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SUBJECTWISE WEIGHTAGE

S.No.	Name of the Subject	One Mark Questions	Two Marks Questions	Total No. of Questions
1	Engineering Mathematics	12	14	26
2	Database Management & Warehousing	3	4	7
5	Machine Learning	4	5	9
6	Artificial Intelligence	2	2	4
7	Programing, DS & Algorithms	4	5	9
8	General Aptitude	5	5	10
Total No. of Questions		**30**	**35**	**65**

Q.1 – Q.5 Carry ONE mark Each

01. Courage : Bravery :: Yearning : _____
Select the most appropriate option to complete the analogy.
(a) Longing (b) Yelling
(c) Yawning (d) Glaring

01. Ans: (a)

Sol: This is an analogy question, where the relationship between the first pair (Courage : Bravery) needs to be applied to the second pair (Yearning : ?).
- Courage and Bravery are synonyms.
- Yearning means a deep desire for something.
- Yearning and Longing are synonyms.

(b) Yelling – Incorrect
- Yelling means shouting, which is unrelated.

(c) Yawning – Incorrect
- Yawning means opening your mouth due to tiredness or boredom.

(d) Glaring – Incorrect
- Glaring means staring intensely, which is unrelated.

02. We _____ tennis in the lawn when it suddenly started to rain.
Select the most appropriate option to complete the above sentence.
(a) have been playing
(b) had been playing
(c) would have been playing
(d) could be playing

02. Ans: (b)

Sol: The phrase "when it suddenly started to rain" indicates that an action was already in progress before an interruption happened.
- This requires the past perfect continuous tense (had been + verb + ing).

Option Analysis:

(a) have been playing – Incorrect
- Present perfect continuous is used for an action that started in the past and continues to the present, but here the event is fully in the past.

(b) had been playing – Correct
- Past perfect continuous is used for actions that were happening before another past event occurred.

(c) would have been playing – Incorrect
- This suggests an unreal conditional (hypothetical situation).

(d) could be playing – Incorrect
- This indicates a possibility, not a continuous past action.

03. A 4×4 digital image has pixel intensities (U) as shown in the figure. The number of pixels with $U \leq 4$ is:

0	1	0	2
4	7	3	3
5	5	4	4
6	7	3	2

(a) 3 (b) 8 (c) 11 (d) 9

03. Ans: (c)

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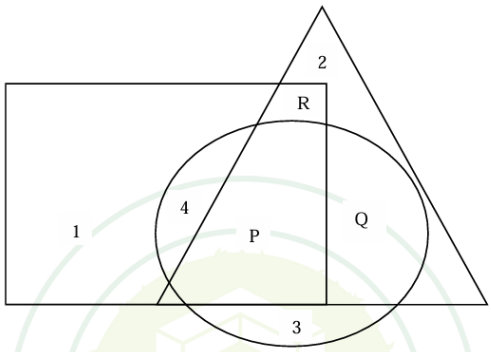
04. In the given figure, the numbers associated with the rectangle, triangle, and ellipse are 1, 2, and 3, respectively. Which one among the given options is the most appropriate combination of P, Q, and R ?



(a) P = 6; Q = 5; R = 3
(b) P = 5; Q = 6; R = 3
(c) P = 3; Q = 6; R = 6
(d) P = 5; Q = 3; R = 6

04. Ans: (a)

05. A rectangle has a length L and a width W, where L > W. If the width, W, is increased by 10%, which one of the following statements is correct for all values of L and W?
(a) Perimeter increases by 10%.
(b) Length of the diagonals increases by 10%.
(c) Area increases by 10%.
(d) The rectangle becomes a square.

05. Ans: (c)

Q.6 – Q.10 Carry TWO marks Each

06. Column-I has statements made by Shanthala; and, Column-II has responses given by Kanishk.

Column-I		Column-II	
P.	This house is in a mess	1.	Alright, I won't bring it up during our conversations.
Q.	I am not happy with the marks given to me	2.	Well, you can easily look it up.
R.	Politics is a subject I avoid talking about.	3.	No problem, let me clear it up for you.
S.	I don't know what this word means.	4.	Don't worry, I will take it up with your teacher.

Identify the option that has the correct match between Column-I and Column-II.
(a) P – 2; Q – 3; R – 1; S – 4
(b) P – 3; Q – 4; R – 1; S – 2
(c) P – 4; Q – 1; R – 2; S – 3
(d) P – 1; Q – 2; R – 4; S – 3

06. Ans: (b)

Sol: Analyzing each pair:

P. "This house is in a mess."
- The expected response should be about cleaning or organizing the house.
- **Option 3:** "No problem, let me clear it up for you." (Makes sense, as it offers a solution.)

Q. "I am not happy with the marks given to me."
- The expected response should be about dealing with marks or talking to the teacher.
- **Option 4:** "Don't worry, I will take it up with your teacher." (This is the correct response.)

R. "Politics is a subject I avoid talking about."
- The expected response should acknowledge and agree not to bring it up.

- **Option 1:** "Alright, I won't bring it up during our conversations." (This response respects the preference.)

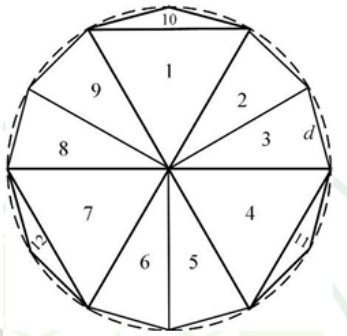
S. "I don't know what this word means."

- The expected response should be about looking up the meaning of the word.
- **Option 2:** "Well, you can easily look it up." (Encourages using a dictionary or the internet.)

07. Weight of a person can be expressed as a function of their age. The function usually varies from person to person. Suppose this function is identical for two brothers, and it monotonically increases till the age of 50 years and then it monotonically decreases. Let a_1 and a_2 (in years) denote the ages of the brothers and $a_1 < a_2$.
Which one of the following statements is correct about their age on the day when they attain the same weight?
(a) $a_1 < a_2 < 50$ (b) $a_1 < 50 < a_2$
(c) $50 < a_1 < a_2$ (d) Either $a_1 = 50$ or $a_2 = 50$

07. Ans: (b)

08. A regular dodecagon (12-sided regular polygon) is inscribed in a circle of radius r cm as shown in the figure. The side of the dodecagon is d cm. All the triangles (numbered 1 to 12) in the figure are used to form squares of side r cm and each numbered triangle is used only once to form a square. The number of squares that can be formed and the number of triangles required to form each square, respectively, are:
Note: The figure shown is representative.



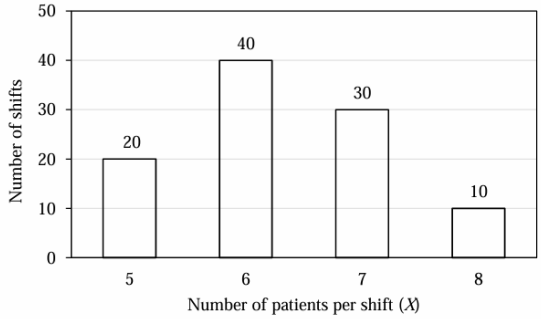
(a) 3; 4 (b) 4; 3 (c) 3; 3 (d) 3; 2

08. Ans: (a)

09. If a real variable x satisfies $3^{x^2} = 27 \times 9^x$, then the value of $\frac{2^{x^2}}{(2^x)^2}$ is:
(a) 2^{-1} (b) 2^0 (c) 2^3 (d) 2^{15}

09. Ans: (c)

10. The number of patients per shift (x) consulting Dr. Gita in her past 100 shifts is shown in the figure. If the amount she earns is ₹ 1000(x−0.2), what is the average amount (in ₹) she has earned per shift in the past 100 shifts?
Note: The figure shown is representative.



(a) 6,100 (b) 6,300
(c) 6,000 (d) 6,500

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10. Ans: (a)

Sol: $P(X=5)=\frac{20}{100}=0.2$

$P(X=6)=\frac{40}{100}=0.4$

$P(X=7)=\frac{30}{100}=0.3$

$P(X=8)=\frac{10}{100}=0.1$

$$E[\text{amount}]=\sum_{\forall x}(\text{Amount})P(X=x)$$

$$=1000\begin{bmatrix}(5-0.2)(0.2)+(6-0.2)(0.4)+(7-0.2)\\(0.3)+(8-0.2)(0.1)\end{bmatrix}$$

$=6100$

Q.11 – Q.35 Carry ONE mark Each

11. Suppose X and Y are random variables. The conditional expectation of X given Y is denoted by E[X|Y]. Then E[E[X|Y]] equals

(a) E[XY] (b) $\frac{E[X]}{E[Y]}$

(c) E[X] (d) E[Y]

11. Ans: (c)

Sol: Law of iterated expectation states that

$E[E[X|Y]=E[X]$

Note: E[X|Y] is a function of Y.

12. The number of additions and multiplications involved in performing Gaussian elimination on any n × n upper triangular matrix is of the order

(a) O(n) (b) $O(n^2)$

(c) $O(n^3)$ (d) $O(n^4)$

12. Ans: (b)

Sol: Let

$$A=\begin{bmatrix}a_{11} & a_{12} & a_{13}\\0 & a_{22} & a_{23}\\0 & 0 & a_{33}\end{bmatrix}$$

Consider the system of linear equations

$$Ax=b$$

$$\begin{bmatrix}a_{11} & a_{12} & a_{13}\\0 & a_{22} & a_{23}\\0 & 0 & a_{33}\end{bmatrix}\begin{bmatrix}x_1\\x_2\\x_3\end{bmatrix}=\begin{bmatrix}b_1\\b_2\\b_3\end{bmatrix}$$

$a_{33}x_3=b_3\Rightarrow x_3=\left(\frac{1}{a_{33}}\right).b_3$

$\Rightarrow$ One multiplication and 0 additions

$a_{22}x_2+a_{23}x_3=b_2$

$x_2=\left(\frac{1}{a_{22}}\right).(b_2+(-a_{23}x_3))$

Two multiplication and 1 addition

$a_{11}x_1+a_{12}x_2+a_{13}x_3=b_1$

$x_1=\left(\frac{1}{a_{11}}\right).(b_1+(-a_{12}.x_2)+(-a_{13}.x_3))$

Three multiplications and two additions.

Now for a $A_{n\times n}$ upper triangular matrix, the total multiplications needed are 1 + 2 +...+n

$$=\frac{n(n+1)}{2}\approx O(n^2)$$

The total additions needed are 0 + 1 + 2 +...n–1

$$=\frac{(n-1)n}{2}\approx O(n^2)$$

13. The sum of the elements in each row of $A\in R^{n\times n}$ is 1. If $B=A^3-2A^2+A$, which one of the following statements is correct (for $x\in R^n$)?

(a) The equation Bx=0 has no solution
(b) The equation Bx=0 has exactly two solutions
(c) The equation Bx=0 has infinitely many solutions
(d) The equation Bx=0 has a unique solution

13. Ans: (c)

Sol: If sum of the elements in each row of $A \in R^{n\times n}$ is 1 then one of the eigen value of A is 1. The eigen value of B is $1^3 - 2(1)^2 + 1 = 0$ since one of the eigen value is 0, the determinant of B is 0. Therefore Bx = 0 has infinite solutions.

14. Let $f(x) = \frac{e^x - e^{-x}}{2}$, $x \in R$. Let $f^{(k)}(a)$ denote the k^{th} derivative of f evaluated at a.
What is the value of $f^{(10)}(0)$?
(**Note:**!denotes factorial)
(a) 0 (b) 1 (c) $\frac{1}{10!}$ (d) $\frac{2}{10!}$

14. Ans: (a)

Sol: $f(x) = \frac{e^x - e^{-x}}{2}$

$f'(x) = \frac{e^x + e^{-x}}{2}$

$f''(x) = \frac{e^x - e^{-x}}{2}$

Similarly $f^{10}(x) = \frac{e^x - e^{-x}}{2}$

$f^{10}(0) = \frac{e^0 - e^{-0}}{2} = 0$

15. Let p and q be any two propositions. Consider the following propositional statements.
$S_1 : p \rightarrow q$, $S_2 : \neg p \wedge q$, $S_3 : \neg p \vee q$, $S_4 : \neg p \vee \neg q$,
where $\wedge$ denotes conjunction (AND operation), denotes disjunction (OR operation), and $\neg$ denotes negation(NOT operation). Which one of the following options is correct?
(Note: $\equiv$ denotes logical equivalence)
(a) $S_1 \equiv S_3$ (b) $S_2 \equiv S_3$
(c) $S_2 \equiv S_4$ (d) $S_1 \equiv S_4$

15. Ans: (c)

16. If a relational decomposition is not dependency-preserving, which one of the following relational operators will be executed more frequently in order to maintain the dependencies?
(a) Selection (b) Projection
(c) Join (d) Set union

16. Ans: (c)

Sol: If a relational decomposition is not dependency preserving, the relational operator that will be executed frequently to preserve the dependencies is a join operation, specially a natural join, as it allows you to reassemble the original relations by combining data from the decomposed relations when needed to enforce the lost functional dependencies.

17. Consider the following three relations:
Car (model, year, <u>serial,</u> color)
Make (maker, <u>model</u>)
Own (<u>owner</u>, <u>serial</u>)
A tuple in Car represents a specific car of a given model, made in a given year, with a serial number and a color. A tuple in Make specifies that a maker company makes cars of a certain model. A tuple in Own specifies that an owner owns the car with a given serial number. Keys are underlined; (<u>owner,</u> <u>serial</u>) together form key for Own. ($\bowtie$ denotes natural join)
$\pi_{owner}(Own \bowtie (\sigma_{color="red"}(Car \bowtie (\sigma_{maker="ABC"}Make))))$

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Which one of the following options describes what the above expression computes?

(a) All owners of a red car, a car made by ABC, or a red car made by ABC

(b) All owners of more than one car, where at least one car is red and made by ABC

(c) All owners of a red car made by ABC

(d) All red cars made by ABC

17. Ans: (c)

Sol: The 1st inner most query returns all makers of 'ABC' 2nd inner query returns red color cars made by 'ABC' final outer query returns all owners of a red car made by ABC.

18. Consider a hash table of size 10 with indices {0,1,...9}, with the hash function

$h(x) = 3x \pmod{10}$,

where linear probing is used to handle collisions. The hash table is initially empty and then the following sequence of keys is inserted into the hash table: 1,4,5,6,14,15. The indices where the keys 14 and 15 are stored are, respectively

(a) 2 and 5 (b) 2 and 6

(c) 4 and 5 (d) 4 and 6

18. Ans: (d)

Sol: Solution for Hashing with linear Probing

We are given :

- Hash table size = 10
- Hash function:

$$h(x) = (3x) \quad \text{mod } 10$$

- Collision handling: Linear probing (increment sequentially if the slot is occupied).
- Insertion order : 1, 4, 5, 6, 14, 15.

Step-by-step insertion

1. Insert 1

   $h(1) = (3 \times 1) \bmod 10 = 3$

   stored at index 3.
2. Insert 4

   $h(4) = (3 \times 4) \bmod 10 = 2$

   stored at index 2.
3. Insert 5

   $h(5) = (3 \times 5) \bmod 10 = 5$

   stored at index 5.
4. Insert 6

   $h(6) = (3 \times 6) \bmod 10 - 8$

   stored at index 8
5. Insert 14

   $h(14) = (3 \times 14) \bmod 10 = 2$

- Collision at index 2 (already occupied by 4).
- Linear probing → Next available slot = index 4.

stored at index 4.

6. Insert 15

   $h(15) = (3 \times 15) \bmod 10 = 5$

- Collision at index 5 (already occupied by 5).
- Linear probing → Next available slot = index 6.

stored at index 6.

19. Let X be a continuous random variable whose cumulative distribution function (CDF) $F_X(x)$, for some t, is given as follows:

$$F_X(x) = \begin{cases} 0 & x \le t \\ \dfrac{x-t}{4-t} & t \le x \le 4 \\ 1 & x \ge 4 \end{cases}$$

If the median of X is 3, then what is the value of t?

(a) 2 (b) 1 (c) −1 (d) 0

19. Ans: (a)

Sol: Given median = 3

$\Rightarrow F_x(3) = 0.5$

$\Rightarrow \frac{3-t}{4-t} = 0.5$

$3 - t = 2 - 0.5t \Rightarrow t = 2$

20. Let X = aZ +b, where Z is a standard normal random variable, and a, b are two unknown constants. It is given that

E[X]=1 E[(X−E [X])Z]= −2 E[(X−E[X])^2] = 4, where E[X] denotes the expectation of random variable X. The values of a,b are:

(a) a = −2, b = 1 (b) a = 2, b = −1

(c) a = −2, b = −1 (d) a =1, b =1

20. Ans: (a)

Sol: X = aZ + b

E[X] = a E[Z] + b = 1

a(0) + b = 1

$\Rightarrow$ b = 1

Var(X) = Var(aZ + b) = 4

a^2 var(Z) = 4

$a^7(1) = 4 \Rightarrow a = 2$ (or) −2

21. It is given that P(X ≥ 2) = 0.25 for an exponentially distributed random variable X with E[X] = $\frac{1}{\lambda}$, where E[X] denotes the expectation of X. What is the value of λ?

(ln denotes natural logarithm)

(a) ln 2 (b) ln 4

(c) ln 3 (d) ln 0.25

21. Ans: (a)

Sol: For an exponential R.V with parameter λ

$P(X \geq k) = e^{-k\lambda}$

$P(X \geq 2) = 0.25$

$e^{-2\lambda} = 0.25$

$\ell n\, e^{-2\lambda} = \ell n(0.25)$

$-2\lambda = \ell n\left(\frac{1}{4}\right)$

$\lambda = -\frac{1}{2}\ell n 2^{-2} \Rightarrow \lambda = \ell n 2$

22. Consider designing a linear classifier

y =sign(f(x;w,b)), f(x;w,b) = w^Tx+b

on a dataset D = (x_1,y_1) (x_2, y_2), ..., (x_N, y_N) , $x_i \in R^d$, $y_i \in \{+1 -1\}$, i = 1, 2, ...N. Recall that the sign function outputs +1 if the argument is positive, and −1 if the argument is non-positive. The parameters w and b are updated as per the following training algorithm:

$w_{new} = w_{old} + y_n, x_n, \; b_{new} = b_{old} + y_n$

whenever sign($f(x_n; w_{old}, b_{old})$) ≠ y_n. In other words, whenever the classifier wrongly predicts a sample (x_n, y_n) from the dataset, w_{old} gets updated to w_{new}, and likewise b_{old} gets updated to b_{new}. Consider the case $(x_n,+1)$, $f(x_n,w_{old}, b_{old}) < 0$. Then

(a) $f(x_n, w_{new}, b_{new}) > f(x_n,w_{old}, b_{old})$

(b) $f(x_n, w_{new}, b_{new}) < f(x_n,w_{old}, b_{old})$

(c) $f(x_n, w_{new}, b_{new}) = f(x_n,w_{old}, b_{old})$

(d) y_n $f(x_n,w_{old}, b_{old}) > 1$

22. Ans: (a)

Sol: The given classifier function is,

$f(x; w, b) = w^T x + b$

It is given that the update occurs when the classifier incorrectly predicts

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x_n. i.e.,

sign $(f(x_n; w_{old}, b_{old})) \neq y_n$

under such case, the parameters are update as,

$w_{new} = w_{old} + y_n x_n$ ..... (i)

$b_{new} = b_{old} + y_n$ ..... (ii)

Given case is,

$y_n = +1$ and $f(x_n; w_{old}, b_{old}) < 0$

$\Rightarrow$ sign $(f(x_n; w_{old}, b_{old}))$ is negative and it results -1.

Thus the parameters are to be updated

$f(x_n; w_{new}, b_{new}) = W^T_{new} x_n + b_{new}$ ..... (iii)

By using (i) and (ii) and on substituting them in (iii),

$$f(x_n; w_{new}, b_{new}) = (w_{old} + y_n x_n)^T x_n + (b_{old} + y_n)$$

$$= w_{old}^T x_n + y_n x_n^T x_n + b_{old} + y_n$$

$$= f(x_n; w_{old}, b_{old}) + y_n (x_n^t x_n + 1)$$

$\because (x_n^T x_n + 1)$ is always positive;

$f(x_n, w_{new}, b_{new}) > f(x_n, w_{old}, b_{old})$

Thus, option (a) is correct answer.

23. Consider the following Python declarations of two lists.

A = [1,2,3]

B = [4,5,6]

Which one of the following statements results in A = [1, 2, 3, 4, 5, 6]?

(a) A.extend(B) (b) A.append(B)

(c) A.update(B) (d) A.insert(B)

23. Ans: (a)

Sol: (a) a. extend (b) correct

- extend () aapends elements of b individually to a.
- Result: A = [1, 2, 3, 4, 5, 6].

(b) a. append (b)

- append () adds b as a single element (a nested list).
- result : a = [1, 2, 3, [4, 5, 6]] (incorrect format)

(c) a. update (b)

- update () is not valid method for lists, it is used for sets and dictionaries.
- results in an attributer error.

(d) a. insert (b)

- insert () requires two argument : index and element
- results in a type error

24. Consider two functions f: R$\rightarrow$R and g : R $\rightarrow (1,\infty)$. Both functions are differentiable at a point c. Which of the following functions is/are ALWAYS differentiable at c? The symbol '$\cdot$'denotes product and the symbol 'o' denotes composition of functions.

(a) $f \pm g$ (b) $f \cdot g$

(c) $\frac{f}{g}$ (d) $f \circ g + g \circ f$

24. Ans: (a), (b) & (c)

Sol: If f and g are two differentiable functions then $f \pm g$, $f \cdot g$ and $\frac{f}{g}$ are also differentiable.

Note: $g(x) \neq 0$ as range of g(x) is $(1,\infty)$.

Let $P(x) = (f \circ g)(x) + (g \circ f)(x)$

$P(x) = f(g(x)) + g(f(x))$

$P'(x) = g'(x).f'(g(x)) + f'(x)g'(f(x))$

$P'(c) = g'(c)f'(g(c)) + f'(c)g'(f(c))$

f(x) may or may not be differentiable at x = g(c).

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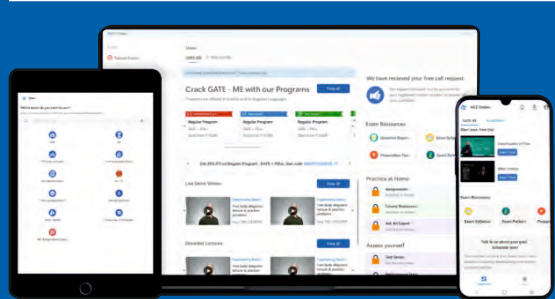

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Similarly g(x) may or may not be differentiable at x = f(c).

∴ fog+gof ,may or may not be differential at x = c.

25. Which of the following statements is/are correct?
(a) R^n has a unique set of orthonormal basis vectors
(b) R^n does not have a unique set of orthonormal basis vectors
(c) Linearly independent vectors in R^n are orthonormal
(d) Orthonormal vectors R^n are linearly independent

25. Ans:(b), (d)

Sol: Orthonormal vectors are always linearly independent whereas linearly independent vectors need not be orthonormal.
(c) is false and (d) is true.
R^n has different sets of orthonormal basis vectors.
(a) is false and (b) is true.

26. Which of the following statements is/are correct in a Bayesian network?
(a) Variable elimination is an approximate inference algorithm
(b) Gibbs sampling is an exact inference algorithm
(c) Variable elimination is used to determine conditional probabilities
(d) Rejection sampling is an approximate inference algorithm

26. Ans: (c), (d)

Sol: In a Bayesian N/w, variable elimination is used to determine conditional probabilities and rejection sampling is an approximate inference algorithm.

27. For which of the following inputs does binary search take time O(logn) in the worst case?
(a) An array of n integers in any order
(b) A linked list of n integers in any order
(c) An array of n integers in increasing order
(d) A linked list of n integers in increasing order

27. Ans: (c)

Sol: (a) An array of n integers in any order

- Binary search requires a sorted array.
- If the array is unordered, sorting takes O(n log n) before searching.
- Not applicable

(b) A linked list of n integers in any order

- Binary search needs random access for middle element comparison
- Linked lists do not support random access in O(1) (must traverse sequentially)
- Takes O(n) in the worst case.

(c) An array of n integers in increasing order correct

- Binary search works optimally on a sorted array.
- Each step halves the search space → O(log) complexity

(d) A linked list of n integers in increasing order

- Even though sorted, linked lists do not support random access
- Each middle element search requires O(n) traversal.
- Worst case complexity is O(n), not O(log n).

28. Let $A = I_n + xx^T$, where I_n is the n×n identity matrix and $x \in R^n$, $x^Tx = 1$. Which of the following options is/are correct?
(a) Rank of A is n
(b) A is invertible
(c) 0 is an eigenvalue of A
(d) A^{-1} has a negative eigenvalue

28. Ans: (a), (b)

Sol: Let n = 2

$$A = \begin{bmatrix}1 & 0\\ 0 & 1\end{bmatrix} + \begin{bmatrix}x_1\\ x_2\end{bmatrix}\begin{bmatrix}x_1 & x_2\end{bmatrix}$$

$$= \begin{bmatrix}1 & 0\\ 0 & 1\end{bmatrix} + \begin{bmatrix}x_1^2 & x_1x_2\\ x_1x_2 & x_2^2\end{bmatrix}$$

$$A = \begin{bmatrix}1+x_1^2 & x_1x_2\\ x_2x_1 & 1+x_2^2\end{bmatrix}$$

$$|A| = (1+x_1^2)(1+x_2^2) - x_1^2x_2^2$$
$$= 1 + x_2^2 + x_1^2 + x_1^2x_2^2 - x_1^2x_2^2$$
$$= 1 + x_1^2 + x_2^2$$

Since $x^Tx = 1 \Rightarrow x_1^2 + x_2^2 = 1$

$\Rightarrow |A| = 1 + 1 = 2 \neq 0$

A if full rank and invertible matrix

Since $|A| \neq 0$, $\Rightarrow 0$ is not an eigen value of A.

A is a symmetric matrix

Consider $v^T Av = v^T (I_n + x\,x^T)v$

$= (v^T + v^T\,x\,x^T)v$

$= v^T v + v^T xx^T v$

$= v^T v + (x^Tv)^T x^T v$

$\Rightarrow v^T Av > 0$

A is positive definite matrix $\Rightarrow A^{-1}$ is also positive definite matrix $\Rightarrow A^{-1}$ cannot have negative eigen values.

29. Suppose that insertion sort is applied to the array [1, 3, 5, 7, 9, 11, x, 15, 13] and it takes exactly two swaps to sort the array. Select all possible values of x.
(a) 10 (b) 12 (c) 14 (d) 16

29. Ans: (a), (c)

Sol:

- If we select x = 10, then we have two swaps needed.

  first swap between (11, 10)

  second swap between (15, 13)

- If we select x = 14 then, we have two swaps needed

  first swap between (15, 13)

  second swap between (14, 13)

30. Let C_1 and C_2 be two sets of objects. Let D(x, y) be a measure of dissimilarity between two objects x and y. Consider the following definitions of dissimilarity between C_1 and C_2.

$$\text{DIS-1}(C_1, C_2) = \max_{x \in C_1, y \in C_2} D(x, y)$$

$$\text{DIS-2}(C_1, C_2) = \min_{x \in C_1, y \in C_2} D(x, y)$$

Which of the following statements is/are correct?
(a) Single Linkage Clustering uses DIS-1
(b) Single Linkage Clustering uses DIS-2
(c) Complete Linkage Clustering uses DIS-2
(d) Complete Linkage Clustering uses DIS-1

30. Ans: (b), (d)

Sol: Single linkage clustering merges clusters based on the "minimum" pair wise dissimilarity.

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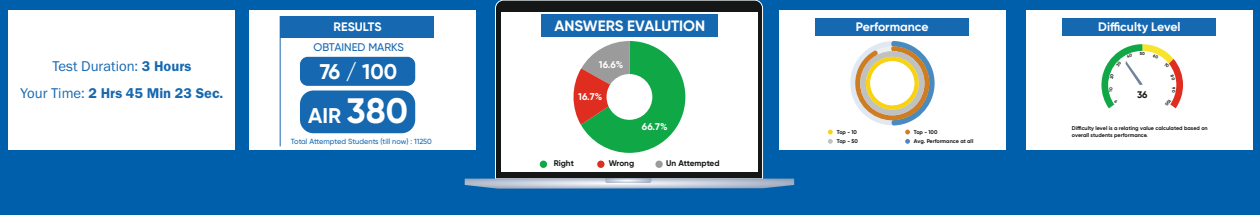

Thus single linkage clustering uses Dis-2, which is given in option (b).

Complete linkage clustering merges clusters based on the "maximum" pairwise dissimilarity.

Thus complete linkage clustering used Dis-1, which is given in option (d).

31. There are three boxes containing white balls and black balls.

Box-1 contains 2 black and 1 white balls.

Box-2 contains 1 black and 2 white balls.

Box-3 contains 3 black and 3 white balls.

In a random experiment, one of these boxes is selected, where the probability of choosing Box-1 is $\frac{1}{2}$, Box-2 is $\frac{1}{6}$, and Box-3 is $\frac{1}{3}$. A ball is drawn at random from the selected box. Given that the ball drawn is white, the probability that it is drawn from Box-2 is_____(Round off to two decimal places)

31. Ans: Range(0.25 to 0.25)

Sol:

$$P(\text{Box2} \mid \text{White}) = \frac{\frac{1}{6}\left(\frac{2}{3}\right)}{\frac{1}{2}\left(\frac{1}{3}\right)+\frac{1}{6}\left(\frac{2}{3}\right)+\frac{1}{3}\left(\frac{3}{6}\right)}$$

$$= \frac{1}{4} = 0.25$$

32. $\lim_{t\to+\infty} \sqrt{t^2+t} - t =$_____

(Round off to one decimal place)

32. Ans: (Range 0.5 to 0.5)

Sol: $\lim_{t\to\infty} \frac{(\sqrt{t^2+t}-t)(\sqrt{t^2+t}+t)}{(\sqrt{t^2+t}+t)}$

$\lim_{t\to\infty} \frac{t^2+t-t^2}{\sqrt{t^2+t}+t}$

$$\lim_{t\to\infty} \frac{t}{t\left(\sqrt{1+\frac{1}{t}}+1\right)} = \frac{1}{\sqrt{1+\frac{1}{t}}+1} = \frac{1}{\sqrt{1+0}+1} = 0.5$$

33. On a relation named Loan of a bank:

Loan		
loan_number	**branch_name**	**amount**
L11	Banjara Hills	90000
L14	Kondapur	50000
L15	SR Nagar	40000
L22	SR Nagar	25000
L23	Balanagar	80000
L25	Kondapur	70000
L19	SR Nagar	65000

the following SQL query is executed.

```
SELECT L1.loan number
FROM Loan L1
WHERE L1.amount>(SELECT MAX (L2.amount)
                 FROM Loan L2
                 WHERE L2.branch_name = 'SR Nagar');
```

The number of rows returned by the query is (Answer in integer)

33. Ans: (Range 3 to 3)

Sol: Inner query returns maximum loan amount of a loan whose branch is 'SR Nagar' (65,000) outer query returns loan-number of loans whose loan amount is above 65,000 (L11, L23, L25)

34. Given data {(−1, 1), (2,−5), (3; 5)} of the form (x,y), we fit a model y = wx using linear least-squares regression. The optimal value of w is_____

(Round off to three decimal places)

34. Ans: 0.286 (Range 0.285 to 0.287)

Sol: The formula for computing W in simple linear regression without an intercept (i.e., y = wx) is;

$$W = \frac{\sum x_i y_i}{\sum (x_i)^2}$$

Given data set is,

x	y	$x_i y_i$	$x_i^{(2)}$
–1	1	– 1	1
2	–5	– 10	4
3	5	+ 15	9
		4	14

$$\therefore W = \frac{4}{14} = 0.286$$

35. The naive Bayes classifier is used to solve a two-class classification problem with class labels y_1, y_2. Suppose the prior probabilities are $P(y_1) = \frac{1}{3}$ and $P(y_2) = \frac{2}{3}$. Assuming a discrete feature space with $P(x|y_1) = \frac{3}{4}$ and $P(x|y_2) = \frac{1}{4}$ for a specific feature vector x. The probability of misclassifying x is _____(Round off to two decimal places)

35. Ans: 0.4 (Range 0.39 to 0.41)

Sol: Given,

Prior probabilities: $P(y_i) = \frac{1}{3}$ & $P(y_2) = \frac{2}{3}$

Likelihoods : $P(x \mid y_1) = \frac{3}{4}$ & $P(x \mid y_2) = \frac{1}{4}$

On applying naive Baye's classification rule,

$$P(y_k \mid x) = \frac{P(x \mid y_k)\, P(y_k)}{P(x)} \quad \text{.....(i)}$$

The maximum $P(y_k \mid x)$ gives the correct classification thus, $(1 - [\max P(y_k \mid x)])$ results the mis classification probability.

From expression (1),

$$P(y_1 \mid x) = \frac{P(x \mid y_1)\, P(y_1)}{P(x)} \text{ and}$$

$$P(y_2 \mid x) = \frac{P(x \mid y_2)\, P(y_2)}{P(x)}$$

where,

$P(x) = P(x|y_1)\, P(y_1) + P(x|y_2)\, P(y_2)$

$$= \left(\frac{3}{4} \times \frac{1}{3}\right) + \left(\frac{2}{3} \times \frac{1}{4}\right)$$

$$= \frac{1}{4} + \frac{1}{6} = \frac{5}{12}$$

Thus, the posterior probabilities can be given as,

$$P(y_1 \mid x) = \frac{P(x \mid y_1) P(y_1)}{P(x)} = \frac{\frac{3}{4} \times \frac{1}{3}}{\frac{5}{12}}$$

$$P(y_1 \mid x) = \frac{1}{4} \times \frac{12}{5} = \frac{3}{5} = 0.6$$

$$P(y_2 \mid x) = \frac{P(x \mid y_2) P(y_2)}{P(x)} = \frac{\frac{1}{4} \times \frac{2}{3}}{\frac{5}{12}}$$

$$= \frac{1}{6} \times \frac{12}{5} = \frac{2}{5} = 0.4$$

Max (0.6, 0.4) = 0.6 $\Rightarrow P(y_1 \mid x)$ is the correct classification probability

$\therefore$ Mis classification probability = 1 – 0.6 = 0.4

Q.36 – Q.65 Carry TWO marks Each

36. Let $Y = Z^2$, $Z = \frac{X-\mu}{\sigma}$, where X is a normal random variable with mean μ and variance σ^2. The variance of Y is

(a) 1 (b) 2 (c) 3 (d) 4

36. Ans: (b)

Sol: Clearly $Y = Z^2$ is a chi squarel random variable with 1 degree of freedom. The variance of chi square random variable with n degrees of freedom is 2n. Hence variance of Y is 2.

37. Let $A \in R^{n\times n}$ be such that $A^3 = A$. Which one of the following statements is ALWAYS correct?

(a) A is invertible

(b) Determinant of A is 0

(c) The sum of the diagonal elements of A is 1

(d) A and A^2 have the same rank

37. Ans: (d)

Sol: $A^3 = A$

$A^3 - A = 0$

$A(A^2 - I) = 0$

$\Rightarrow A = 0$ (or) $A^2 = I$

If $A = 0$ then A is not invertible. Option (a) is not always true.

If $A^2 = I$ then $|A| \neq 0$. So option (b) is not always true.

If $A = 0$ then sum of the diagonal elements of A is not 1 option (c) is not always true.

38. Let $\{x_1, x_2, \ldots, x_n\}$ be a set of linearly independent vectors in R^n. Let the (i, j)-th element of matrix $A \in R^{n\times n}$ be given by $A_{ij} = x_i^T x_j$, $1 \le i, j \le n$. Which one of the following statements is correct?

(a) A is invertible

(b) 0 is a singular value of A

(c) Determinant of A is 0

(d) $z^T Az = 0$ for some non-zero $z \in R^n$

38. Ans: (a)

Sol: Let us verify the options by taking two linearly independent vectors

$$x_1 = \begin{bmatrix}1\\0\end{bmatrix} x_2 = \begin{bmatrix}0\\1\end{bmatrix}$$

$A_{11} = x_1^T x = 1$, $A_{12} = x_1^T x_2 = 0$,

$A_{21} = x_2^T x_1 = 0$, $A_{22} = x_2^T x_2 = 1$

$\Rightarrow A = \begin{bmatrix}1 & 0\\0 & 1\end{bmatrix} \Rightarrow$ A is invertible

Since Rank (A) = 2, there are two non zero singular values $\Rightarrow$ option (b) is false.

$|A| \neq 0 \Rightarrow$ option (c) is false

$z^T Az = z^T Iz = z^T z > 0 \Rightarrow$ option (d) is false.

39. Consider the cumulative distribution function (CDF) of a random variable X:

$$F_x(x) = \begin{cases} 0 & x \le -1 \\ \frac{1}{4}(x+1)^2 & -1 \le x \le 1 \\ 1 & x \ge 1 \end{cases}$$

The value of $P(X^2 \le 0.25)$ is

(a) 0.625 (b) 0.25

(c) 0.5 (d) 0.5625

39. Ans: (c)

Sol: The PDF f(x) is given by

$$f(x) = \frac{d}{dx}F(x)$$

$$f(x) = \begin{cases} 0 & x \le -1 \\ \frac{1}{2}(x+1) & -1 \le x \le 1 \\ 0 & x \ge 1 \end{cases}$$

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$$P(x^2 \le 0.25) = P(-0.5 \le x \le 0.5)$$

$$= \int_{-0.5}^{0.5} \left(\frac{x+1}{2}\right) dx$$

$$= \frac{(x+1)^2}{4}\Big|_{-0.5}^{0.5}$$

$$= \frac{1}{4}((1.5)^2 - (0.5)^2) = 0.5$$

40. A random variable X is said to be distributed as Bernoulli(θ), denoted by X ~Bernoulli(θ), if $P(X = 1) = \theta, P(X = 0) = 1 - \theta$ for $0 < \theta < 1$. Let $Y = \sum_{i=1}^{300} X_i$, where $X_i \sim$ Bernoulli(θ), i = 1, 2,..., 300 be independent and identically distributed random variables with θ = 0.25. The value of $P(60 \le Y \le 90)$, after approximation through Central Limit Theorem, is given by $\left(\text{Recall that } \phi(x) = \frac{1}{\sqrt{2\pi}}\int_{-\infty}^{x} e^{-\frac{t^2}{2}} dt\right)$

(a) $\phi(2) - \phi(-2)$ (b) $\phi(1) - \phi(-1)$
(c) $\phi(3) - \phi(-3)$ (d) $\phi(90) - \phi(60)$

40. Ans: (a)

Sol: $E[X] = \sum_{\forall x} x\,P(x) = 0(1-\theta) + 1(\theta)$

$$\Rightarrow E[X] = \theta = 0.25$$

$$E[X^2] = \sum_{\forall x} x^2 P(x) = 0^2(1-\theta) + 1^2(\theta)$$

$$\Rightarrow E[X^2] = \theta$$

$$\Rightarrow Var(X) = \theta - \theta^2 = \theta(1-\theta)$$

$$Y = \sum_{i=1}^{300} X_i$$

$$E[Y] = \sum_{i=1}^{300} E[X_i] = \sum_{i=1}^{300} 0.25 = 75$$

$$Var(Y) = Var\left(\sum_{i=1}^{300} X_i\right) = \sum_{i=1}^{300} var(X_i) = \sum_{i=1}^{300} (0.25)(0.75)$$

$$Var(Y) = 56.25$$

$$\sigma_Y = 7.5$$

$$P(60 \le Y \le 90) = P\left(\frac{60-75}{7.5} \le \frac{Y-75}{7.5} \le \frac{90-75}{7.5}\right)$$

$$= P(-2 \le z \le 2)$$

$$= \phi(2) - \phi(-2)$$

41. For $x \in R$, the floor function is denoted by $f(x) = \lfloor x \rfloor$ and defined as follows $\lfloor x \rfloor = k, k \le x < k+1$, where k is an integer. Let $Y = \lfloor X \rfloor$, where X is an exponentially distributed random variable with mean $\frac{1}{\ell n\, 10}$, where ln denotes natural logarithm. For any positive integer ℓ, one can write the probability of the event $Y = \ell$ as follows $P(Y = \ell) = q^{\ell}(1-q)$ The value of q is

(a) 0.1 (b) 0.01 (c) 0.5 (d) 0.434

41. Ans: (a)

Sol: $E[X] = \frac{1}{\ell n 10} = \frac{1}{\lambda}$

$$\Rightarrow \lambda = \ell n 10$$

$X \ge 0$ as X is exponential random variable.

If $X \ge 0$ then Y takes the values 0,1,2,3,.....

$$P(Y = 0) = P(0 \le X < 1) = \int_0^1 f(x)dx$$

$$= \int_0^1 \lambda e^{-\lambda x} dx$$

$$= \frac{\lambda e^{-\lambda x}}{-\lambda}\Big|_0^1$$

$$= 1 - e^{-\lambda}$$

$$= 1 - e^{-\ell n 10}$$

$$= 1 - e^{\ln\frac{1}{10}}$$

$$= 1 - \frac{1}{10} = 0.9$$

$$\sum_{y=0}^{\infty} P(Y = y) = 1$$

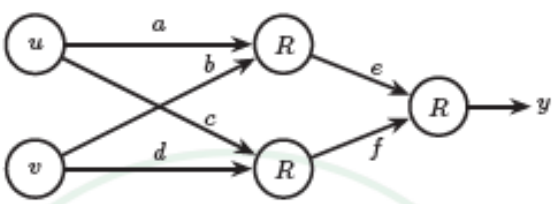
$$P(Y = 0) + P(Y = 1) + P(Y = 2) + P(Y = 3) + ... = 1$$

$$0.9 + q(1-q) + q^2(1-q) + q^3(1-q) + ... = 1$$

$$(1-q)\frac{q}{(1-q)} = 0.1$$

$$\Rightarrow q = 0.1$$

42. Consider the neural network shown in the figure with inputs: u, v
weights: a, b, c, d, e, f
output: y
R denotes the ReLU function, R(x) = max(0, x).



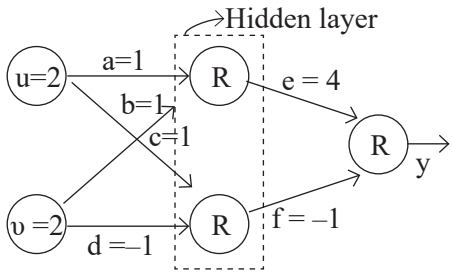
Given u = 2; v = 3,
a = 1, b = 1, c = 1, d = −1; e = 4; f = −1,
which one of the following is correct?

(a) $\frac{\partial y}{\partial a} = 8, \frac{\partial y}{\partial f} = 0$ (b) $\frac{\partial y}{\partial a} = 1, \frac{\partial y}{\partial f} = 0$

(c) $\frac{\partial y}{\partial a} = 1, \frac{\partial y}{\partial f} = -1$ (d) $\frac{\partial y}{\partial a} = 2, \frac{\partial y}{\partial f} = -1$

42. Ans: (a)

Sol: The inputs and weights are given as,
u = 2; υ = 3
a = 1; b = 1, c = 1; d = –1; e = 4; f = –1



The inputs to ReLu activation functions in the hidden layer are:

$Z_1 = au + c\upsilon = (1\times2) + (1\times3) = 5$

$Z_2 = bu + d\upsilon = (1\times2) + (-1\times3) = -1$

on applying ReLu activation function;

hidden layer –1 output $(h_1) = R(Z_1)$

$= \max(0, 5) = 5$

$\therefore h_1 = Z_1 = au + c\upsilon$ ...(i)

hidden layer –2 output $(h_2) = R(Z_2)$

$h_2 = \max(0, -1) = 0$

Now, the output layer gives an output,

$y = eh_1 + fh_2$ ...(ii)

From (i) & (ii)

$y = e(au + c\upsilon) + fh_2$ ...(iii)

$\frac{\partial y}{\partial a} = e \times u = 4\times2 = 8$

Similarly,

$\frac{\partial y}{\partial f} = h_2 = 0$

$\frac{\partial y}{\partial a} = 8, \frac{\partial y}{\partial f} = 0$ is given in option (a)

43. Consider game trees Tree-1 and Tree-2 as shown. The first level is a MAX agent and the second level is a MIN agent. The value in the square node is the output of the utility function.

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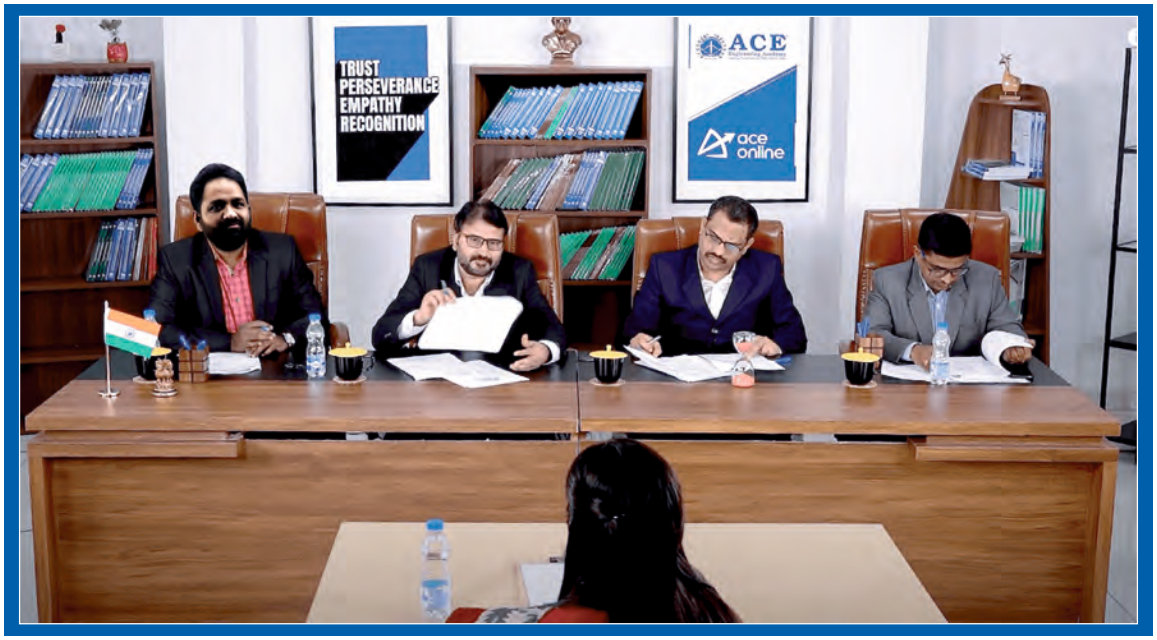

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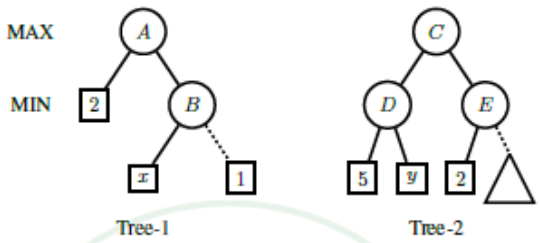


For what ranges of x and y, the right child of node B and the right child of node E will be pruned by alpha-beta pruning algorithm?

(a) $x \in [1,\infty)$ and $y \in (-\infty, 2]$

(b) $x \in [-\infty, 2)$ and $y \in (-\infty, 5]$

(c) $x \in [-\infty, 2)$ and $y \in (2,\infty]$

(d) $x \in [1,\infty)$ and $y \in (-\infty, 5]$

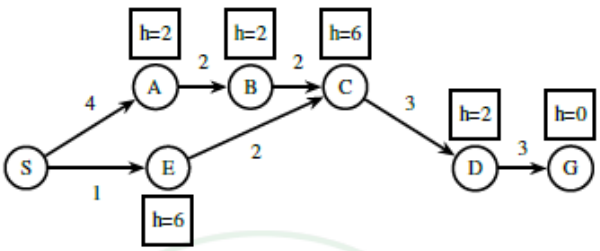
43. Ans: (c)

Sol: In the game tree-1, 'x' can take any value which is less than or equal to '2'. The root node value of 'A' does not effect, means $x \in (-\infty, 2]$

In the game tree-2, 'y' can take value which is greater than or equal to '2'. the root node value of 'C' doesnot effects, means $y \in [2,\infty]$)

$\therefore x \in (-\infty, 2]$ and $y \in [2, \infty)$

44. The state graph shows the action cost along the edges and the heuristic function h associated with each state.



Suppose A* algorithm is applied on this state graph using priority queue to store the frontier. In what sequence are the nodes expanded?

(a) S,A,E,C,B,D,G (b) S,E,A,C,B,D,G

(c) S,A,E,B,C,D,G (d) S,A,B,E,C,D,G

44. Ans: (c)

Sol: Given nodes with g(n) and h(n) value

Node(n)	g(n)	h(n)	f(n)
S	–	–	–
A	4	2	6
B	6	2	8
E	1	6	7
C	8	6	14
D	11	2	13
G	14	0	14

The sequence of the nodes expanded by applying A* algorithm is SAE BCDG.

45. A random experiment consists of throwing 100 fair dice, each die having six faces numbered 1 to 6. An event A represents the set of all outcomes where at least one of the dice shows a 1. Then, P(A) =

(a) 0 (b) 1 (c) $1-\left(\frac{5}{6}\right)^{100}$ (d) $\left(\frac{5}{6}\right)^{100}$

45. Ans: (c)

Sol: P(A) = 1 – P (No dice show 1)

$$= 1-\left(\frac{5}{6}\right)\left(\frac{5}{6}\right).....\left(\frac{5}{6}\right)$$

$$= 1-\left(\frac{5}{6}\right)^{100}$$

46. Consider a fact table in an OLAP application: Facts(D1, D2, val), where D1 and D2 are its dimension attributes and val is a dependent attribute. Suppose attribute D1 takes 3 values and

D2 takes 2 values, and all combinations of these values are present in the table Facts. How many tuples are there in the result of the following query?

```
SELECT D1, D2, sum(val)
FROM Facts
GROUP BY CUBE (D1, D2);
```

(a) 1 (b) 6 (c) 9 (d) 12

46. Ans: (d)

Sol: Suppose attribute D_1 takes 3 values and D_2 takes 2 values, then the number of tuples returned by the query is $(3+1) \times (2+1) = 12$ tuples.

47. Consider the following Python code snippet.

```
A = {"this", "that"}
B = {"that", "other"}
C = {"other", {"this"}
while "other" in C:
    if "this" in A:
      A,B, C= A−B, B−C, C−A
    if "that" in B:
      A,B,C=C|A,A|B,B|C
```

When the above program is executed, at the end, which of the following sets contains "this"?

(a) Only A (b) Only B
(c) Only C (d) A, C

47. Ans: (b)

Sol: Step 1 : Initial set Definitions

A = {"this", "that"}

B = {"that", "other"}

C = {"other", "this"}

Step 2 : While Loop Condition

While "other" in C:

The loop runs as long as "other " is in C.

Initially. "Other" is in C, so the loop executes.

Step 3: First if condition

if "this" in A:

Since A = {"this", "that"}, is in A, so this block executes

Step 4 : First set transformation

A, B, C = A –B, B – C, C – A

Calculating new A, B, AND C

- A – B = {"this", "that"} – {"that", "other"} = {"this"}
- B – C = {"that", "other"} – {"other", "this"} = {"that"}
- C – A = {"other", "this"} – {"this", "that"} = {"other"}

A = {"this"}

B = {"that"}

C = {"other"}

Since B = {"that"}, "that" is present, so this block executes

Calculating new A, B, and C'

- C|A = {"other", "this"} – {"this", "other"}
- A|B = {"this", "that"} – {"this", "that"}
- B|C = {"that", "other"} – {"that", "other"}

Calculating new A, B, and C'

- A – B = {"this", "other"} – {"this", "that"} = {"other"}
- B – C = {"this", "that"} – {"that", "other"} = {"this"}
- C – A = {"that", "other"} – {"this", "other"} = {"that"}

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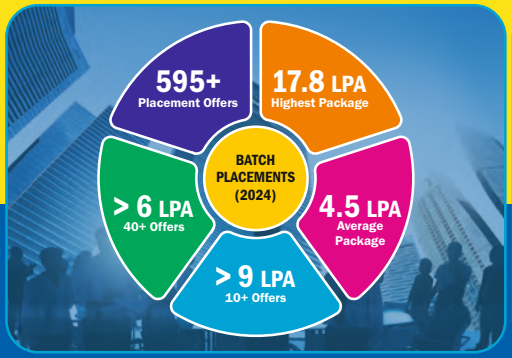

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A = {"other"}

B = {"this"}

C = {"that"

"other" not in c anymore (c = {"that"}), so the loop terminates.

A = {"other"}

B = {"this"}

C = {"that"}

The only set that contains "this" is B.

Thus the final answer is :

B contains "this".

48. Which of the following statements is/are correct about the rectified linear unit (ReLU) activation function defined as ReLU(x) = max(x, 0), where $x \in R$?

(a) ReLU is continuous everywhere

(b) ReLU is differentiable everywhere

(c) ReLU is not differentiable at x = 0

(d) ReLU(x) = ReLU(ax), for all $a \in R$

48. Ans: (a), (c)

Sol: ReLU (x) = max (x, 0)

If $x \geq 0$, then ReLU (x) = x

If $x < 0$, then ReLU (x) = 0

(a) ReLU is continuous, because it doesn't have any jumps (or) gaps.

The left hand limit and right hand limit are equal at every point including x = 0. i.e.,

$$\lim_{x \to 0^-} \text{ReLU}(x) = \lim_{x \to 0^+} \text{ReLU}(x) = 0$$

$\therefore$ ReLU is continuous every where.

(b) and (c):

ReLU function is not differentiable at x = 0, because the left derivative and right derivative are different.

$$\lim_{x \to 0^-} \frac{d}{dx}\text{ReLU}(x) = 0 \text{ and}$$

$$\lim_{x \to 0^+} \frac{d}{dx}\text{ReLU}(x) = 1$$

(d) ReLU (x) $\neq$ ReLU (ax)

For example consider a = –1

For a positive (x) value

ReLU (x) = x and

$\because$ a = – 1;

ReLU (ax) = ReLU (–x) = 0

Thus options (a) and (c) are correct.

49. Consider the function $f(x)=\frac{x^3}{3}+\frac{7}{2}x^2+10x+\frac{133}{2}$, $x \in [-8,0]$. Which of the following statements is/are correct?

(a) The maximum value of f is attained at x = –5

(b) The minimum value of f is attained at x = –2

(c) The maximum value of f is $\frac{133}{2}$

(d) The minimum value of the derivative of f is attained at $x = -\frac{7}{2}$

49. Ans: (c), (d)

Sol: $f'(x) = \frac{3x^2}{3} + \frac{7}{2}(2)x + 10$

$f'(x) = x^2 + 7x + 10$

$x^2 + 7x + 10 = 0$

$x^2 + 5x + 2x + 10 = 0$

$x(x + 5) + 2(x + 5) = 0$

$(x + 5)(x + 2) = 0$

$x = -2, -5$

$f(-8) = \frac{-512}{3} + \frac{7}{2}(64) - 80 + \frac{133}{2}$

$= 39.83$

$$f(-5)=\frac{-125}{3}+\frac{7}{2}(25)-50+\frac{133}{2}$$
$$=62.33$$
$$f(-2)=-\frac{8}{3}+\frac{7}{4}(4)-20+\frac{133}{2}$$
$$=57.83$$
$$f(0)=\frac{133}{2}=66.5$$

Max value of f(x) in [–8, 0] is $\frac{133}{2}$ and max value occurs at x = 0. Minimum value is attained at x = –8.

Let $g(x)=f'(x)=x^2+7x+10$

$g'(x)=2x+7$

$2x+7=0 \Rightarrow x=-\frac{7}{2}$

$g''(x)=2>0$

$\Rightarrow$ The minimum value the derivative of f is attained at $x=-\frac{7}{2}$

50. Let x_1, x_2, x_3, x_4, x_5 be a system of orthonormal vectors in R^{10}. Consider the matrix $A=x_1x_i^T+\ldots+x_5x_5^T$. Which of the following statements is/are correct?
(a) Singular values of A are also its eigenvalues
(b) Singular values of A are either 0 or 1
(c) Determinant of A is 1
(d) A is invertible

50. Ans: (a), (b)

Sol: $x_1=[1\ 0\ 0.....0]^T$, $x_2=[0\ 1\ 0.....0]^T$,
$x_3=[0\ 0\ 1....0]^T$

$x_4=[0\ 0\ 0\ 1.....0]^T$, $x_5=[0\ 0\ 0\ 0\ 1.....0]^T$

$$\Rightarrow A=\begin{bmatrix}1\ 0\ 0..... \\ 0\ 1\ 0..... \\ 0\ 0\ 1..... \\ 0\ 0\ 0\ 1..... \\ 0\ 0\ 0\ 0\ 1..... \\ 0\ 0\ 0\ 0\ 0\ 1..... \\ 0\ 0..... \\ 0..... \end{bmatrix}$$

A is clearly a diagonal matrix with diagonal entries (1,1,1,1,1,0,0,0,0,0). The eigen values of A are (1,1,1,1,1,0,0,0,0,0). The singular values of a diagonal matrix are simply the absolute values of its diagonal entries. Hence the singular values of A are 0,1 |A| = 0 and A is non-invertible.

51. Let $f: R \to R$ be a twice-differentiable function and suppose its second derivative satisfies $f''(x) > 0$ for all $x \in R$. Which of the following statements is/are ALWAYS correct?
(a) f has a local minima
(b) There does not exist x and y, $x \neq y$, such that $f'(x) = f'(y) = 0$
(c) f has at most one global minimum
(d) f has at most one local minimum

51. Ans: (b), (c), (d)

Sol: →Option (a) is not true always. Functions like e^x, $e^x + x^2$ second derivative is positive but do not have local minima.

→Since $f^{11}(x)>0$ which implies $f^1(x)$ is strictly increasing hence f will have atmost one stationary point.

Option (b) is true

→Since f has atmost one stationary point we can conclude that there is atmost one global minimum and atmost one local minimum.

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500+ SELECTIONS CE : 434 | EE : 61 | ME : 20

52. An $n \times n$ matrix A with real entries satisfies the property: $\|Ax\|^2 = \|x\|^2$, for all $x \in R^n$, where $\| \cdot \|$ denotes the Euclidean norm. Which of the following statements is/are ALWAYS correct?
(a) A must be orthogonal
(b) A = I, where I denotes the identity matrix, is the only solution
(c) The eigenvalues of A are either +1 or –1
(d) A has full rank

52. Ans: (a), (d)

Sol: $\|Ax\|^2 = \|x\|^2 \Rightarrow$ A is orthogonal matrix.

Orthogonal matrix is a full rank matrix. The absolute value of eigen values of orthogonal matrix is equal to 1.

Let $A = \begin{bmatrix} \cos\theta & -\sin\theta \\ \sin\theta & \cos\theta \end{bmatrix}$ be an orthogonal matrix.

The eigen values of the above orthogonal matrix are $\cos\theta \pm i \sin\theta$. The eigen values of orthogonal matrix can be complex.

A = I is not the only solution.

53. Consider designing a linear binary classifier $f(x) = \text{sign}(w^T x + b)$, $x \in R^2$ on the following training data:

$$\text{Class} - 1: \left\{\begin{pmatrix}2\\0\end{pmatrix}, \begin{pmatrix}0\\2\end{pmatrix}, \begin{pmatrix}2\\2\end{pmatrix}\right\}, \text{Class} - 2: \left\{\begin{pmatrix}0\\0\end{pmatrix}\right\}$$

Hard-margin support vector machine (SVM) formulation is solved to obtain w and b.

Which of the following options is/are correct?

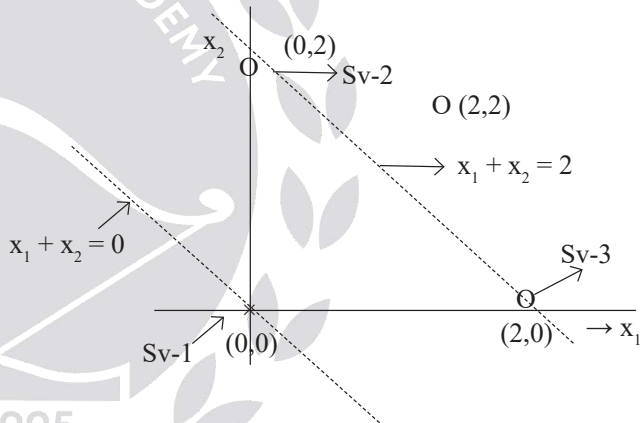
(a) $w = \begin{pmatrix}4\\4\end{pmatrix}$ and b = 1
(b) The number of support vectors is 3
(c) The margin is $\sqrt{2}$
(d) Training accuracy is 98%

53. Ans: (b), (c)

Sol: The given data set is,

x_1	x_2	y
2	0	class -1
0	2	class -1
2	2	class -1
0	0	class -2

A clear separability between class-1 and class-2 is possible with the training set in hard margin SVM. Thus the training accuracy in hard margin SVM is 100%. Thus, option (d) is incorrect



Identifying the data observation with their class labels on the feature space as shown above gives 3- support vectors. Thus, option (b) is correct.

In hard margin SVM, the necessary and sufficient condition is,

$y^{(i)} (W^T x^{(i)} + b) \geq 0$ for all data examples.

If we consider class-1 as +1 and class-0 as -1 the above condition fails at $\begin{bmatrix}0\\0\end{bmatrix}$.

Thus, $W = \begin{bmatrix}4\\4\end{bmatrix}$ & b = 1 are not the model parameters

$\therefore$ option (a) is incorrect

Here, the decision boundary is the line which is exactly in between the lines;

$x_1 + x_2 = 0$ & $x_1 + x_2 = 2$ (refer the above figure)

i.e.,

$x_1 + x_2 = 1 \Rightarrow W_1 = 1, W_2 = 1$

$$\therefore \text{Margin} = \frac{2}{\|W\|} = \frac{2}{\sqrt{1^2+1^2}} = \frac{2}{\sqrt{2}} = \sqrt{2}$$

$\therefore$ Option (c) is correct answer.

54. Consider a coin-toss experiment where the probability of head showing up is p. In the i^{th} coin toss, let $X_i = 1$ if head appears, and $X_i = 0$ if tail appears. Consider

$$\hat{p} = \frac{1}{n}\sum_{i=1}^{n} X_i$$

where n is the total number of independent coin tosses.

Which of the following statements is/are correct?

(a) $E[\hat{p}] = p$

(b) $E[\hat{p}] = \frac{p}{n}$

(c) As n increases, variance of $\hat{p}$ decreases

(d) Variance of $\hat{p}$ does not depend on n

54. Ans: (a), (c)

Sol: X_i is a Bernoulli random variable.

X_i	0	1
$P(X_i)$	1–P	P

$E[X_i] = 0(1–P) + 1(P) = P$

$E[X_i] = P$

$E[X_i^2] = 0^2(1-P) + 1^2(P) = P$

$Var(X_i) = P - P^2 = P(1–P)$

$$\hat{P} = \frac{1}{n}\sum_{i=1}^{n} X_i$$

$$E[\hat{P}] = \frac{1}{n}\sum_{i=1}^{n} E[X_i] = \frac{1}{n}\sum_{i=1}^{n} P = \frac{1}{n}(np) = P$$

$$Var(\hat{P}) = Var\left(\frac{1}{n}\sum_{i=1}^{n} X_i\right) = \frac{1}{n^2}\sum_{i=1}^{n} var(X_i)$$

$$Var(\hat{P}) = \frac{1}{n^2} nP(1-P) = \frac{P(1-P)}{n}$$

55. Consider a two-class problem in R^d with class labels red and green. Let μ_{red} and μ_{green} be the means of the two classes. Given test sample $x \in R^d$, a classifier calculates the squared Euclidean distance (denoted by $\|.\|^2$) between x and the means of the two classes and assigns the class label that the sample x is closest to. That is, the classifier computes

$$f(x) = \|\mu_{red} - x\|^2 - \|\mu_{green} - x\|^2$$

and assigns the label red to x if $f(x) < 0$, and green otherwise. Which of the following statements is/are correct?

(a) The sample x = 0 is assigned the label green if $\|\mu_{red}\| < \|\mu_{green}\|$

(b) f is a linear function of x

(c) $f(x) = w^T x + b$, where w and b are functions of μ_{red} and μ_{green}

(d) f is a quadratic polynomial in x

55. Ans: (b), (c)

Sol: The classifier assigns a test point x to a class based on squared euclidean distance from the means u_{red} and u_{green}

Given,

$$f(x) = \|\mu_{red} - x\|^2 - \|\mu_{green} - x\|^2 \quad ...(i)$$

where

$$\|\mu - x\|^2 = (\mu - x)^T(\mu - x) \quad ...(ii)$$

$$\therefore f(x) = (\mu_{red} - x)^T(\mu_{red} - x) - (\mu_{green} - x)^T(\mu_{green} - x)$$

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$= \mu_{red}^T \mu_{red} - 2\,x^T \mu_{red} + x^T x$

$-\left(\mu_{green}^T \mu_{green} - 2x^T \mu_{green} + x^T x\right)$

$f(x) = \left(\mu_{red}^T \mu_{red} - \mu_{green}^T \mu_{green}\right) + 2x^T\left(\mu_{green} - \mu_{red}\right) \ldots (iii)$

Option (a):

If $x = 0$; and $\|\mu_{red}\| < \|\mu_{green}\|$ then

$f(0) = \mu_{red}^T \mu_{red} - \mu_{green}^T \mu_{green}$

$\because \|\mu_{red}\| < \|\mu_{green}\|$; $f(0)$ is negative

$\because f(0)$ is a negative value, the classifier assigns red, thus option (a) is incorrect.

Options (b) & (c):

In expression (iii), we can say that,

$\mu_{red}^T \mu_{red} - \mu_{green}^T \mu_{green} = b$ &

$2\left(\mu_{green} - \mu_{red}\right) = W$

Thus $f(x) = x^T W + b$ (or)

It also matches with the form $f(x) = W^T x + b$, which is linear.

Thus, options (b) & (c) both are correct

Option (d):

A quadratic function must contain $x^T x$ term, which is absent in expression (iii). Thus, option (d) is incorrect.

56. Consider the following two relations, named Customer and Person, in a database:

```
Person (
    aadhaar CHAR(12) PRIMARY KEY,
    name VARCHAR(32));
Customer (
    name VARCHAR(32),
    email VARCHAR(32) PRIMARY KEY,
    phone CHAR(10),
    aadhaar CHAR(12),
        FOREIGN KEY (aadhaar) REFERENCES
                        Person(aadhaar));
```

Which of the following statements is/are correct?

(a) aadhaar is a candidate key in the Customer relation

(b) phone can be NULL in the Customer relation

(c) aadhaar is a candidate key in the Person relation

(d) aadhaar can be NULL in the Person relation

56. Ans: (b), (c)

Sol: As there is no constraint on phone then it can allow null values.

Aadhar is primary key in person is definitely a candidate key which will not allow null values.

As email is primary key in customer then aadhar is not a candidate key [A person may have multiple emails but only one aadhar in such case there will duplicates in aadhar]

57. Consider a database relation R with attributes ABCDEFG, and having the following functional dependencies:

$A \rightarrow BCEF$ $\quad E \rightarrow DG$ $\quad BC \rightarrow A$

Which of the following statements is/are correct?

(a) A is the only candidate key of R

(b) A, BC are the candidate keys of R

(c) A, BC, E are the candidate keys of R

(d) Relation R is not in Boyce-Codd Normal Form (BCNF)

57. Ans: (b), (d)

Sol: $A^+ = ABCDEFG$

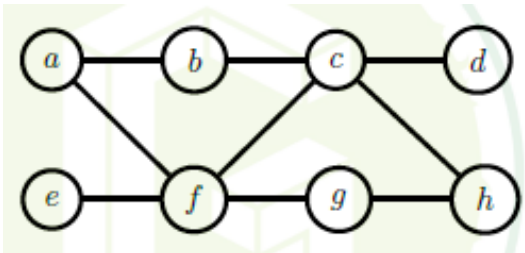
$E^+ = EDG$

$BC^+ = BCADEFG$

A, BC are candidate key's of the relation.

$E \rightarrow DG$ is transitive dependency, R is in 2NF but not in 3NF and BCNF.

58. Let G be a simple, unweighted, and undirected graph. A subset of the vertices and edges of G are shown below.



It is given that a – b – c – d is a shortest path between a and d; e – f – g – h is a shortest path between e and h; a–f –c–h is a shortest path between a and h. Which of the following is/are NOT the edges of G?

(a) (b, d) (b) (b, g)
(c) (b, h) (d) (e, g)

58. Ans: (a), (c), (d)

Sol:

(a) If <b, d> edge present then shortest path from a to d will become a – b – d but it is given that shortest path is

a – b – c – d

(c) if <b, h> edge present in the graph than shortest path from a to h will become a – b – h but it is given that a – f – c – h

(d) If <e,g> edge present then shortest path is e – g – h but it is given that shortest path e – f – g – h

59. Let $f : R \to R$ be such that $|f(x) - f(y)| \le (x - y)^2$ for all $x, y \in R$. Then $f(1) - f(0) =$_____ (Answer in integer)

59. Ans: (Range 0 to 0)

Sol: The only function which satisfies the given condition is $f(x) = K$

$f(1) = K,\ f(0) = K$

$\Rightarrow f(1) - f(0) = K - K = 0$

60. Let $D = \{x^{(1)}; \ldots, x^{(n)}\}$ be a dataset of n observations where each $x^{(i)} \in R^{100}$. It is given that $\sum_{i=1}^{n} x^{(i)} = 0$. The covariance matrix computed from D has eigenvalues $\lambda_i = 100^{2-i}$, $1 \le i \le 100$. Let $u \in R^{100}$ be the direction of maximum variance with $u^T u = 1$. The value of $\frac{1}{n}\sum_{i=1}^{n}(u^T x^{(i)})^2 =$_____ (Answer in integer)

60. Ans: (Range 100 to 100)

Sol: Given data set,

$D = \{x^{(1)}, x^{(2)}, \ldots x^{(n)}\}$ where $x^{(i)} \in R^{100}$

The centroid of the data set,

$$\bar{x} = \sum_{i=1}^{n} x^{(i)} = 0 \quad \ldots(i)$$

and also given that

$\lambda_i = 100^{2-i},\ 1 \le i \le 100$ ....(ii)

gives the eigen value of i^{th} dimension.

$u \in R^{100}$ defines the direction of the maximum variance i.e., the first principal comoponent.

As $u^T u = 1$, it indicates that 'u' is an unit eigen vector.

In PCA, The 'maximum eigen value' is a measure of the maximum variance in it's corresponding eigen vector direction.

From expression (ii), we can say that

The maximum possible eigen value is at i = 1

$\therefore$ The eigen value corresponding to $u = 100^{2-1} = 100$

Here, we need to obtain

$$\frac{1}{n}\sum_{i=1}^{n}(u^T x^{(i)})^2.$$

The emperical variance of the data set is given as,

$$\frac{1}{n}\sum_{i=1}^{n}(x^{(i)}-\bar{x})^2 \quad ....(iii)$$

From expression (i), it be comes

$$\frac{1}{n}\sum_{i=1}^{m}(x^{(i)})^2 \ (\because \bar{x}=0)$$

$\because$ u is a unit vector $u^Tx^{(i)}$ represents the projection of $x^{(i)}$ in the direction of u.

In a similar lines, $\frac{1}{n}\sum_{i=1}^{n}(u^Tx^{(i)})^2$ results the emperical variance in the direction of u.

Thus,

$\frac{1}{n}\sum_{i=1}^{n}(u^Tx^{(i)})^2 =$ The eigen value in the direction of maximum variance (or) in the direction of u

$$\therefore \frac{1}{n}\sum_{i=1}^{n}(u^Tx^{(i)})^2 = 100$$

61. A bag contains 5 white balls and 10 black balls. In a random experiment, n balls are drawn from the bag one at a time with replacement. Let S_n denote the total number of black balls drawn in the experiment. The expectation of S_{100} denoted by $E[S_{100}] =$ _____ (Round off to one decimal place)

61. Ans: (Range 66.6 to 66.7)

Sol: Probability of drawing a black ball $= \frac{10}{15} = \frac{2}{3}$

S_{100} is a binomial random variable with parameters $n = 100,\ P = \frac{2}{3}$

$$E[S_{100}] = np = 100\left(\frac{2}{3}\right) = 66.666 \approx 66.7$$

62. Consider the following tables, Loan and Borrower, of a bank.

Loan		
loan_number	**branch_name**	**amount**
L11	Banjara Hills	90000
L14	Kondapur	50000
L15	SR Nagar	40000
L22	SR Nagar	25000
L23	Balanagar	80000
L25	Kondapur	70000
L19	SR Nagar	65000

Borrower	
customer_name	**loan_num**
Anand	L11
Karteek	L11
Karteek	L14
Ankita	L15
Gopal	L19
Karteek	L22
Karteek	L23
Sunil	L23
Sunil	L25

Query: $\pi_{branch\_name,\ customer\_name}$ (Loan⋈Borrower)÷ π_{branch_name}(Loan) where ⋈ denotes natural join.

The number of tuples returned by the above relational algebra query is _____ (Answer in integer)

62. Ans: (Range 1 to 1)

Sol: The output of II branch, name, customer name (Loan ∞ Borrower) is

Branch name	Customer Name
Banjarahills	Anand
Banjara hills	karteek
Kondapur	Karteek
SR nagar	Ankita
SR Nagar	Karteek
Bala nagar	Karteek
Bala nagar	Sunil
Kondapur	Sunil
SR nagar	Gopal

Final query returns customer name who have loan in all the branches i.e Karteek.

63. Consider the following Python code snippet.

```
def f(a,b):
    if (a= =0):
        return b
    if (a%2= =1):
        return 2*f((a−1),b)
    return b+f (a−1)/2,b)
print(f(15,10))
```

The value printed by the code snippet is _____
(Answer in integer)

63. Ans: (Range 160 to 160)

Sol: Step-by-step evaluation of f(15, 10)

we start with f (15, 10) :

Step 1 : a -15, b -10

15 is odd so we use:

$f(15, 10) = 2 \times f((15 - 1)/2, 10) = 2 \times f(7,10)$

Step 2 : a -7, b -10

7 is odd so:

$f(7, 10) = 2 \times f((7 - 1)/2, 10) = 2 \times f(3,10)$

Step 3 : a -3, b -10

3 is odd so:

$f(3, 10) = 2 \times f((3 - 1)/2, 10) = 2 \times f(1,10)$

Step 4 : a -1, b -10

1 is odd so:

$f(1, 10) = 2 \times f((1 - 1)/2, 10) = 2 \times f(0,10)$

Step 5 : a = 0 , b = 10

Base case : f(0, 10) = 10

Back-substituting the values

Now, we backtrack:

1. f(0, 10) = 10
2. f(1–10) = 2× 10 = 20
3. f(3–10) = 2× 20 = 40
4. f(7–10) = 2× 40 = 80
5. f(15–10) = 2× 80 = 160

64. Consider the following pseudocode.

```
Create empty stack S
Set x=0, flag=0, sum=0
Push x onto S
while (S is not empty){
    if (flag equals 0){
      Set x = x+1
      Push x onto S}
    if (x equals 8):
      Set flag=1
   if (flag equals 1){
      x = Pop(S)
  if (x is odd):
     Pop(S)
 Set sum = sum + x}
}
Output sum
```

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AIR 10

AKSHAY VIDHATE

TOTAL 36 SELECTIONS IN TOP 10

CE: 09 | ME: 10 | EE: 08 | E&T: 09

The value of output by a program executing the above pseudocode is_____ (Answer in integer)

64. Ans: (Range 24 to 24)

Sol: Step 1: Initialization

- Create an empty stack S.
- Variables:
  - x = 0
  - flag = 0
  - sum = 0
  - Push x onto S S = [0].

Step 2: First While Loop (Pushing into Stack)

While flag = 0, we increment x and push it onto S.

Iteration	X	Stack S After Push
1	1	[0,1]
2	2	[0,1,2]
3	3	[0,1,2,3]
4	4	[0,1,2,3,4]
5	5	[0,1,2,3,4,5]
6	6	[0,1,2,3,4,5,6]
7	7	[0,1,2,3,4,5,6,7]
8	8	[0,1,2,3,4,5,6,7,8]

At x = 8, flag is set to 1 (stop pushing).

Step 3: Second While Loop (Popping from Stack)

Now, we pop elements from S and update sum.

If x is odd, pop again immediately whithout adding to sum.

Otherwise, add x to sum.

Popped x	Stack After Pop	Action Taken
8	[0,1,2,3,4,5,6,7]	Add 8 to sum
7	[0,1,2,3,4,5,6]	7 is odd→Pop again
6	[0,1,2,3,4,5]	Add 6 to sum
5	[0,1,2,3,4]	5 is odd→Pop again
4	[0,1,2,3]	Add 4 to sum
3	[0,1,2]	3 is odd→Pop again
2	[0,1]	Add 2 to sum
1	[0]	1 is odd→Pop again
0	[]	Add 4 (CORRECTION)

65. Consider a directed graph G = (VE), where V = {0, 1, 2, ...,100} and E = {(i, j) : $0 < j - i \leq 2$ for all i, j∈V}. Suppose the adjacency list of each vertex is in decreasing order of vertex number, and depth-first search (DFS) is performed at vertex 0. The number of vertices that will be discovered after vertex 50 is_____ (Answer in integer).

65. Ans: (Range 75 to 75)

Sol: We are given a directed graph G = (V, E) where:

- Vertices: V = {0, 1, 2, ...,100}
- Edges: E = {(i, j)|$0 < j - i \leq 2$}

  This means each vertex i has directed edges to:
  - i + 1
  - i+2 (if they exist)
- The adjacency list is in decreasing order, meaning:

From i, DFS explores i+2 before i+1.

Setp 2: Dfs Traversal Order

1. Starting at vertex 0:

- DFS first explores 0→02→4→6→...→100 (taking the larger-numbered neighbor first).
- All even-numbered vertices are visited first.

2. Backtracking from 100:

- DFS will now visit all odd-numbered vertices in decreasing order:
- 999795...→1

Step 3: Counting Vertices Discovered After Vertex 50

- DFS reaches vertex 50 while exploring even numbers
- After reaching 100. DFS backtracks and discovers all odd-numbered vertices.
- The vertices discovered after 50 are:
  - Even numbers from 52 to 100.
  - All odd numbers from 99 to 1.

Counting the Discovered Vertices

Even numbers from 52 to 100:

- Sequence: 52, 54, 56, ...,100
- Arithmetic progression with:
  - First term a = 52
  - Common difference d = 2
  - Last team $l = 100$
  - Number of terms:

$$n = \frac{100-52}{2} + 1 + \frac{48}{2} + 1 = 25$$

Odd numbers from 99 to 1:

- Sequence: 99, 97, 95, ...1
- Arithmetic progression with:
  - First term a=99
  - Common difference d = −2
  - last term $l = 1$
  - Number of terms:

$$n = \frac{99-1}{2} + 1 + \frac{98}{2} + 1 = 50$$

Total Count

25(even numbers) + 55 (odd numbers) = 75.

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