heads. Let E_2 be the event that among the first, second, third, and fifth coin tosses, there are equal number of heads and tails.
The conditional probability $P(E_1 | E_2)$ is equal to _____. (rounded off to one decimal place)

Ans. (0.5)

End of Solution

Q.64 Consider a function $f : (0,1) \rightarrow \{0, 1\}$ defined as follows.
For a real number $r \in (0, 1)$, $f(r) = 1$ if the second digit after the decimal point in r is one of the four digits 2, 3, 6 and 7. Otherwise, $f(r)$ is equal to 0.
The number of points in (0,1) at which f is discontinuous is _____. (answer in integer)

Ans. (40)

End of Solution

Q.65 It is necessary to design a link-layer protocol between two hosts that are directly connected over a lossless link of length 3000 kilometers. Assume that the link bandwidth is 10^8 bits per second and that the propagation delay in the link is 5 nanoseconds per meter. Every transmitted data byte is assigned a unique sequence number.
Let N be the minimum number of bits needed for the sequence number field in the protocol header such that
(i) the sequence numbers do not wrap around before 60 seconds, and
(ii) the maximum utilization of the link is achieved.
The value of N is _____. (answer in integer)

Ans. (30)

End of Solution

■■■■