

Question Paper

Conducted by the Central Board of Secondary Education (CBSE)



Time Allowed: 3 Hours

Maximum Marks: 80

General Instructions

- (i) This question paper contains **38 questions**. All questions are compulsory.
- (ii) Section A: Questions 1 to 18 are multiple choice questions and Questions 19 and 20 are Assertion-Reason questions. Each carries 1 mark.
- (iii) Section B: Questions 21 to 25 carry 2 marks each.
- (iv) Section C: Questions 26 to 31 carry 3 marks each.
- (v) Section D: Questions 32 to 35 carry 5 marks each.
- (vi) Section E: Questions 36 to 38 carry 4 marks each. These are case study questions.
- (vii) Attempt one alternative where an internal choice is provided. Follow the instructions within each question.
- (viii) Use of calculators is not allowed.

Section A

1. Let R be a relation in the set $\mathbb{N}$ given by $R = \{(a, b) : a = b - 2, b > 6\}$. Then:

- (A) $(8, 7) \in R$ (B) $(6, 8) \in R$
(C) $(3, 8) \in R$ (D) $(2, 4) \in R$

2. If $A = \begin{pmatrix} 5 & x \\ y & 0 \end{pmatrix}$ and $A = A^T$, where A^T is the transpose of the matrix A , then:

- (A) $x = 0, y = 5$ (B) $x = y$
(C) $x + y = 5$ (D) $x = 5, y = 0$

3. $\sin \left[\frac{\pi}{3} + \sin^{-1} \left(\frac{1}{2} \right) \right]$ is equal to:

- (A) 1 (B) $\frac{1}{2}$
(C) $\frac{1}{3}$ (D) $\frac{1}{4}$

4. For a square matrix A , if $A^2 - A + I = O$, then A^{-1} equals:

- (A) A (B) $A + I$
(C) $I - A$ (D) $A - I$

5. If $\begin{vmatrix} \alpha & 3 & 4 \\ 1 & 2 & 1 \\ 1 & 4 & 1 \end{vmatrix} = 0$, then the value of α is:

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

6. If $f(x) = |\cos x|$, then $f\left(\frac{3\pi}{4}\right)$ is:

- (A) 1 (B) -1
(C) $\frac{-1}{\sqrt{2}}$ (D) $\frac{1}{\sqrt{2}}$

7. If $x = A \cos 4t + B \sin 4t$, then $\frac{d^2x}{dt^2}$ is equal to:

- (A) x (B) $-x$
(C) $16x$ (D) $-16x$

8. The function $f(x) = [x]$, where $[x]$ denotes the greatest integer less than or equal to x , is continuous at:

- (A) $x = 1$ (B) $x = 1.5$
(C) $x = -2$ (D) $x = 4$

9. The function $f(x) = x^3 + 3x$ is increasing in interval:

- (A) $(-\infty, 0)$ (B) $(0, \infty)$
(C) $\mathbb{R}$ (D) $(0, 1)$

10. The value of $\int_{-1}^1 \frac{|x-2|}{x-2} dx$, $x \neq 2$, is:

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

11. $\int \frac{\sec x}{\sec x - \tan x} dx$ equals:

- (A) $\sec x - \tan x + c$ (B) $\sec x + \tan x + c$
(C) $\tan x - \sec x + c$ (D) $-(\sec x + \tan x) + c$

12. The order and the degree of the differential equation $\left(1 + 3 \frac{dy}{dx}\right)^2 = 4 \frac{d^3y}{dx^3}$ respectively are:

- (A) 1, $\frac{2}{3}$ (B) 3, 1
(C) 3, 3 (D) 1, 2

13. If $\vec{a} \cdot \hat{i} = \vec{a} \cdot (\hat{i} + \hat{j}) = \vec{a} \cdot (\hat{i} + \hat{j} + \hat{k}) = 1$, then $\vec{a}$ is:

- (A) $\hat{k}$ (B) $\hat{i}$
(C) $\hat{j}$ (D) $\hat{i} + \hat{j} + \hat{k}$

14. Five fair coins are tossed simultaneously. The probability of the event that at least one head comes up is:

- (A) $\frac{27}{32}$ (B) $\frac{5}{32}$
(C) $\frac{31}{32}$ (D) $\frac{1}{32}$

15. If for any two events A and B , $P(A) = \frac{4}{5}$ and $P(A \cap B) = \frac{7}{10}$, then $P(B/A)$ is equal to:

- (A) $\frac{1}{10}$ (B) $\frac{1}{8}$
(C) $\frac{7}{8}$ (D) $\frac{17}{20}$

16. The angle between the lines $2x = 3y = -z$ and $6x = -y = -4z$ is:

- (A) 0° (B) 30°
(C) 45° (D) 90°

17. If a line makes angles of 90° , 135° and 45° with the x , y and z axes respectively, then its direction cosines are:

- (A) $0, -\frac{1}{\sqrt{2}}, \frac{1}{\sqrt{2}}$ (B) $-\frac{1}{\sqrt{2}}, 0, \frac{1}{\sqrt{2}}$
(C) $\frac{1}{\sqrt{2}}, 0, -\frac{1}{\sqrt{2}}$ (D) $0, \frac{1}{\sqrt{2}}, \frac{1}{\sqrt{2}}$

18. The magnitude of the vector $6\hat{i} - 2\hat{j} + 3\hat{k}$ is:

- (A) 1 (B) 5
(C) 7 (D) 12

19. Assertion (A): $\int_2^8 \frac{\sqrt{10-x}}{\sqrt{x} + \sqrt{10-x}} dx = 3$.

Reason (R): $\int_a^b f(x) dx = \int_a^b f(a+b-x) dx$.

- (A) Both (A) and (R) are true and (R) is the correct explanation of (A).
(B) Both (A) and (R) are true, but (R) is not the correct explanation of (A).
(C) (A) is true and (R) is false.
(D) (A) is false, but (R) is true.

20. Assertion (A): Two coins are tossed simultaneously. The probability of getting two heads, if it is known that at least one head comes up, is $\frac{1}{3}$.

Reason (R): Let E and F be two events with a random experiment, then $P(F/E) = \frac{P(E \cap F)}{P(E)}$.

- (A) Both (A) and (R) are true and (R) is the correct explanation of (A).
(B) Both (A) and (R) are true, but (R) is not the correct explanation of (A).
(C) (A) is true and (R) is false.
(D) (A) is false, but (R) is true.

Section B

21. (a) Find the value of k for which the function f given as $f(x) = \begin{cases} \frac{1 - \cos x}{2x^2}, & x \neq 0 \\ k, & x = 0 \end{cases}$ is continuous at $x = 0$.

OR

- (b) If $x = a \cos t$ and $y = b \sin t$, then find $\frac{d^2y}{dx^2}$.

22. Find the value of $\tan^{-1} \left[2 \cos \left(2 \sin^{-1} \frac{1}{2} \right) \right] + \tan^{-1} 1$.

23. Find the vector and the cartesian equations of a line that passes through the point $A(1, 2, -1)$ and is parallel to the line $5x - 25 = 14 - 7y = 35z$.

24. Sketch the region bounded by the lines $2x + y = 8$, $y = 2$, $y = 4$ and the y -axis. Hence, obtain its area using integration.

- 25(a). If the vectors $\vec{a}$ and $\vec{b}$ are such that $|\vec{a}| = 3$, $|\vec{b}| = \frac{2}{3}$ and $\vec{a} \times \vec{b}$ is a unit vector, then find the angle between $\vec{a}$ and $\vec{b}$.

OR

- 25(b). Find the area of a parallelogram whose adjacent sides are determined by the vectors $\vec{a} = \hat{i} - \hat{j} + 3\hat{k}$ and $\vec{b} = 2\hat{i} - 7\hat{j} + \hat{k}$.

Section C

26. Show that the determinant

$$\begin{vmatrix} x & \sin \theta & \cos \theta \\ -\sin \theta & -x & 1 \\ \cos \theta & 1 & x \end{vmatrix} \text{ is independent of } \theta.$$

27. Using integration, find the area of the region bounded by $y = mx$ ($m > 0$), $x = 1$, $x = 2$ and the x -axis.

28. (a) Find the coordinates of the foot of the perpendicular drawn from point $(5, 7, 3)$ to the line $\frac{x-15}{3} = \frac{y-29}{8} = \frac{z-5}{-5}$.

OR

(b) If $\vec{a} = \hat{i} + \hat{j} + \hat{k}$ and $\vec{b} = \hat{i} + 2\hat{j} + 3\hat{k}$, then find a unit vector perpendicular to both $\vec{a} + \vec{b}$ and $\vec{a} - \vec{b}$.

29. Find the distance between the lines:

$$\vec{r} = (\hat{i} + 2\hat{j} - 4\hat{k}) + \lambda(2\hat{i} + 3\hat{j} + 6\hat{k})$$

$$\vec{r} = (3\hat{i} + 3\hat{j} - 5\hat{k}) + \mu(4\hat{i} + 6\hat{j} + 12\hat{k})$$

30(a). Differentiate $\sec^{-1}\left(\frac{1}{\sqrt{1-x^2}}\right)$ w.r.t. $\sin^{-1}(2x\sqrt{1-x^2})$.

OR

30(b). If $y = \tan x + \sec x$, then prove that $\frac{d^2y}{dx^2} = \frac{\cos x}{(1 - \sin x)^2}$.

31(a). Evaluate: $\int_0^{2\pi} \frac{1}{1 + e^{\sin x}} dx$.

OR

31(b). Find: $\int \frac{x^4}{(x-1)(x^2+1)} dx$.

Section D

32. Solve the following Linear Programming Problem graphically:

Minimise $Z = 60x + 80y$ subject to constraints
 $3x + 4y \geq 8$, $5x + 2y \geq 11$, $x, y \geq 0$.

33(a). The median of an equilateral triangle is increasing at the rate of $2\sqrt{3}$ cm/s. Find the rate at which its side is increasing.

OR

33(b). Sum of two numbers is 5. If the sum of the cubes of these numbers is least, then find the sum of the squares of these numbers.

34. Evaluate: $\int_0^{\pi/2} \sin 2x \tan^{-1}(\sin x) dx$.

35(a). In answering a question on a multiple choice test, a student either knows the answer or guesses. Let $\frac{3}{5}$ be the probability that he knows the answer and $\frac{2}{5}$ be the probability that he guesses. Assuming that a student who guesses at the answer will be correct with probability $\frac{1}{3}$. What is the probability that the student knows the answer, given that he answered it correctly?

OR

35(b). A box contains 10 tickets, 2 of which carry a prize of ₹ 8 each, 5 of which carry a prize of ₹ 4 each, and remaining 3 carry a prize of ₹ 2 each. If one ticket is drawn at random, find the mean value of the prize.

36. An organization conducted a bike race under two different categories - Boys and Girls. There were 28 participants in all. Among all of them, finally three from category 1 and two from category 2 were selected for the final race. Ravi forms two sets B and G with these participants for his college project.

Let $B = \{b_1, b_2, b_3\}$ and $G = \{g_1, g_2\}$, where B represents the set of Boys selected and G the set of Girls selected for the final race.

Based on the above information, answer the following questions.

36(I). How many relations are possible from B to G ?

36(II). Among all the possible relations from B to G , how many functions can be formed from B to G ?

36(III). (a) Let $R : B \rightarrow B$ be defined by $R = \{(x, y) : x \text{ and } y \text{ are students of the same sex}\}$. Check if R is an equivalence relation.

OR

(b) A function $f : B \rightarrow G$ be defined by $f = \{(b_1, g_1), (b_2, g_2), (b_3, g_1)\}$. Check if f is bijective. Justify your answer.

37. Gautam buys 5 pens, 3 bags and 1 instrument box and pays a sum of Rs. 160. From the same shop, Vikram buys 2 pens, 1 bag and 3 instrument boxes and pays a sum of Rs. 190. Also Ankur buys 1 pen, 2 bags and 4 instrument boxes and pays a sum of Rs. 250.

Based on the above information, answer the following questions.

37(I). Convert the given above situation into a matrix equation of the form $AX = B$.

37(II). Find $|A|$.

37(III). (a) Find A^{-1} .

OR

(b) Determine $P = A^2 - 5A$.

38. An equation involving derivatives of the dependent variable with respect to the independent variables is called a differential equation. A differential equation of the form $\frac{dy}{dx} = F(x, y)$ is said to be homogeneous if $F(x, y)$ is a homogeneous function of degree zero, whereas a function $F(x, y)$ is a homogeneous function of degree n if $F(\lambda x, \lambda y) = \lambda^n F(x, y)$. To solve a homogeneous differential equation of the type $\frac{dy}{dx} = F(x, y) = g\left(\frac{y}{x}\right)$, we make the substitution $y = vx$ and then separate the variables.

Based on the above, answer the following questions.

38(I). Show that $(x^2 - y^2) dx + 2xy dy = 0$ is a differential equation of the type $\frac{dy}{dx} = g\left(\frac{y}{x}\right)$.

38(II). Solve the above equation to find its general solution.

- End of Question Paper -