SELECTED H.O.T.S. QUESTIONS
FROM CBSE 2025 EXAMINATIONS

Unit I - Relations & Functions

Relations and Functions; Inverse Trig. Functions

01. For real x, let $f(x)=x^3+5x+1$. Then

    (a) f is one-one but not onto on $\mathbb{R}$
    (b) f is onto on $\mathbb{R}$ but not one-one
    (c) f is one-one and onto on $\mathbb{R}$
    (d) f is neither one-one nor onto on $\mathbb{R}$

02. If $f:N\to W$ is defined as $f(n)=\begin{cases}\frac{n}{2}, \text{ if } n \text{ is even}\\ 0, \text{ if } n \text{ is odd}\end{cases}$. Then f is

    (a) injective only
    (b) surjective only
    (c) a bijection
    (d) neither surjective nor injective

03. If R be a relation defined as $a\,R\,b$ iff $|a-b|>0$; $a, b\in\mathbb{R}$, then R is

    (a) reflexive (b) symmetric (c) transitive (d) symmetric and transitive

***Direction :** Following Questions are Assertion (A) and Reason (R) based carrying **1 mark** each. Two statements are given, one labeled Assertion (A) and other labeled Reason (R). Select the correct answer from the options given below.*

(a) Both Assertion (A) and Reason (R) are true and Reason (R) is the correct explanation of Assertion (A).
(b) Both Assertion (A) and Reason (R) are true and Reason (R) is **not** the correct explanation of Assertion (A).
(c) Assertion (A) is true but Reason (R) is false.
(d) Assertion (A) is false but Reason (R) is true.

04. **Assertion (A) :** Let Z be the set of integers. A function $f:Z\to Z$ defined as $f(x)=3x-5$, $\forall x\in Z$ is a bijective.

    Reason (R) : A function is a bijective if it is both surjective and injective.

05. **Assertion (A) :** Let $A=\{x\in\mathbb{R}:-1\le x\le 1\}$. If $f:A\to A$ be defined as $f(x)=x^2$, then f is not an onto function.

    Reason (R) : If $y=-1\in A$, then $x=\pm\sqrt{-1}\notin A$.

06. **Assertion (A) :** Let $f(x)=e^x$ and $g(x)=\log x$. Then $(f+g)x=e^x+\log x$, where domain of $(f+g)$ is $\mathbb{R}$.

    Reason (R) : $\text{Dom.}(f+g)=\text{Dom.}(f)\cap\text{Dom.}(g)$.

07. Let R be a relation defined over N, where N is set of natural numbers, defined as "$m\,R\,n$ if and only if m is a multiple of n; $m, n\in N$." Find whether R is reflexive, symmetric and transitive or not.

08. Prove that $f:N\to N$ defined as $f(x)=ax+b$, $(a, b\in N)$ is one-one but not onto.

09. If $f:\mathbb{R}^+\to\mathbb{R}$ is defined as $f(x)=\log_a x$, $(a>0$ and $a\ne 1)$, prove that f is a bijection.

    ($\mathbb{R}^+$ is a set of all positive real numbers.)

10. Let $A=\{1, 2, 3\}$ and $B=\{4, 5, 6\}$. A relation R from A to B is defined as $R=\{(x, y): x+y=6, x\in A, y\in B\}$.

    (i) Write all elements of R.

(ii) Is R a function? Justify.

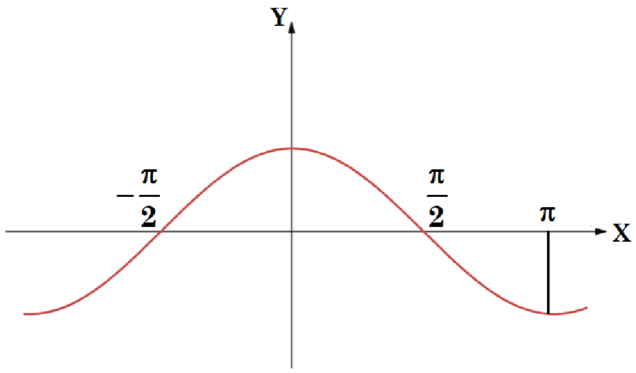
(iii) Determine domain and range of R.

11. A student wants to pair up natural numbers in such a way that they satisfy the equation $2x+y=41;\ x,\ y\in N$. Find the domain and range of the relation. Check if the relation thus formed is reflexive, symmetric and transitive. Hence, state whether it is an equivalence relation or not.

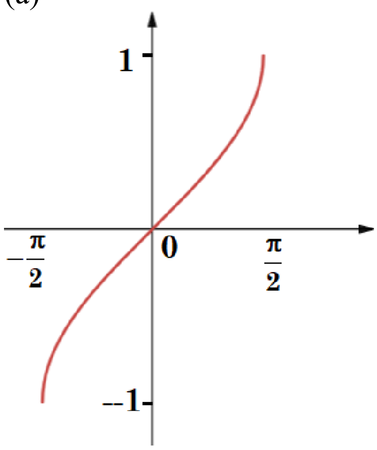
12. Show that the function $f:\mathbb{R}\to\mathbb{R}$ defined by $f(x)=4x^3-5,\ \forall\, x\in\mathbb{R}$ is one-one and onto.

13. Let R be a relation defined on a set N of natural numbers such that $R=\{(x,\ y): xy$ is a square of a natural number; $x,\ y\in N\}$. Determine if the relation R is an equivalence relation.

14. The graph of a trigonometric function is as shown. Which of the following will represent graph of its inverse? *Assume that the given function is made invertible after domain restrictions.*



(a)



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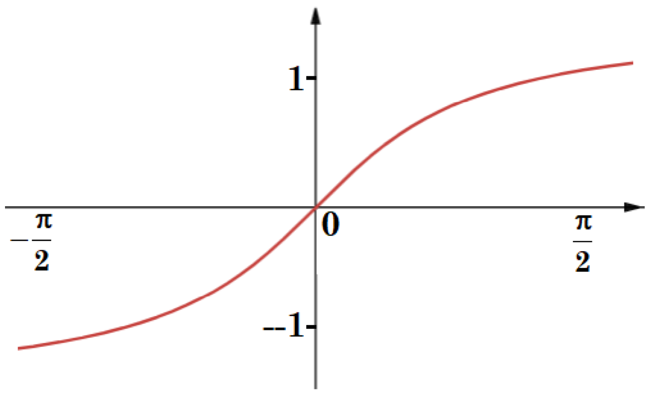

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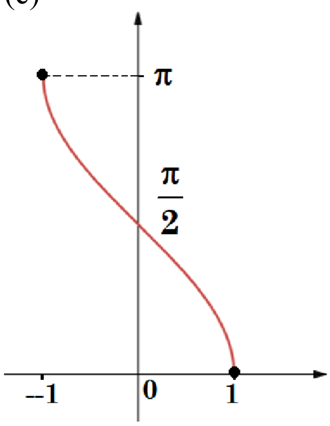

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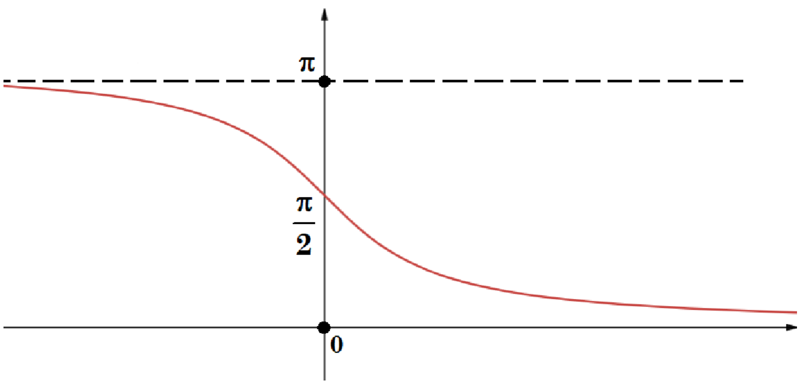
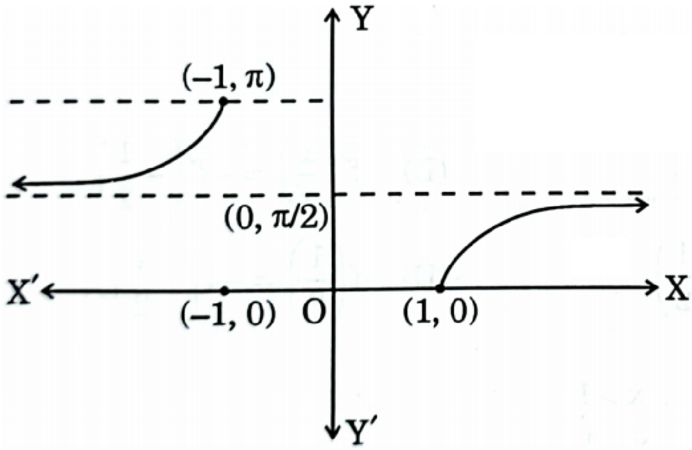
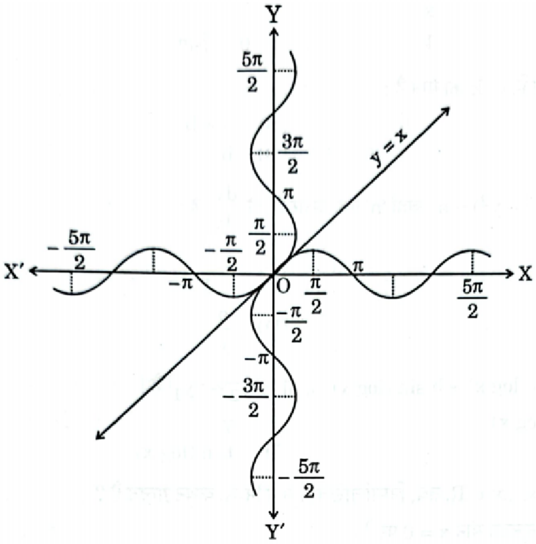


15. The given graph illustrates



(a) $y = \sec^{-1} x$ (b) $y = \cot^{-1} x$ (c) $y = \tan^{-1} x$ (d) $y = \text{cosec}^{-1} x$

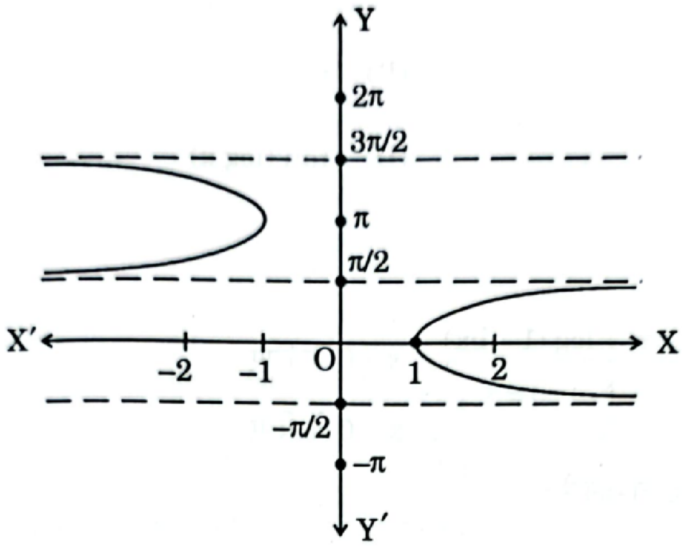
16. The following graph is a combination of



(a) $y = \sin^{-1} x$ and $y = \cos^{-1} x$ (b) $y = \cos^{-1} x$ and $y = \cos x$

(c) $y = \sin^{-1} x$ and $y = \sin x$ (d) $y = \cos^{-1} x$ and $y = \sin x$

17. The graph shown below depicts



(a) $y = \sec^{-1} x$ (b) $y = \sec x$ (c) $y = \text{cosec}^{-1} x$ (d) $y = \text{cosec}\, x$

18. Domain of $f(x) = \cos^{-1} x + \sin x$ is

(a) $\mathbb{R}$ (b) $(-1, 1)$ (c) $[-1, 1]$ (d) ϕ

19. Domain of $\sin^{-1}(2x^2-3)$ is

(a) $(-1, 0)\cup(1, \sqrt{2})$ (b) $(-\sqrt{2}, -1)\cup(0, 1)$

(c) $[-\sqrt{2}, -1]\cup[1, \sqrt{2}]$ (d) $(-\sqrt{2}, -1)\cup(1, \sqrt{2})$

20. If $y=\sin^{-1}x$, $-1\le x\le 0$, then the range of y is

(a) $\left(-\frac{\pi}{2}, 0\right)$ (b) $\left[-\frac{\pi}{2}, 0\right]$ (c) $\left[-\frac{\pi}{2}, 0\right)$ (d) $\left(-\frac{\pi}{2}, 0\right]$

21. The principal value of $\sin^{-1}\left(\cos\frac{43\pi}{5}\right)$ is

(a) $-\frac{7\pi}{5}$ (b) $-\frac{\pi}{10}$ (c) $\frac{\pi}{10}$ (d) $\frac{3\pi}{5}$

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(c) Assertion (A) is true but Reason (R) is false.
(d) Assertion (A) is false but Reason (R) is true.

22. **Assertion (A) :** Set of values of $\sec^{-1}\left(\frac{\sqrt{3}}{2}\right)$ is a null set.

Reason (R) : $\sec^{-1}x$ is defined for $x\in\mathbb{R}-(-1, 1)$.

23. Find domain of $\sin^{-1}\sqrt{x-1}$.

24. Find the domain of $\sec^{-1}(2x+1)$.

25. Find the domain of $f(x)=\sin^{-1}(-x^2)$.

26. Find the domain of $\sin^{-1}(x^2-3)$.

27. Find the domain of the function $f(x)=\cos^{-1}(x^2-4)$.

28. Solve for x : $2\tan^{-1}x+\sin^{-1}\left(\frac{2x}{1+x^2}\right)=4\sqrt{3}$.

29. Simplify $\sin^{-1}\left(\frac{x}{\sqrt{1+x^2}}\right)$.

30. A class-room teacher is keen to assess the learning of her students on the concept of "relations" taught to them. She writes the following five relations each defined on the set $A=\{1, 2, 3\}$.

$R_1=\{(2, 3), (3, 2)\}$

$R_2=\{(1, 2), (1, 3), (3, 2)\}$

$R_3=\{(1, 2), (2, 1), (1, 1)\}$

$R_4=\{(1, 1), (1, 2), (3, 3), (2, 2)\}$

$R_5=\{(1, 1), (1, 2), (3, 3), (2, 2), (2, 1), (2, 3), (3, 2)\}$

The students are asked to answer the following questions about the above relations.

(i) Identify the relation which is reflexive, transitive but not symmetric.
(ii) Identify the relation which is reflexive and symmetric but not transitive.
(iii) (a) Identify the relations which are symmetric but neither reflexive nor transitive.

OR

(iii) (b) What pairs should be added to the relation R_2 to make it an equivalence relation?

31. A school is organizing a debate competition with participants as speakers $S = \{S_1, S_2, S_3, S_4\}$ and these are judged by judges $J = \{J_1, J_2, J_3\}$. Each speaker can be assigned one judge. Let R be a relation from S to J defined as $R = \{(x, y) : \text{speaker } x \text{ is judged by judge } y;\ x \in S,\ y \in J\}$.

Based on the above, answer the following.
(i) How many relations can be there from S to J?
(ii) A student identifies a function from S to J as $f = \{(S_1, J_1), (S_2, J_2), (S_3, J_2), (S_4, J_3)\}$.
Check if it is bijective.
(iii) (a) How many one-one functions can be there from set S to set J?

OR

(iii) (b) Another student considers a relation $R_1 = \{(S_1, S_2), (S_2, S_4)\}$ in set S. Write minimum ordered pairs to be included in R_1 so that R_1 is reflexive but not symmetric.

32. Let A be the set of 30 students of class XII in a school. Let $f : A \to N$, N is a set of natural numbers such that function $f(x) = \text{Roll Number of student } x$.

On the basis of the above information, answer the following questions.
(i) Is f a bijective function?
(ii) Give reasons to support your answer to **(i)**.
(iii) (a) Let R be a relation defined by the teacher to plan the seating arrangement of students in pairs, where $R = \{(x, y) : x, y \text{ are Roll Numbers of students such that } y = 3x\}$.
List all the elements of R. Is the relation R reflexive, symmetric and transitive? Justify your answer.

OR

(iii) (b) Let R be a relation defined by $R = \{(x, y) : x, y \text{ are Roll Numbers of students such that } y = x^3\}$. List the elements of R. Is R a function? Justify your answer.

Unit II - *Algebra*

Matrices; Determinants

01. If $A = \begin{bmatrix} -1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix}$, then A^{-1} is

(a) $\begin{bmatrix} -1 & 0 & 0 \\ 0 & -1 & 0 \\ 0 & 0 & -1 \end{bmatrix}$ (b) $\begin{bmatrix} 1 & 0 & 0 \\ 0 & -1 & 0 \\ 0 & 0 & -1 \end{bmatrix}$ (c) $\begin{bmatrix} -1 & 0 & 0 \\ 0 & -1 & 0 \\ 0 & 0 & 1 \end{bmatrix}$ (d) $\begin{bmatrix} -1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix}$

02. Let $A=\begin{bmatrix}1 & -2 & -1\\ 0 & 4 & -1\\ -3 & 2 & 1\end{bmatrix}$, $B=\begin{bmatrix}-2\\ -5\\ -7\end{bmatrix}$, $C=\begin{bmatrix}9 & 8 & 7\end{bmatrix}$, which of the following is defined?
(a) Only AB (b) Only AC (c) Only BA (d) All AB, AC and BA

03. If $A=\begin{bmatrix}7 & 0 & x\\ 0 & 7 & 0\\ 0 & 0 & y\end{bmatrix}$ is a scalar matrix, then y^x is equal to
(a) 0 (b) 1 (c) 7 (d) ± 7

04. If A and B are two square matrices of the same order, then $(A+B)(A-B)$ is equal to
(a) $A^2-AB+BA-B^2$ (b) $A^2+AB-BA-B^2$
(c) $A^2-AB-BA-B^2$ (d) $A^2-B^2+AB+BA$

05. If A and B are invertible matrices, then which of the following is **not** correct?
(a) $(A+B)^{-1}=B^{-1}+A^{-1}$ (b) $(AB)^{-1}=B^{-1}A^{-1}$
(c) $adj.(A)=|A|A^{-1}$ (d) $|A|^{-1}=|A^{-1}|$

06. Let A be a matrix of order $m\times n$ and B is matrix such that A^TB and BA^T are defined. Then, the order of B is
(a) $m\times m$ (b) $n\times n$ (c) $m\times n$ (d) $n\times m$

07. Let $A=\left[a_{ij}\right]$ be a square matrix of order 3 such that $a_{ij}=j-2i$. Then which of the following is true?
(a) $a_{12}>0$ (b) all $a_{ij}<0$ (c) $a_{13}+a_{31}=-6$ (d) $a_{23}>a_{32}$

08. Sum of two skew-symmetric matrices of same order is always a/an
(a) skew-symmetric matrix (b) symmetric matrix
(c) null matrix (d) identity matrix

09. The system of linear equations is represented as $AX=B$, where A is coefficient matrix, X is variable matrix and B is the constant matrix. Then the system of equations
(a) is consistent, if $|A|\neq 0$, solution is given by $X=BA^{-1}$
(b) is inconsistent, if $|A|=0$ and $(adj\,A)B=O$
(c) is inconsistent, if $|A|\neq 0$
(d) may or may not be consistent, if $|A|=0$ and $(adj\,A)B=O$

10. If $A=\begin{bmatrix}1 & 12 & 4y\\ 6x & 5 & 2x\\ 8x & 4 & 6\end{bmatrix}$ is a symmetric matrix, then $(2x+y)$ is
(a) -8 (b) 0 (c) 6 (d) 8

11. Four friends Abhay, Bina, Chhaya and Devesh were asked to simplify $4AB+3(AB+BA)-4BA$, where A and B are both matrices of order 2×2. It is known that $A\neq B\neq I$ and $A^{-1}\neq B$.
Their answers are given as

Abhay	: $6AB$
Bina	: $7AB-BA$
Chhaya	: $8AB$
Devesh	: $7BA-AB$

Who answered it correctly?

(a) Abhay (b) Bina (c) Chhaya (d) Devesh

12. If A and B are square matrices of order m such that $A^2 - B^2 = (A-B)(A+B)$, then which of the following is always correct?

(a) $A = B$ (b) $AB = BA$ (c) $A = O$ or $B = O$ (d) $A = I$ or $B = I$

13. Let P be a skew-symmetric matrix of order 3. If $\det(P) = \alpha$, then $(2025)^{\alpha}$

(a) 0 (b) 1 (c) 2025 (d) $(2025)^3$

14. If M and N are square matrices of order 3 such that $\det(M) = m$ and $MN = mI$, then $\det(N)$ is equal to

(a) –1 (b) 1 (c) $-m^2$ (d) m^2

15. The matrix $\begin{bmatrix} 0 & 1 & -2 \\ -1 & 0 & -7 \\ 2 & 7 & 0 \end{bmatrix}$ is a

(a) diagonal matrix (b) symmetric matrix
(c) skew symmetric matrix (d) scalar matrix

16. If $\begin{vmatrix} -1 & 2 & 4 \\ 1 & x & 1 \\ 0 & 3 & 3x \end{vmatrix} = -57$, the product of the possible values of x is

(a) –24 (b) –16 (c) 16 (d) 24

17. If A and B are invertible matrices of order 3×3 such that $\det(A) = 4$ and $\det[(AB)^{-1}] = \dfrac{1}{20}$, then $\det(B)$ is equal to

(a) $\dfrac{1}{20}$ (b) $\dfrac{1}{5}$ (c) 20 (d) 5

18. If $A = \begin{bmatrix} 5 & 0 & 0 \\ 0 & 5 & 0 \\ 0 & 0 & 5 \end{bmatrix}$, then A^3 is

(a) $3\begin{bmatrix} 5 & 0 & 0 \\ 0 & 5 & 0 \\ 0 & 0 & 5 \end{bmatrix}$ (b) $\begin{bmatrix} 125 & 0 & 0 \\ 0 & 125 & 0 \\ 0 & 0 & 125 \end{bmatrix}$ (c) $\begin{bmatrix} 15 & 0 & 0 \\ 0 & 15 & 0 \\ 0 & 0 & 15 \end{bmatrix}$ (d) $\begin{bmatrix} 5^3 & 0 & 0 \\ 0 & 5 & 0 \\ 0 & 0 & 5 \end{bmatrix}$

19. If $A = \begin{bmatrix} 1 & 2 & 3 \\ -4 & 3 & 7 \end{bmatrix}$ and $B = \begin{bmatrix} 4 & 3 \\ -1 & 2 \\ 0 & 5 \end{bmatrix}$, then the correct statement is

(a) Only AB is defined (b) Only BA is defined
(c) AB and BA, both are defined (d) AB and BA, both are not defined

20. If $A = [a_{ij}]$ is a 3×3 diagonal matrix such that $a_{11} = 1$, $a_{22} = 5$ and $a_{33} = -2$, then $|A|$ is

(a) 0 (b) –10 (c) 10 (d) 1

21. If $\begin{bmatrix} 2x-1 & 3x \\ 0 & y^2-1 \end{bmatrix} = \begin{bmatrix} x+3 & 12 \\ 0 & 35 \end{bmatrix}$, then the value of $(x-y)$ is

(a) 2 or 10 (b) –2 or 10 (c) 2 or –10 (d) –2 or –10

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(c) Assertion (A) is true but Reason (R) is false.
(d) Assertion (A) is false but Reason (R) is true.

22. **Assertion (A) :** $A = \text{diag}\begin{bmatrix}3 & 5 & 2\end{bmatrix}$ is a scalar matrix of order 3×3.

Reason (R) : If a diagonal matrix has all non-zero elements equal, it is known as a scalar matrix.

23. Using matrices and determinants, find the value (s) of k for which the pair of equations $5x - ky = 2$, $7x - 5y = 3$ has a unique solution.

24. If $A = \begin{bmatrix} 2 & -2 \\ -2 & 2 \end{bmatrix}$ and $A^2 = kA$, then find the value of k.

25. Let $A = \begin{bmatrix} 1 \\ 4 \\ -2 \end{bmatrix}$ and $C = \begin{bmatrix} 3 & 4 & 2 \\ 12 & 16 & 8 \\ -6 & -8 & -4 \end{bmatrix}$ be two matrices. Then, find the matrix B, if $AB = C$.

26. If $A = \begin{bmatrix} 1 & -1 & 0 \end{bmatrix}$, $B = \begin{bmatrix} 2 & 0 & 1 \\ -1 & 3 & 4 \\ 0 & 5 & 1 \end{bmatrix}$ and $C = \begin{bmatrix} 2 \\ 3 \\ 4 \end{bmatrix}$, are three matrices, then find ABC.

27. Let $2x + 5y - 1 = 0$ and $3x + 2y - 7 = 0$ represent the equations of two lines on which the ants are moving on the ground. Using matrix method, find a point common to the paths of the ants.

28. A shopkeeper sells 50 Chemistry, 60 Physics and 35 Maths books on day I and sells 40 Chemistry, 45 Physics and 50 Maths books on day II. If the selling price for each such subject book is ₹150 (Chemistry), ₹175 (Physics) and ₹180 (Maths), then find his total sale in two days, using matrix method. If cost price of all the books together is ₹35, 000, what profit did he earn after the sale of two days?

29. If A is a 3×3 invertible matrix, show that for any scalar $k \neq 0$, $(kA)^{-1} = \frac{1}{k}A^{-1}$. Hence calculate $(3A)^{-1}$, where $A = \begin{bmatrix} 2 & -1 & 1 \\ -1 & 2 & -1 \\ 1 & -1 & 2 \end{bmatrix}$.

30. A school wants to allocate students into three clubs : Sports, Music and Drama, under following conditions.
    - The number of students in Sports club should be equal to the sum of the number of students in Music and Drama club.
    - The number of students in Music club should be 20 more than half the number of students in Sports club.
    - The total number of students to be allocated in all three clubs are 180.

    Find the number of students allocated to different clubs, using matrix method.

31. A furniture workshop produces three types of furniture - chairs, tables and beds each day. On a particular day the total number of furniture pieces produced is 45. It was also found that production of beds exceeds that of chairs by 8, while the total production of beds and chairs together is twice the production of tables. Determine the units produced of each type of furniture, using matrix method.

32. Three students run on a racing track such that their speeds add up to 6 km/h. However, double the speed of the third runner added to the speed of the first results in 7 km/h. If thrice the speed

of the first runner is added to the original speeds of the other two, the result is 12 km/h. Using matrix method, find the original speed of each runner.

33. An amount of ₹10000 is put into three investments at the rate of 10%, 12% and 15% per annum. The combined annual income of all three investments is ₹1310, however the combined annual income of the first and the second installments is ₹190 short of the income from the third. Use matrix method and find the investment amount in each at the beginning of the year.

34. Three students, Neha, Rani and Sam go to a market to purchase stationary items. Neha buys 4 pens, 3 notepads and 2 erasers and pays ₹60. Rani buys 2 pens, 4 notepads and 6 erasers for ₹90. Sam pays ₹70 for 6 pens, 2 notepads and 3 erasers.

Based upon the above information, answer the following questions.

(i) Form the equations required to solve the problem of finding the price of each item, and express it in the matrix from $AX = B$.

(ii) Find $|A|$ and confirm if it is possible to find A^{-1}.

(iii) (a) Find A^{-1}, if possible, and write the formula to find X.

OR

(iii) (b) Find $A^2 - 8I$, where I is an identity matrix.

Unit III - *Calculus*

Continuity and Differentiability; Applications of Derivatives; Integrals; Applications of Integrals; Differential Equations

01. If $f(x) = |x| + |x-1|$, then which of the following is correct?

(a) $f(x)$ is both continuous and differentiable, at $x = 0$ and $x = 1$

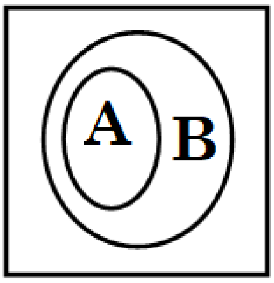
(b) $f(x)$ is differentiable but not continuous, at $x = 0$ and $x = 1$

(c) $f(x)$ is continuous but not differentiable, at $x = 0$ and $x = 1$

(d) $f(x)$ is neither continuous nor differentiable, at $x = 0$ and $x = 1$

02. If A denotes the set of continuous functions and B denotes set of differentiable functions, then which of the following depicts the correct relation between set A and B?

(a)



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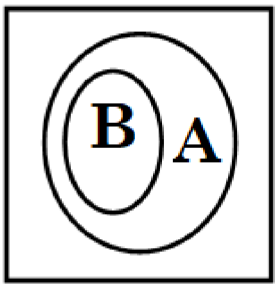

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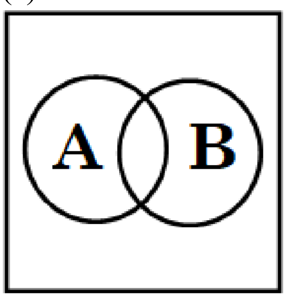

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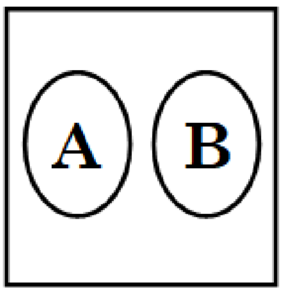


03. If $f(x)=\begin{cases}3x-2, & 0<x\le 1\\ 2x^2+ax, & 1<x<2\end{cases}$ is continuous for $x\in(0,\ 2)$, then a is equal to

(a) –4 (b) $-\frac{7}{2}$ (c) –2 (d) –1

04. If $y=\log_{2x}(\sqrt{2x})$, then $\frac{dy}{dx}$ is equal to

(a) 0 (b) 1 (c) $\frac{1}{x}$ (d) $\frac{1}{\sqrt{2x}}$

05. If $f(x)=\{[x],\ x\in\mathbb{R}\}$ is the greatest integer function, then the correct statement is

(a) f is continuous but not differentiable at $x=2$
(b) f is neither continuous nor differentiable at $x=2$
(c) f is continuous as well as differentiable at $x=2$
(d) f is not continuous but differentiable at $x=2$

06. Let $f(x)=|x|,\ x\in\mathbb{R}$. Then, which of the following statement is **incorrect**?

(a) f has a minimum value at $x=0$ (b) f has no maximum value in $\mathbb{R}$
(c) f is continuous at $x=0$ (d) f is differentiable at $x=0$

Direction : *Following Question is Assertion (A) and Reason (R) based carrying **1 mark** each. Two statements are given, one labeled Assertion (A) and other labeled Reason (R). Select the correct answer from the options given below.*

(a) Both Assertion (A) and Reason (R) are true and Reason (R) is the correct explanation of Assertion (A).
(b) Both Assertion (A) and Reason (R) are true and Reason (R) is **not** the correct explanation of Assertion (A).
(c) Assertion (A) is true but Reason (R) is false.
(d) Assertion (A) is false but Reason (R) is true.

07. **Assertion (A) :** $f(x)=\begin{cases}x\sin\frac{1}{x}, & x\ne 0\\ 0, & x=0\end{cases}$ is continuous at $x=0$.

Reason (R) : When $x\to 0$, $\sin\frac{1}{x}$ is a finite value between -1 and 1.

08. Differentiate $2^{\cos^2 x}$ w.r.t. $\cos^2 x$.

09. Differentiate $\sqrt{e^{\sqrt{2x}}}$ with respect to $e^{\sqrt{2x}}$ for $x>0$.

10. Check the differentiability of function $f(x)=x|x|$ at $x=0$.

11. If $x=e^{\frac{x}{y}}$, then prove that $\frac{dy}{dx}=\frac{x-y}{x\log x}$.

12. If $f(x)=\begin{cases}2x-3, & -3\le x\le -2\\ x+1, & -2<x\le 0\end{cases}$, check the differentiability of $f(x)$ at $x=-2$.

13. Differentiate $\tan^{-1}\frac{\sqrt{1-x^2}}{x}$ w.r.t. $\cos^{-1}\left(2x\sqrt{1-x^2}\right)$, $x\in\left(\frac{1}{\sqrt{2}},\ 1\right)$.

14. For a positive constant ‘a’, differentiate $a^{t+\frac{1}{t}}$ with respect to $\left(t+\frac{1}{t}\right)^a$, where $t\ne 0$.

15. Differentiate $y=\sin^{-1}(3x-4x^3)$ w.r.t. x, if $x\in\left[-\frac{1}{2},\ \frac{1}{2}\right]$.

16. Differentiate $y=\cos^{-1}\left(\dfrac{1-x^2}{1+x^2}\right)$ with respect to x, when $x\in(0,1)$.

17. If $f(x)=\begin{cases}1, \text{ if } x\le 3\\ ax+b, \text{ if } 3<x<5\\ 7, \text{ if } 5\le x\end{cases}$ is continuous in $\mathbb{R}$, then the values of a and b are

(a) $a=3,\ b=-8$ (b) $a=3,\ b=8$ (c) $a=-3,\ b=-8$ (d) $a=-3,\ b=8$

18. If $f(x)=-2x^8$, then the correct statement is

(a) $f'\left(\frac{1}{2}\right)=f'\left(-\frac{1}{2}\right)$ (b) $f'\left(\frac{1}{2}\right)=-f'\left(-\frac{1}{2}\right)$

(c) $-f'\left(\frac{1}{2}\right)=f\left(-\frac{1}{2}\right)$ (d) $f\left(\frac{1}{2}\right)=-f\left(-\frac{1}{2}\right)$

19. Differentiate $y=\sqrt{\log\left\{\sin\left(\dfrac{x^3}{3}-1\right)\right\}}$ with respect to x.

20. Differentiate $\log(x^x+\operatorname{cosec}^2 x)$ with respect to x.

21. The values of λ so that $f(x)=\sin x-\cos x-\lambda x+C$ decreases for all real values of x are

(a) $1<\lambda<\sqrt{2}$ (b) $\lambda\ge 1$ (c) $\lambda\ge\sqrt{2}$ (d) $\lambda<1$

22. If $f(x)=2x+\cos x$, then $f(x)$

(a) has a maxima at $x=\pi$ (b) has a minima at $x=\pi$

(c) is an increasing function (d) is a decreasing function

23. The absolute maximum value of function $f(x)=x^3-3x+2$ in $[0,2]$ is

(a) 0 (b) 2 (c) 4 (d) 5

24. The slope of the curve $y=-x^3+3x^2+8x-20$ is maximum at

(a) (1, –10) (b) (1, 10) (c) (10, 1) (d) (–10, 1)

25. Let $f(x)=x^2,\ x\in\mathbb{R}$. Then, which of the following statements is **incorrect**?

(a) Minimum value of f does not exist (b) There is no point of maximum value of f in $\mathbb{R}$

(c) f is continuous at $x=0$ (d) f is differentiable at $x=0$

26. $f(x)=x^x$ has a critical point at

(a) $x=e$ (b) $x=e^{-1}$ (c) $x=0$ (d) $x=1$

27. If $f:\mathbb{R}\to\mathbb{R}$ is defined as $f(x)=2x-\sin x$, then f is

(a) a decreasing function (b) an increasing function

(c) maximum at $x=\dfrac{\pi}{2}$ (d) maximum at $x=0$

28. Determine those values of x for which $f(x)=\dfrac{2}{x}-5,\ x\ne 0$ is increasing or decreasing.

29. Find the interval in which $f(x)=x+\dfrac{1}{x}$ is always increasing, $x\ne 0$.

30. Find the intervals in which $f(x)=5x^{\frac{3}{2}}-3x^{\frac{5}{2}}$ is (i) increasing (ii) decreasing.

31. Find the absolute maximum and absolute minimum of function $f(x)=2x^3-15x^2+36x+1$ on $[1,5]$.

32. Find the values of 'a' for which $f(x)=x^2-2ax+b$ is an increasing function for $x>0$.

33. The area of an expanding rectangle is increasing at the rate of $48\text{ cm}^2/\text{s}$. The length of the rectangle is always square of its breadth. At what rate the length of rectangle increasing at an instant, when breadth $= 4.5$ cm?

34. Find the value of 'a' for which $f(x) = \sqrt{3}\sin x - \cos x - 2ax + 6$ is decreasing in $\mathbb{R}$.

35. A spherical medicine ball when dropped in water dissolves in such a way that the rate of decrease of volume at any instant is proportional to its surface area. Calculate the rate of decrease of its radius.

36. Find the values of 'a' for which $f(x) = \sin x - ax + b$ is increasing on $\mathbb{R}$.

37. Find the least value of a (if possible), so that the function $f(x) = 2x^2 - ax + 3$ is an increasing function on $[2, 4]$.

38. If $f(x) = x + \frac{1}{x}$, $x \geq 1$, show that f is an increasing function.

39. The relation between the height of the plant (y cm) with respect to exposure to sunlight is governed by the equation $y = 4x - \frac{1}{2}x^2$, where x is the number of days exposed to sunlight.
    (i) Find the rate of growth of the plant with respect to sunlight.
    (ii) In how many days will the plant attain its maximum height? What is the maximum height?

40. Find the local maxima and local minima of the function $f(x) = \frac{8}{3}x^3 - 12x^2 + 18x + 5$.

41. Let the volume of a metallic hollow sphere be constant. If the inner radius increases at the rate of 2 cm/s, then find the rate of increase of the outer radius when the radii are 2 cm and 4 cm respectively.

42. Find the interval (s) in which the function $f(x) = \sin 3x - \cos 3x$, $0 < x < \frac{\pi}{2}$ is strictly increasing.

43. Determine the values of x for which $f(x) = \frac{x-4}{x+1}$, $x \neq -1$ is an increasing or a decreasing function.

44. Amongst all pairs of positive integers with product as 289, find which of the two numbers add up to the least.

45. Show that the derivative of $\tan^{-1}(\sec x + \tan x)$, $\left[-\frac{\pi}{2} < x < \frac{\pi}{2}\right]$ with respect to x is equal to $\frac{1}{2}$.

46. Find dimensions of a rectangle of perimeter 12 cm which will generate maximum volume when swept along a circular rotation keeping the shorter side fixed as the axis.

47. If $\int \frac{2^{\frac{1}{x}}}{x^2}dx = k \cdot 2^{\frac{1}{x}} + C$, then k is equal to
    (a) $-\frac{1}{\log 2}$ (b) $-\log 2$ (c) -1 (d) $\frac{1}{2}$

48. If $\int_0^1 \frac{e^x}{1+x}dx = \alpha$, then $\int_0^1 \frac{e^x}{(1+x)^2}dx$ is equal to
    (a) $\alpha - 1 + \frac{e}{2}$ (b) $\alpha + 1 - \frac{e}{2}$ (c) $\alpha - 1 - \frac{e}{2}$ (d) $\alpha + 1 + \frac{e}{2}$

49. If $\int_0^a x\,dx \leq \frac{a}{2} + 6$, then

(a) $-4 \le a \le 3$ (b) $a \ge 4,\ a \le -3$ (c) $-3 \le a \le 4$ (d) $-3 \le a \le 0$

50. The value of $\int_0^1 \frac{dx}{e^x + e^{-x}}$ is

(a) $-\frac{\pi}{4}$ (b) $\frac{\pi}{4}$ (c) $\tan^{-1} e - \frac{\pi}{4}$ (d) $\tan^{-1} e$

51. $\int \frac{a^x}{\sqrt{1-a^{2x}}} dx$ is equal to

(a) $\frac{\sin^{-1}(a^x)}{\log_e a} + C$ (b) $\log_e(1-a^{2x}) + C$ (c) $\frac{\cos^{-1}(a^x)}{\log_e a} + C$ (d) $\frac{\sin^{-1}(a^x)}{a^x} + C$

52. $\int \frac{e^{-x}}{16+9e^{-2x}} dx$ is equal to

(a) $\frac{16}{9}\tan^{-1}(e^{-x}) + C$ (b) $-\frac{1}{12}\tan^{-1}\left(\frac{3e^{-x}}{4}\right) + C$

(c) $\tan^{-1}\left(\frac{e^{-x}}{4}\right) + C$ (d) $-\frac{1}{3}\tan^{-1}\left(\frac{e^{-x}}{4}\right) + C$

53. $\int_0^{\pi/2} \cos x . e^{\sin x} dx$ is equal to

(a) 0 (b) $1-e$ (c) $e-1$ (d) e

54. Let $f'(x) = 3(x^2 + 2x) - \frac{4}{x^3} + 5$, $f(1) = 0$. Then, $f(x)$ is

(a) $x^3 + 3x^2 + \frac{2}{x^2} + 5x + 11$ (b) $x^3 + 3x^2 + \frac{2}{x^2} + 5x - 11$

(c) $x^3 + 3x^2 - \frac{2}{x^2} + 5x - 11$ (d) $x^3 - 3x^2 - \frac{2}{x^2} + 5x - 11$

55. Find $\int \frac{\sqrt{x}}{1+\sqrt{x^{3/2}}} dx$.

56. Find $\int \frac{\cos x\, dx}{1 + \cos x + \sin x}$.

57. Find $\int \frac{1}{x}\sqrt{\frac{x+a}{x-a}}\, dx$.

58. Evaluate $\int_0^{\pi} \frac{\sin 2px}{\sin x} dx$, $p \in N$.

59. f and g are continuous functions on interval $[a, b]$.

Given that $f(a-x) = f(x)$ and $g(x) + g(a-x) = a$, show that $\int_0^a f(x)g(x)dx = \frac{a}{2}\int_0^a f(x)dx$.

60. Find $\int 2x^3 e^{x^2} dx$.

61. If $\int_a^b x^3 dx = 0$ and $\int_a^b x^2 dx = \frac{2}{3}$, then find the values of a and b.

62. Find $\int \frac{\cos 2x}{(\sin x + \cos x)^2} dx$.

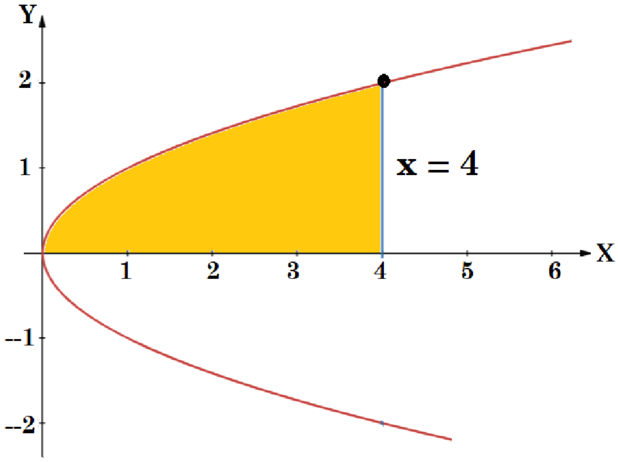
63. The area of the shaded region bounded by the curves $y^2 = x$, $x = 4$ and the x-axis is given by

(a) $\int_0^4 x\,dx$

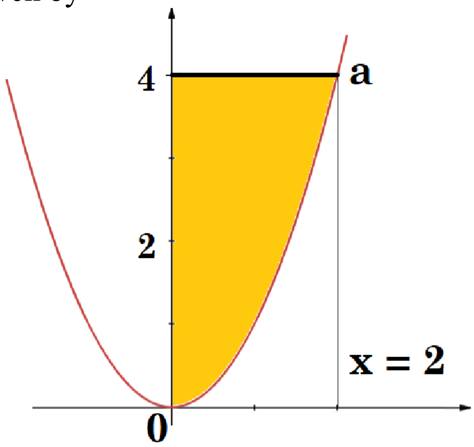
(b) $\int_0^2 y^2\,dy$

(c) $2\int_0^4 \sqrt{x}\,dx$

(d) $\int_0^4 \sqrt{x}\,dx$



64. The area of the shaded region (figure) represented by the curves $y = x^2$, $0 \le x \le 2$ and y-axis is given by



(a) $\int_0^2 x^2\,dx$

(b) $\int_0^2 \sqrt{y}\,dy$

(c) $\int_0^4 x^2\,dx$

(d) $\int_0^4 \sqrt{y}\,dy$

65. The area of the region bounded by the curve $y^2 = x$ between $x = 0$ and $x = 1$ is

(a) $\frac{3}{2}$ Sq.units (b) $\frac{2}{3}$ Sq.units (c) 3 Sq.units (d) $\frac{4}{3}$ Sq.units

66. The area of the region enclosed between the curve $y = x|x|$, x-axis, $x = -2$ and $x = 2$ is

(a) $\frac{8}{3}$ (b) $\frac{16}{3}$ (c) 0 (d) 8

67. The area of the region enclosed by the curve $y = \sqrt{x}$ and the lines $x = 0$ and $x = 4$ and x-axis is

(a) $\frac{16}{9}$ Sq.units (b) $\frac{32}{9}$ Sq.units (c) $\frac{16}{3}$ Sq.units (d) $\frac{32}{3}$ Sq.units

68. Draw a rough sketch of the curve $y = \sqrt{x}$. Using integration, find the area of the region bounded by the curve $y = \sqrt{x}$, $x = 4$ and x-axis, in the first quadrant.

69. In a rough sketch, mark the region bounded by $y = 1 + |x+1|$, $x = -2$, $x = 2$ and $y = 0$. Using integration, find the area of the marked region.

70. Draw a rough sketch for the curve $y = 2 + |x+1|$. Using integration, find the area of the region bounded by the curve $y = 2 + |x+1|$, $x = -4$, $x = 3$ and $y = 0$.

71. Using integration, find the area of the region bounded by the line $y = 5x + 2$, the x-axis and the ordinates $x = -2$ and $x = 2$.

72. Sketch the graph of $y = |x+3|$ and find the area of the region enclosed by the curve, x-axis, between $x=-6$ and $x=0$, using integration.

73. Use integration to find the area of the region enclosed by curve $y=-x^2$ and the straight lines $x=-3,\ x=2$ and $y=0$. Sketch a rough figure to illustrate the bounded region.

74. Using integration, find the area of the ellipse $\dfrac{x^2}{a^2}+\dfrac{y^2}{b^2}=1$ bounded between the lines $x=-\dfrac{a}{2}$ to $x=\dfrac{a}{2}$.

75. A woman discovered a scratch along a straight line on a circular table top of radius 8 cm. She divided the table top into 4 equal quadrants and discovered the scratch passing through the origin inclined at an angle $\dfrac{\pi}{4}$ anticlockwise along the positive direction of x-axis. Find the area of the region enclosed by the x-axis, the scratch and the circular table top in the first quadrant, using integration.

76. Which of the following is **not** a homogeneous function of x and y?

(a) $y^2 - xy$ (b) $x-3y$ (c) $\sin^2\dfrac{y}{x}+\dfrac{y}{x}$ (d) $\tan x - \sec y$

77. The order and degree of the differential equation $-\dfrac{d^4y}{dx^4}+2e^{\frac{dy}{dx}}+y^2=0$ are, respectively

(a) –4, 1 (b) 4, not defined (c) 1, 1 (d) 4, 1

78. The solution for the differential equation $\log\left(\dfrac{dy}{dx}\right)=3x+4y$ is

(a) $3e^{4y}+4e^{-3x}+C=0$ (b) $e^{3x+4y}+C=0$

(c) $3e^{-3y}+4e^{4x}+12C=0$ (d) $3e^{-4y}+4e^{3x}+12C=0$

79. The integrating factor of the differential equation $\dfrac{dx}{dy}=\dfrac{x\log x}{\frac{2}{x}\log x - y}$ is

(a) $\dfrac{1}{8x}$ (b) e (c) $e^{\log x}$ (d) $\log x$

80. The integrating factor of the differential equation $\dfrac{dx}{dy}=\dfrac{-(1+\sin x)}{x+y\cos x}$ is

(a) $\log\cos x$ (b) $1+\sin x$ (c) $e^{(1+\sin x)}$ (d) $e^{\log\cos x}$

81. If p and q are respectively the order and degree of the differential equation $\dfrac{d}{dx}\left(\dfrac{dy}{dx}\right)^3=0$, then $(p-q)$ is

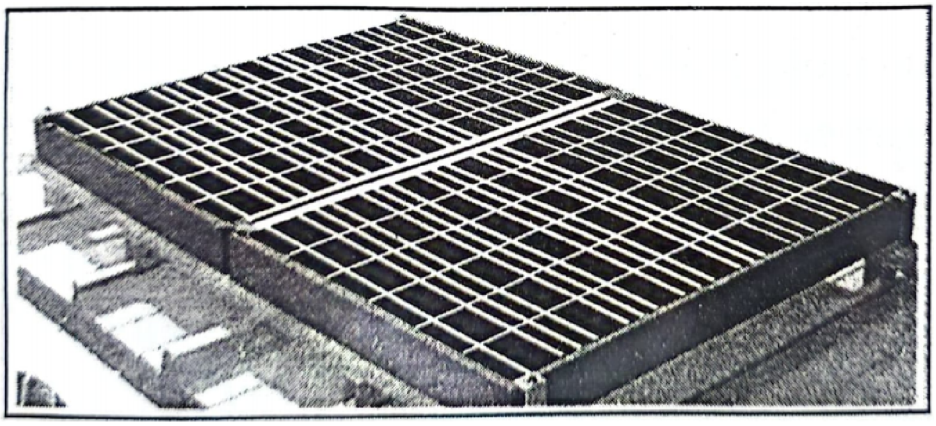
(a) 0 (b) 1 (c) 2 (d) 3

82. Solve the differential equation $2(y+3)-xy\dfrac{dy}{dx}=0$; given that $y(1)=-2$.

83. Solve the differential equation $(x^2+y^2)\,dx+xy\,dy=0,\ y(1)=1$.

84. Solve the differential equation $\dfrac{dy}{dx}=\cos x-2y$.

85. A technical company is designing a rectangular solar panel installation on a roof using 300 metres of boundary material. The design includes a partition running parallel to one of the sides dividing the area (roof) into two sections.



Let the length of the side perpendicular to the partition be x metres and with parallel to the partition be y metres.

Based on this information, answer the following questions.

(i) Write the equation for the total boundary material used in the boundary and parallel to the partition in terms of x and y.

(ii) Write the area of the solar panel as a function of x.

(iii) (a) Find the critical points of the area function. Use second derivative test to determine critical points at the maximum area. Also, find the maximum area.

OR

(iii) (b) Using first derivative test, calculate the maximum area the company can enclose with the 300 metres of boundary material, considering the parallel partition.

Remark Since diagram / language in this question is unclear so, students may have solved this problem by taking $2x+2y=300$ OR $2x+4y=300$ OR $2x+3y=300$ OR $4x+4y=300$ OR $4x+2y=300$ OR $4x+3y=300$. The solution of sub-parts will differ accordingly.

86. A small town is analyzing the pattern of a new street light installation. The lights are set up in such a way that the intensity of light at any point x metres from the start of the street can be modeled by $f(x)=e^x \sin x$, where x is in metres.

Based on the above, answer the following.

(i) Find the intervals on which the $f(x)$ is increasing or decreasing $x \in [0, \pi]$.

(ii) Verify, whether each critical point when $x \in [0, \pi]$ is a point of local maximum or local minimum or a point of inflexion.

87. A carpenter needs to make a wooden cuboidal box, closed from all sides, which has a square base and fixed volume. Since he is short of the paint required to paint the box on completion, he wants the surface area to be minimum.

On the basis of the above information, answer the following questions.

(i) Taking length = breadth = x m and height = y m, express the surface area (S) of the box in terms of x and its volume (V), which is constant.

(ii) Find $\dfrac{dS}{dx}$.

(iii) (a) Find a relation between x and y such that the surface area (S) is minimum.

OR

(iii) (b) If surface area (S) is constant, the volume $(V)=\frac{1}{4}(Sx-2x^3)$, x being the edge of base.

Show that volume (V) is maximum for $x=\sqrt{\frac{S}{6}}$.

88. A ladder of fixed length 'h' is to be placed along the wall such that it is free to move along the height of the wall.

Based upon the above information, answer the following questions.

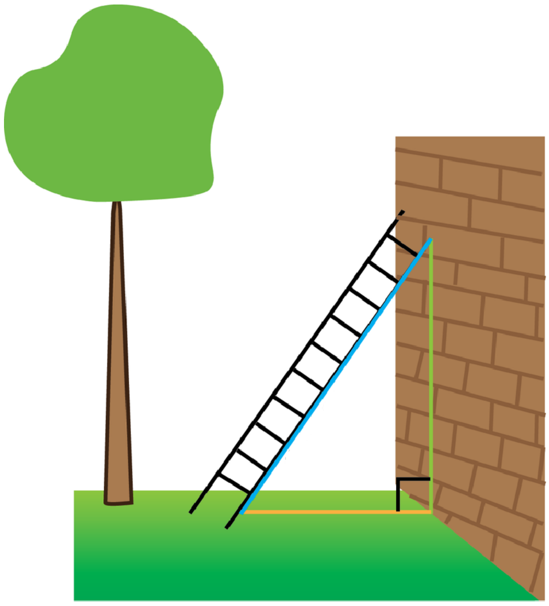
(i) Express the distance (y) between the wall and foot of the ladder in terms of 'h' and height (x) on the wall at a certain instant. Also, write an expression in terms of h and x for the area (A) of the right triangle, as seen from the side by an observer.

(ii) Find the derivative of the area (A) with respect to the height on the wall (x), and find its critical point.

(iii) (a) Show that the area (A) of the right triangle is maximum at the critical point.

OR

(iii) (b) If the foot of the ladder whose length is 5 m, is being pulled towards the wall such that the rate of decrease of distance (y) is 2 m/s, then at what rate is the height on the wall (x) increasing, when the foot of the ladder is 3 m away from the wall?



89. During a heavy gaming session, the temperature of a student's laptop processor increases significantly. After the session, the processor begins to cool down, and the rate of cooling is proportional to the difference between the processor's temperature and the room temperature ($25^\circ C$). Initially the processor's temperature is $85^\circ C$. The rate of cooling is defined by the equation $\frac{d}{dt}\big(T(t)\big)=-k\big(T(t)-25\big)$, where $T(t)$ represents the temperature of the processor at time t (in minutes) and k is a constant.

Based on the above information, answer the following questions.

(i) Find the expression for temperature of processor $T(t)$, given that $T(0)=85^\circ C$.

(ii) How long will it take for the processor's temperature to reach $40^{o}C$?
Given that $k = 0.03$, $\log_e 4 = 1.3863$.

90. Camphor is a waxy, colourless solid with strong aroma that evaporates through the process of sublimation, if left in the open at room temperature.

A cylindrical camphor tablet whose height is equal to its radius (r) evaporates when exposed to air such that the rate of reduction of its volume is proportional to its total surface area. Thus, $\frac{dV}{dt} = kS$ is the differential equation, where V is the volume, S is the surface area and t is the time in hours.

Based upon the above information, answer the following questions.
(i) Write the order and degree of the given differential equation.
(ii) Substituting $V = \pi r^3$ and $S = 2\pi r^2$, we get the differential equation $\frac{dr}{dt} = \frac{2}{3}k$. Solve it, given that $r(0) = 5$ mm.
(iii) (a) If it is given that $r = 3$ mm when $t = 1$ hour, find the value of k. Hence, find t for $r = 0$ mm.

OR

(iii) (b) If it is given that $r = 1$ mm when $t = 1$ hour, find the value of k. Hence, find t for $r = 0$ mm.

Unit IV - *Vector & 3 D Geometry*

Vector Algebra; Three Dimensional Geometry

01. If vector $\vec{a} = 3\hat{i} + 2\hat{j} - \hat{k}$ and $\vec{b} = \hat{i} - \hat{j} + \hat{k}$, then which of the following is correct?
(a) $\vec{a} \parallel \vec{b}$ (b) $\vec{a} \perp \vec{b}$ (c) $|\vec{b}| > |\vec{a}|$ (d) $|\vec{a}| = |\vec{b}|$

02. The projection vector of vector $\vec{a}$ on vector $\vec{b}$ is
(a) $\left(\frac{\vec{a}.\vec{b}}{|\vec{b}|^2}\right)\vec{b}$ (b) $\frac{\vec{a}.\vec{b}}{|\vec{b}|}$ (c) $\frac{\vec{a}.\vec{b}}{|\vec{a}|}$ (d) $\left(\frac{\vec{a}.\vec{b}}{|\vec{a}|^2}\right)\vec{b}$

03. The unit vector perpendicular to the vectors $\hat{i} - \hat{j}$ and $\hat{i} + \hat{j}$ is
(a) $\hat{k}$ (b) $-\hat{k} + \hat{j}$ (c) $\frac{\hat{i} - \hat{j}}{\sqrt{2}}$ (d) $\frac{\hat{i} + \hat{j}}{\sqrt{2}}$

04. If $\vec{p}$ and $\vec{q}$ are unit vectors, then which of the following values of $\vec{p}.\vec{q}$ is not possible?
(a) $-\frac{1}{2}$ (b) $\frac{1}{\sqrt{2}}$ (c) $\frac{\sqrt{3}}{2}$ (d) $\sqrt{3}$

05. The values of x for which the angle between the vectors $\vec{a} = 2x^2\hat{i} + 4x\hat{j} + \hat{k}$ and $\vec{b} = 7\hat{i} - 2\hat{j} + x\hat{k}$ is obtuse, is

(a) 0 or $\frac{1}{2}$ (b) $x > \frac{1}{2}$ (c) $\left(0, \frac{1}{2}\right)$ (d) $\left[0, \frac{1}{2}\right]$

06. Let $\vec{a}$ be a position vector whose tip is the point (2, –3). If $\overrightarrow{AB} = \vec{a}$, where coordinates of A are (–4, 5), then the coordinates of B are
(a) (–2, –2) (b) (2, –2) (c) (–2, 2) (d) (2, 2)

07. If $\overrightarrow{PQ} \times \overrightarrow{PR} = 4\hat{i} + 8\hat{j} - 8\hat{k}$, then the area (ΔPQR) is
(a) 2 Sq.units (b) 4 Sq.units (c) 6 Sq.units (d) 12 Sq.units

08. If projection of $\vec{a} = \alpha\hat{i} + \hat{j} + 4\hat{k}$ on $\vec{b} = 2\hat{i} + 6\hat{j} + 3\hat{k}$ is 4 units, then α is
(a) –13 (b) –5 (c) 13 (d) 5

09. A student tries to tie ropes, parallel to each other from one end of the wall to the other. If one rope is along the vector $3\hat{i} + 15\hat{j} + 6\hat{k}$ and the other is along the vector $2\hat{i} + 10\hat{j} + \lambda\hat{k}$, then the value of λ is
(a) 6 (b) 1 (c) $\frac{1}{4}$ (d) 4

10. If $|\vec{a} + \vec{b}| = |\vec{a} - \vec{b}|$ for any two vectors, then vectors $\vec{a}$ and $\vec{b}$ are
(a) orthogonal vectors (b) parallel to each other
(c) unit vectors (d) collinear vectors

Direction : *Following Question is Assertion (A) and Reason (R) based carrying* ***1 mark*** *each. Two statements are given, one labeled Assertion (A) and other labeled Reason (R). Select the correct answer from the options given below.*

(a) Both Assertion (A) and Reason (R) are true and Reason (R) is the correct explanation of Assertion (A).
(b) Both Assertion (A) and Reason (R) are true and Reason (R) is **not** the correct explanation of Assertion (A).
(c) Assertion (A) is true but Reason (R) is false.
(d) Assertion (A) is false but Reason (R) is true.

11. **Assertion (A) :** If $|\vec{a} \times \vec{b}|^2 + |\vec{a} . \vec{b}|^2 = 256$ and $|\vec{b}| = 8$, then $|\vec{a}| = 2$.

Reason (R) : $\sin^2\theta + \cos^2\theta = 1$ and $|\vec{a} \times \vec{b}| = |\vec{a}||\vec{b}|\sin\theta$ and $\vec{a}.\vec{b} = |\vec{a}||\vec{b}|\cos\theta$.

12. If $\vec{a}$ and $\vec{b}$ are two non-collinear vectors, then find x, such that $\vec{\alpha} = (x-2)\vec{a} + \vec{b}$ and $\vec{\beta} = (3+2x)\vec{a} - 2\vec{b}$ are collinear.

13. Let $\vec{p} = 2\hat{i} - 3\hat{j} - \hat{k}$, $\vec{q} = -3\hat{i} + 4\hat{j} + \hat{k}$ and $\vec{r} = \hat{i} + \hat{j} + 2\hat{k}$. Express $\vec{r}$ in the form of $\vec{r} = \lambda\vec{p} + \mu\vec{q}$ and hence find the values of λ and μ.

14. A vector $\vec{a}$ makes equal angles with all the three axes. If the magnitude of the vector is $5\sqrt{3}$ units, then find $\vec{a}$.

15. If $\vec{a}$ and $\vec{b}$ are position vectors of point A and point B respectively, find the position vector of point C on BA produced such that $BC = 3BA$.

16. If $\vec{\alpha}$ and $\vec{\beta}$ are position vectors of two points P and Q respectively, then find the position vector of a point R in QP produced such that $QR = \frac{3}{2}QP$.

17. Two friends while flying kites from different locations, find the strings of their kites crossing each other. The strings can be represented by the vectors $\vec{a} = 3\hat{i} + \hat{j} + 2\hat{k}$ and $\vec{b} = 2\hat{i} - 2\hat{j} + 4\hat{k}$. Determine the angle formed between the kite strings. Assume there is no slack in the strings.

18. Find a vector of magnitude 21 units in the direction opposite to that of $\overrightarrow{AB}$, where A are B are the points A(2, 1, 3) and B(8, –1, 0) respectively.

19. During a cricket match, the position of the bowler, the wicket keeper and the leg slip fielder are in a line given by $\vec{B}=2\hat{i}+8\hat{j}$, $\vec{W}=6\hat{i}+12\hat{j}$ and $\vec{F}=12\hat{i}+18\hat{j}$ respectively. Calculate the ratio in which the wicket keeper divides the line segment joining the bowler and the leg slip fielder.

20. Show that the area of a parallelogram whose diagonals are represented by $\vec{a}$ and $\vec{b}$ is given by $\frac{1}{2}|\vec{a}\times\vec{b}|$. Also find the area of a parallelogram whose diagonals are $2\hat{i}-\hat{j}+\hat{k}$ and $\hat{i}+3\hat{j}-\hat{k}$.

21. Let $\vec{a}$, $\vec{b}$ and $\vec{c}$ be three vectors such that $\vec{a}.\vec{b}=\vec{a}.\vec{c}$ and $\vec{a}\times\vec{b}=\vec{a}\times\vec{c}$, $\vec{a}\neq\vec{0}$. Show that $\vec{b}=\vec{c}$.

22. If $\vec{a}$ and $\vec{b}$ are unit vectors inclined with each other at an angle θ, then prove that $\frac{1}{2}|\vec{a}-\vec{b}|=\sin\frac{\theta}{2}$.

23. The equation of a line parallel to the vector $3\hat{i}+\hat{j}+2\hat{k}$ and passing through the point (4, –3, 7) is
(a) $x=4t+3,\ y=-3t+1,\ z=7t+2$ (b) $x=3t+4,\ y=t+3,\ z=2t+7$
(c) $x=3t+4,\ y=t-3,\ z=2t+7$ (d) $x=3t+4,\ y=-t+3,\ z=2t+7$

24. The coordinates of the foot of the perpendicular drawn from the point $A(-2, 3, 5)$ on the y-axis is
(a) (0, 0, 5) (b) (0, 3, 0) (c) (–2, 0, 5) (d) (–2, 0, 0)

25. The line $x=1+5\mu$, $y=-5+\mu$, $z=-6-3\mu$ passes through which of the following point?
(a) (1, –5, 6) (b) (1, 5, 6) (c) (1, –5, –6) (d) (–1, –5, 6)

26. A man needs to hang two lanterns on a straight wire whose end points have coordinates A(4, 1, –2) and B(6, 2, –3). Find the coordinates of the points where he hangs the lanterns such that these points trisect the wire AB.

27. Determine if the lines $\vec{r}=(\hat{i}+\hat{j}-\hat{k})+\lambda(3\hat{i}-\hat{j})$ and $\vec{r}=(4\hat{i}-\hat{k})+\mu(2\hat{i}+3\hat{k})$ intersect with each other.

28. Find the image A' of the point A(1, 6, 3) in the line $\frac{x}{1}=\frac{y-1}{2}=\frac{z-2}{3}$.
Also, find the equation of the line joining A and A'.

29. Let the polished side of the mirror be along the line $\frac{x}{1}=\frac{1-y}{-2}=\frac{2z-4}{6}$. A point P(1, 6, 3), some distance away from the mirror, has its image formed behind the mirror. Find the coordinates of the image point and the distance between the point P and its image.

30. Find a point P on the line $\frac{x+5}{1}=\frac{y+3}{4}=\frac{z-6}{-9}$ such that its distance from point Q(2, 4, –1) is 7 units. Also, find the equation of line joining P and Q.

31. Find the point on the line $\frac{x-1}{3}=\frac{y+1}{2}=\frac{z-4}{3}$ at a distance of $2\sqrt{2}$ units from the point (–1, –1, 2).

32. Find the point Q on the line $\frac{2x+4}{6}=\frac{y+1}{2}=\frac{-2z+6}{-4}$ at a distance of $3\sqrt{2}$ from the point P(1, 2, 3).

33. Find the distance of the point (–1, –5, –10) from the point of intersection of the lines $\frac{x-1}{2}=\frac{y-2}{3}=\frac{z-3}{4}$ and $\frac{x-4}{5}=\frac{y-1}{2}=z$.

34. Show that the line passing through the points A(0, –1, –1) and B(4, 5, 1) intersects the line joining points C(3, 9, 4) and D(–4, 4, 4).

35. An engineer is designing a new metro rail network in a city.

Initially, two metro lines, Line A and Line B, each consisting of multiple stations are designed. The track for Line A is represented by $l_1 : \dfrac{x-2}{3} = \dfrac{y+1}{-2} = \dfrac{z-3}{4}$, while the track for Line B is represented by $l_2 : \dfrac{x-1}{2} = \dfrac{y-3}{1} = \dfrac{z+2}{-3}$.

Based on the above information, answer the following questions.

(i) Find whether the two metro tracks are parallel.

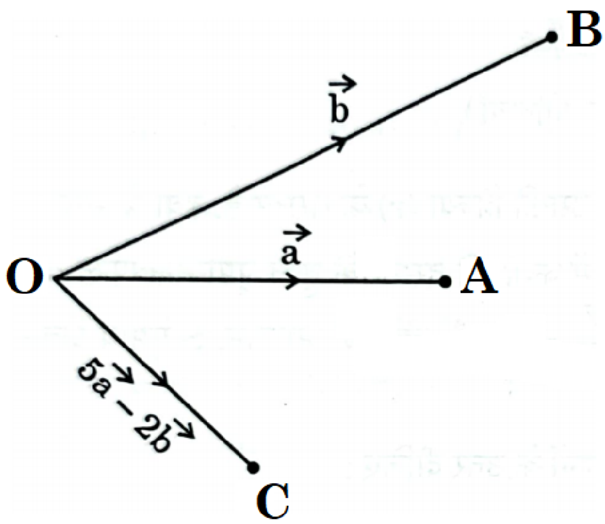
(ii) Solar panels are to be installed on the rooftop of the metro stations. Determine the equation of the line representing the placement of solar panels on the rooftop of Line A's stations, given that panels are to be positioned parallel to Line A's track (l_1) and pass through the point $(1, -2, -3)$.

(iii) (a) To connect the stations, a pedestrian pathway perpendicular to the two metro lines is to be constructed which passes through point (3, 2, 1). Determine the equation of the pedestrian walkway.

OR

(iii) (b) Find the shortest distance between Line A and Line B.

36. Three friends A, B and C move out from the same location O at the same time in three different directions to reach their destinations. They move out on straight paths and decide that A and B after reaching their destinations will meet up with C at his pre-decided destination, following straight paths from A to C and B to C in such a way that $\overrightarrow{OA} = \vec{a}$, $\overrightarrow{OB} = \vec{b}$ and $\overrightarrow{OC} = 5\vec{a} - 2\vec{b}$ respectively.



Based upon the above information, answer the following questions.

(i) Complete the given figure to explain their entire movement plan along the respective vectors.

(ii) Find vectors $\overrightarrow{AC}$ and $\overrightarrow{BC}$.

(iii) (a) If $\vec{a}.\vec{b}=1$, distance of O to A is 1 km and that from O to B is 2 km, then find the angle between $\overrightarrow{OA}$ and $\overrightarrow{OB}$. Also, find $|\vec{a}\times\vec{b}|$.

OR

(iii) (b) If $\vec{a}=2\hat{i}-\hat{j}+4\hat{k}$ and $\vec{b}=\hat{j}-\hat{k}$, then find a unit vector perpendicular to $(\vec{a}+\vec{b})$ and $(\vec{a}-\vec{b})$.

Unit V - *Linear Programming*

Linear Programming

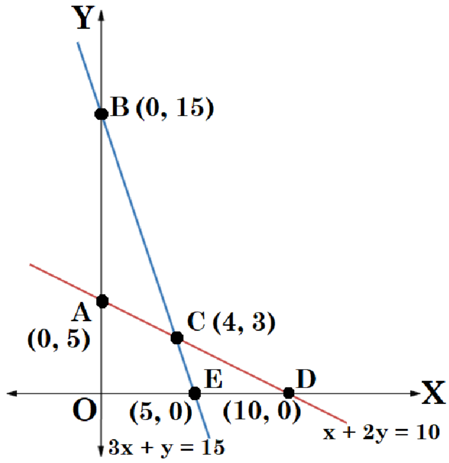
01. The corner points of the feasible region in graphical representation of a L.P.P. are (2, 72), (15, 20) and (40, 15). If $Z=18x+9y$ be the objective function, then
(a) Z is maximum at (2, 72), minimum at (15, 20)
(b) Z is maximum at (15, 20), minimum at (40, 15)
(c) Z is maximum at (40, 15), minimum at (15, 20)
(d) Z is maximum at (40, 15), minimum at (2, 72)

02. If the feasible region of a linear programming problem with objective function $Z=ax+by$, is bounded, then which of the following is correct?
(a) It will only have a maximum value
(b) It will only have a minimum value
(c) It will have both maximum and minimum values
(d) It will have neither maximum nor minimum value

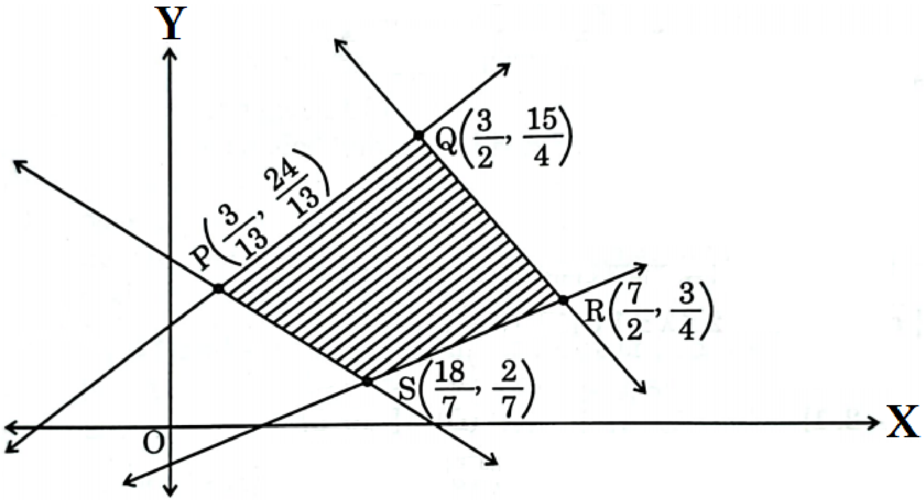
03. A factory produces two products X and Y. The profit earned by selling X and Y is represented by the objective function $Z=5x+7y$, where x and y are the number of units of X and Y respectively sold. Which of the following statement is correct?
(a) The objective function maximizes the difference of the profit earned from products X and Y.
(b) The objective function measures the total production of products X and Y.
(c) The objective function maximizes the combined profit earned from selling X and Y.
(d) The objective function ensures the company produces more of product X than product Y.

04. The corner points of the feasible region of a Linear Programming are (0, 2), (3, 0), (6, 0), (6, 8) and (0, 5). If $Z=ax+by;\ (a, b>0)$ be the objective function, and maximum value of Z is obtained at (0, 2) and (3, 0), then the relation between a and b is
(a) $a=b$ (b) $a=3b$ (c) $b=6a$ (d) $3a=2b$

05. For a Linear Programming Problem (LPP), the given objective function $Z=3x+2y$ is subject to constraints $x+2y\le 10$, $3x+y\le 15$; $x, y\ge 0$.
The correct feasible region is
(a) ABC
(b) AOEC
(c) CED
(d) Open unbounded region BCD



06. For a Linear Programming Problem (LPP), the given objective function is $Z = x + 2y$. The feasible region PQRS determined by the set of constraints is shown as a shaded region in the graph.



(Note : The figure is not to scale.)

$$P = \left(\frac{3}{13}, \frac{24}{13}\right),\ Q = \left(\frac{3}{2}, \frac{15}{4}\right),\ R = \left(\frac{7}{2}, \frac{3}{4}\right),\ S = \left(\frac{18}{7}, \frac{2}{7}\right)$$

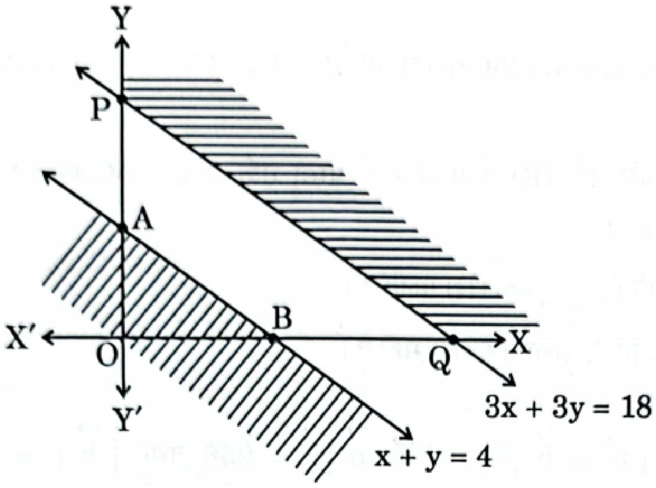
Which of the following statements is correct?

(a) Z is minimum at $S\left(\frac{18}{7}, \frac{2}{7}\right)$ (b) Z is maximum at $R\left(\frac{7}{2}, \frac{3}{4}\right)$

(c) (Value of Z at P) $>$ (Value of Z at Q) (d) (Value of Z at Q) $<$ (Value of Z at R)

07. In a Linear Programming Problem (LPP), the objective function $Z = 2x + 5y$ is to be maximized under the following constraints : $x + y \le 4,\ 3x + 3y \ge 18;\ x,\ y \ge 0$.

Study the graph and select the correct option.



(Note : The figure is not to scale.)

The solution of the given LPP

(a) lies in the shaded unbounded region

(b) lies in ΔAOB

(c) does not exist

(d) lies in the combined region of ΔAOB and unbounded shaded region

Direction : *Following Questions are Assertion (A) and Reason (R) based carrying* ***1 mark*** *each. Two statements are given, one labeled Assertion (A) and other labeled Reason (R). Select the correct answer from the options given below.*

(a) Both Assertion (A) and Reason (R) are true and Reason (R) is the correct explanation of Assertion (A).
(b) Both Assertion (A) and Reason (R) are true and Reason (R) is **not** the correct explanation of Assertion (A).
(c) Assertion (A) is true but Reason (R) is false.
(d) Assertion (A) is false but Reason (R) is true.

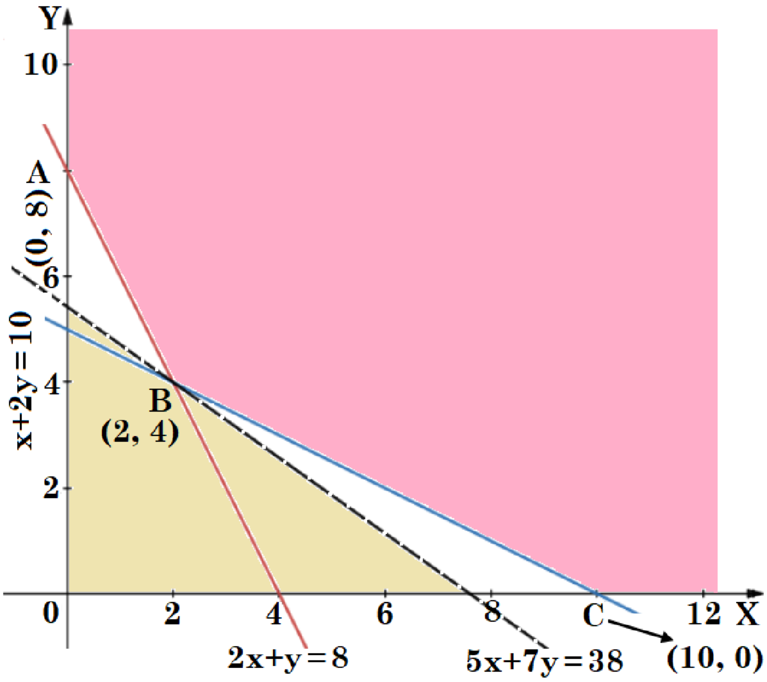
08. **Assertion (A) :** In a Linear Programming Problem, if the feasible region is empty, then the Linear Programming Problem has no solution.

Reason (R) : A feasible region is defined as the region that satisfies all the constraints.

09. **Assertion (A) :** Every point of the feasible region of a Linear Programming Problem is an optimal solution.

Reason (R) : The optimal solution for a Linear Programming Problem exists only at one or more corner point (s) of the feasible region.

10. **Assertion (A) :** The shaded portion of the graph represents the feasible region for the given Linear Programming Problem (LPP).



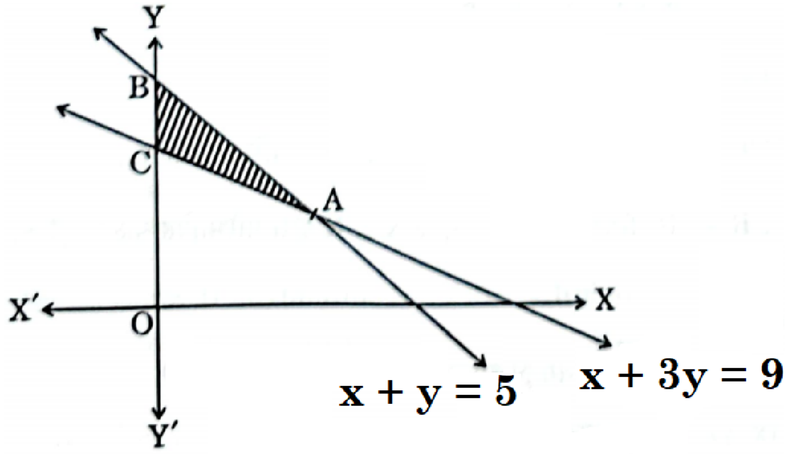
Min $Z = 50x + 70y$
subject to constraints
$2x + y \geq 8,\ x + 2y \geq 10;\ x,\ y \geq 0$.
$Z = 50x + 70y$ has a minimum value $= 380$ at B(2, 4).

Reason (R) : The region representing $50x + 70y < 380$ does not have any point common with the feasible region.

11. In a Linear Programming Problem, the objective function $Z = 5x + 4y$ needs to be maximized under constraints $3x + y \leq 6,\ x \leq 1;\ x,\ y \geq 0$. Express the LPP on the graph and shade the feasible region and mark the corner points.

12. In a Linear Programming Problem (LPP) for objective function $Z = 14x - 10y$ subject to constraints $x + y \leq 8,\ 3x - 2y \geq -6;\ x,\ y \geq 0$ shade the feasible region and mark the corner points in a neatly drawn graph.

13. For a Linear Programming Problem, find min $Z = 5x + 3y$ (where Z is the objective function) for the feasible region shaded in the given figure.



(Note : The figure is not to scale.)

14. Solve the following linear programming problem graphically.

Maximise : $Z = x + 2y$

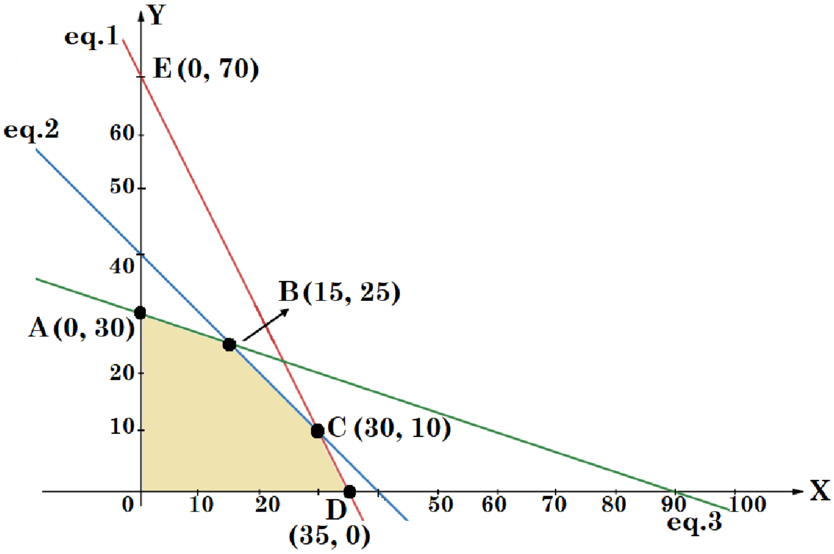
Subject to the constraints : $x - y \geq 0$, $x - 2y \geq -2$, $x \geq 0$, $y \geq 0$.

15. Solve the following linear programming problem graphically.

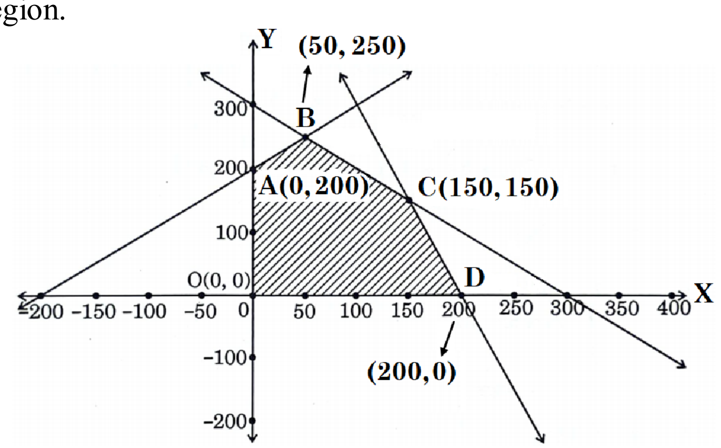
Maximize $Z = 8x + 9y$

Subject to the constraints $2x + 3y \leq 6$, $3x - 2y \leq 6$, $y \leq 1$, $x \geq 0$, $y \geq 0$.

16. The feasible region along with corner points for a linear programming problem is shown in the graph. Write all the constraints for the given linear programming problem.



17. For the given graph of a Linear Programming Problem, write all the constraints satisfying the given feasible region.



18. In the Linear Programming Problem (LPP), find the point / points giving maximum value for $Z=5x+10y$ subject to constraints $x+2y\le120$, $x+y\ge60$, $x-2y\ge0$; $x, y\ge0$.

Unit VI - Probability

Probability

01. If E and F are two independent events such that $P(E)=\frac{2}{3}$, $P(F)=\frac{3}{7}$, then $P(E|\bar{F})$ is equal to

(a) $\frac{1}{6}$ (b) $\frac{1}{2}$ (c) $\frac{2}{3}$ (d) $\frac{7}{9}$

02. If E and F are two events such that $P(E)>0$ and $P(F)\ne1$, then $P(\bar{E}|\bar{F})$ is

(a) $\frac{P(\bar{E})}{P(\bar{F})}$ (b) $1-P(\bar{E}|F)$ (c) $1-P(E|F)$ (d) $\frac{1-P(E\cup F)}{P(\bar{F})}$

03. A box has 4 green, 8 blue and 3 red pens. A student picks up a pen at random, checks its colour and replaces it in the box. He repeats this process 3 times. The probability that at least one pen picked was red is

(a) $\frac{124}{125}$ (b) $\frac{1}{125}$ (c) $\frac{61}{125}$ (d) $\frac{64}{125}$

04. A meeting will be held only if all three members A, B and C are present. The probability that member A does not turn up is 0.10, member B does not turn up is 0.20 and member C does not turn up is 0.05. The probability of the meeting being cancelled is

(a) 0.35 (b) 0.316 (c) 0.01 (d) 0.65

05. A coin is tossed and a card is selected at random from a well shuffled pack of 52 playing cards. The probability of getting head on the coin and a face card from the pack is

(a) $\frac{2}{13}$ (b) $\frac{3}{26}$ (c) $\frac{19}{26}$ (d) $\frac{3}{13}$

06. If A and B are two events such that $P(B)=\frac{1}{5}$, $P(A|B)=\frac{2}{3}$ and $P(A\cup B)=\frac{3}{5}$, then P(A) is

(a) $\frac{10}{15}$ (b) $\frac{2}{15}$ (c) $\frac{1}{5}$ (d) $\frac{8}{15}$

Direction : *Following Question is Assertion (A) and Reason (R) based carrying* ***1 mark*** *each. Two statements are given, one labeled Assertion (A) and other labeled Reason (R). Select the correct answer from the options given below.*

(a) Both Assertion (A) and Reason (R) are true and Reason (R) is the correct explanation of Assertion (A).
(b) Both Assertion (A) and Reason (R) are true and Reason (R) is **not** the correct explanation of Assertion (A).
(c) Assertion (A) is true but Reason (R) is false.
(d) Assertion (A) is false but Reason (R) is true.

07. **Assertion (A) :** If A and B are two events such that $P(A\cap B)=0$, then A and B are independent events.
Reason (R) : Two events are independent if the occurrence of one does not affect the occurrence of the other.

08. In a village of 8000 people, 3000 go out of the village to work and 4000 are women. It is noted that 30% of women go out of the village to work. What is the probability that a randomly chosen individual is either a woman or a person working outside the village?

09. A person is Head of two independent selection committees I and II. If the probability of making a wrong selection in committee I is 0.03 and that in committee II is 0.01, then find the probability that the person makes the correct decision of selection :

(i) in both committee.
(ii) in only one committee.

10. Two dice are thrown. Defined are the following two events A and B :
$A=\{(x, y): x+y=9\}$, $B=\{(x, y): x\neq 3\}$, where (x, y) denote a point in the sample space.
Check if events A and B are independent or mutually exclusive.

11. For the vacancy advertised in the newspaper, 3000 candidates submitted their applications. From the data it was revealed that two third of the total applicants were females and other were males. The selection for the job was done through a written test. The performance of the applicants indicates that the probability of a male getting a distinction in written test is 0.4 and that a female getting a distinction is 0.35. Find the probability that the candidate chosen at random will have a distinction in the written test.

12. Bag I contains 4 white and 5 black balls. Bag II contains 6 white and 7 black balls. A ball drawn randomly from bag I is transferred to bag II and then a ball is drawn randomly from bag II. Find the probability that the ball drawn is white.

13. In a city, a survey was conducted among residents about their preferred mode of commuting. It was found that 50% people preferred using public transport, 35% preferred using a bicycle and 20% use both public transport and a bicycle. If a person is selected at random, find the probability that
(i) the person uses only public transport.
(ii) the person uses a bicycle, given that they also use the public transport.
(iii) the person uses neither public transport nor a bicycle.

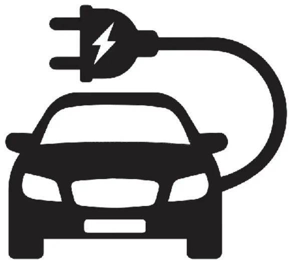
14. The probability that a student buys a colouring book is 0.7 and that she buys a box of colours is 0.2. The probability that she buys a colouring book, given that she buys a box of colours, is 0.3. Find the probability that the student
(i) buys both the colouring book and the box of colours.
(ii) buys a box of colours given that she buys the colouring book.

15. A bank offers loan to its customers on different types of interest namely, fixed rate, floating rate and variable rate.

From the past data with the bank, it is known that a customer avails loan on fixed rate, floating rate or variable rate with probabilities 10%, 20% and 70% respectively. A customer after availing loan can pay the loan or default on loan repayment. The bank data suggests that the probability that a person defaults on loan after availing it at fixed rate, floating rate and variable rate is 5%, 3% and 1% respectively.
Based on the above information, answer the following questions.
(i) What is the probability that a customer after availing the loan will default on the loan repayment?
(ii) A customer after availing the loan, defaults on loan repayment. What is the probability that he availed the loan at a variable rate of interest?

16. Three persons viz. Amber, Bonzi and Comet are manufacturing cars which run on petrol and on battery as well. Their production share in the market is 60%, 30% and 10% respectively.

Of their respective production capacities, 20%, 10% and 5% cars respectively are electric (or battery operated).



Based on the above, answer the following.

(i) (a) What is the probability that a randomly selected car is an electric car?

OR

(i) (b) What is the probability that a randomly selected car is a petrol car?

(ii) A car is selected at random and is found to be electric. What is the probability that it was manufactured by Comet?

(iii) A car is selected at random and is found to be electric. What is the probability that it was manufactured by Amber or Bonzi?

17. Some students are having a misconception while comparing decimals. For example, a student may mention that $78.56 > 78.9$ as $7856 > 789$. In order to assess this concept, a decimal comparison test was administered to the students of class VI through the following question.
In the recently held Sports Day in the school, 5 students participated in a javelin throw competition. The distances to which they have thrown the javelin are shown below in the table.

Name of student	Distance of javelin (in meters)
Ajay	47.7
Bijoy	47.07
Kartik	43.09
Dinesh	43.9
Devesh	45.2

The students were asked to identify who has thrown the javelin the farthest.
Based on the test attempted by the students, the teacher concludes that 40% of the students have the misconception in the concept of decimal comparison and the rest do not have the misconception. 80% of the students having misconception answered Bijoy as the correct answer in the paper. 90% of the students, who are identified with not having misconception, did not answer Bijoy as their answer.

On the basis of the above information, answer the following questions.

(i) What is the probability of a student not having misconception but still answers Bijoy in the test?

(ii) What is the probability that a randomly selected student answers Bijoy as his answer in the test?

(iii) (a) What is the probability that a student who answered as Bijoy is having misconception?

OR

(iii) (b) What is the probability that a student who answered as Bijoy is amongst students who do not have the misconception?

18. A gardener wanted to plant vegetables in his garden. Hence he bought 10 seeds of brinjal plant, 12 seeds of cabbage plant and 8 seeds of radish plant. The shopkeeper assured him of germination probabilities of brinjal, cabbage and radish to be 25%, 35% and 40% respectively.

But before he could plant the seeds, they got mixed up in the bag and he had to sow them randomly.

Radish

Cabbage

Brinjal

Based upon the above information, answer the following questions.
(i) Calculate the probability of a randomly chosen seed to germinate.
(ii) What is the probability that it is a cabbage seed, given that the chosen seed germinates?

19. A shop selling electronic items sells smart phones of only three reputed companies A, B and C because chances of their manufacturing a defective smart phone are only 5%, 4% and 2% respectively. In his inventory he has 25% smart phones from company A, 35% smart phones from company B and 40% smart phones from company C.
A person buys a smart phone from this shop.
(i) Find the probability that it was defective.
(ii) What is the probability that this defective smart phone was manufactured by company B?

20. Based upon the results of regular medical check-ups in a hospital, it was found that out of 1000 people, 700 were very healthy, 200 maintained average health and 100 had a poor health record.
Let A_1 : People with good health,
A_2 : People with average health,
and A_3 : People with poor health.
During a pandemic, the data expressed that the chances of people contracting the disease from category A_1, A_2 and A_3 are 25%, 35% and 50% respectively.
Based on upon the above information, answer the following questions:
(i) A person was tested randomly. What is the probability that he/she has contracted the disease?
(ii) Given that the person has not contracted the disease, what is the probability that the person is from category A_2 ?

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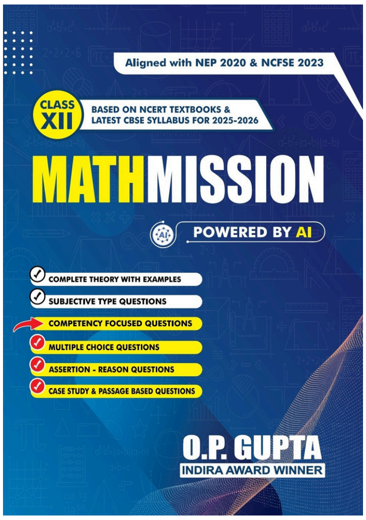

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ABOUT THE AUTHOR

O.P. GUPTA having taught math passionately over a decade, has devoted himself to this subject. Every book, study material or practice sheets, tests he has written, tries to teach serious math in a way that allows the students to learn math without being afraid. Undoubtedly his mathematics books are best sellers on Amazon and Flipkart. His resources have helped students and teachers for a long time across the country. He has contributed in CBSE Question Bank (issued in April 2021). Mr Gupta has been invited by many educational institutions for hosting sessions for the students of senior classes. Being qualified as an electronics & communications engineer, he has pursued his graduation later on with mathematics from University of Delhi due to his passion towards mathematics. He has been honored with the prestigious INDIRA AWARD by the Govt. of Delhi for excellence in education.

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