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PRACTICE QUESTION PAPER - III
CLASS XII - MATHEMATICS (041)

Time Allowed: 3 Hours

Maximum Marks: 80

General Instructions:

1. This Question Paper contains **38** questions. All questions are compulsory.
 2. The question paper is divided into FIVE Sections – A, B, C, D and E.
 3. Section **A** comprises of **20** questions of **1** mark each. (18 MCQs + 2 Assertion-Reasoning)
 4. Section **B** comprises of **5** questions of **2** marks each.
 5. Section **C** comprises of **6** questions of **3** marks each.
 6. Section **D** comprises of **4** questions of **5** marks each.
 7. Section **E** comprises of **3** Case Study Based Questions of **4** marks each.
 8. There is no overall choice in the question paper. However, an internal choice has been provided in **2** questions in Section B, **3** questions in Section C, **2** questions in Section D and **2** questions in Section E (in the sub-parts).
 9. Use of calculators is **not** permitted.
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SECTION A (20 Marks)

This section comprises 20 questions of 1 mark each. Questions 1-18 are Multiple Choice Questions (MCQs) and questions 19-20 are Assertion-Reason based questions.

Multiple Choice Questions (MCQs)

1. Let $f : \mathbb{R} \rightarrow \mathbb{R}$ be defined by $f(x) = x^3$. Then f is:
 - (a) One-one but not onto
 - (b) Onto but not one-one
 - (c) Neither one-one nor onto
 - (d) Both one-one and onto (**Answer**)
2. The value of $\sin^{-1}(\cos x)$ where $x \in (\frac{\pi}{2}, \pi)$ is:
 - (a) $x - \frac{\pi}{2}$ (**Answer**)
 - (b) $\frac{\pi}{2} - x$
 - (c) $\frac{3\pi}{2} - x$
 - (d) $x - \frac{3\pi}{2}$
3. The number of bijective functions from a set A of size n to itself is:
 - (a) n^2
 - (b) 2^n
 - (c) $n!$ (**Answer**)

- (d) n^n
4. The domain of the function $f(x) = \sin^{-1}(2x - 1)$ is:
- (a) $[0, 1]$ (**Answer**)
 - (b) $[-1, 1]$
 - (c) $(-1, 1)$
 - (d) $[-\pi/2, \pi/2]$
5. If $f(x) = |\cos x|$ and $g(x) = x^2$, then $(g \circ f)\left(\frac{\pi}{4}\right)$ is:
- (a) $1/2$ (**Answer**)
 - (b) $1/\sqrt{2}$
 - (c) 1
 - (d) $\pi/2$
6. If A is a square matrix such that $A^2 = I$, then $(A - I)^3 + (A + I)^3 - 7A$ is equal to:
- (a) A (**Answer**)
 - (b) $I - A$
 - (c) $I + A$
 - (d) $3A$
7. For a non-zero scalar k , if A is a square matrix of order 3, then $|kA|$ is equal to:
- (a) $k|A|$
 - (b) $k^2|A|$
 - (c) $k^3|A|$ (**Answer**)
 - (d) $|A|$
8. If $A = \begin{bmatrix} 1 & 2 \\ 3 & 4 \end{bmatrix}$, then $A(\text{adj}(A))$ is equal to:
- (a) $-2I$ (**Answer**)
 - (b) $2I$
 - (c) I
 - (d) 0
9. The system of equations $x + y + z = 1$, $2x + 2y + 2z = 2$, and $3x + 3y + 3z = 3$ has:
- (a) A unique solution
 - (b) No solution
 - (c) Infinitely many solutions (**Answer**)
 - (d) Exactly two solutions
10. If A is a matrix such that $A \cdot \begin{bmatrix} 1 \\ 2 \end{bmatrix} = \begin{bmatrix} 3 \\ 4 \end{bmatrix}$, then the order of matrix A must be:
- (a) 2×2 (**Answer**)
 - (b) 2×1
 - (c) 1×2

- (d) 2×3
11. The derivative of $\log(\sec x + \tan x)$ with respect to x is:
- (a) $\cos x$
 - (b) $\tan x$
 - (c) $\sec x$ (**Answer**)
 - (d) $\sec x + \tan x$
12. If $y = x^{\sin x}$, then $\frac{dy}{dx}$ is:
- (a) $\sin x \cdot x^{\sin x - 1}$
 - (b) $x^{\sin x}(\cos x \log x)$
 - (c) $x^{\sin x} \left(\frac{\sin x}{x} + \cos x \log x \right)$ (**Answer**)
 - (d) $x^{\sin x} \left(\frac{\sin x}{x} \right)$
13. The value of $\int e^x(\tan x + \sec^2 x) dx$ is:
- (a) $e^x \sec x + C$
 - (b) $e^x \tan x + C$ (**Answer**)
 - (c) $e^x(\tan x + \sec x) + C$
 - (d) $e^x \cot x + C$
14. The slope of the normal to the curve $y = 2x^2 + 3 \sin x$ at $x = 0$ is:
- (a) 3
 - (b) $-\frac{1}{3}$ (**Answer**)
 - (c) -3
 - (d) $\frac{1}{3}$
15. The general solution of the differential equation $\frac{dy}{dx} = \frac{1+y^2}{1+x^2}$ is:
- (a) $\tan^{-1} y = \tan^{-1} x + C$ (**Answer**)
 - (b) $\tan^{-1} x = \tan^{-1} y + C$
 - (c) $\log(1 + y^2) = \log(1 + x^2) + C$
 - (d) $\tan(y) = \tan(x) + C$
16. The area bounded by the curve $y = \cos x$ between $x = 0$ and $x = \pi$ is:
- (a) 1 sq. unit
 - (b) 2 sq. units (**Answer**)
 - (c) 4 sq. units
 - (d) π sq. units
17. If \vec{a} and \vec{b} are two vectors such that $|\vec{a} + \vec{b}| = |\vec{a} - \vec{b}|$, then \vec{a} and \vec{b} are:
- (a) Parallel
 - (b) Perpendicular (**Answer**)
 - (c) Inclined at 60°
 - (d) Inclined at 45°

18. The vector equation of the plane $2x - 3y + 4z = 6$ is:

- (a) $\vec{r} \cdot (2\hat{i} - 3\hat{j} + 4\hat{k}) = 6$ (Answer)
- (b) $\vec{r} \cdot (2\hat{i} - 3\hat{j} + 4\hat{k}) = 1$
- (c) $2\hat{i} - 3\hat{j} + 4\hat{k} = 6$
- (d) $\vec{r} \cdot (2\hat{i} + 3\hat{j} + 4\hat{k}) = 6$

Assertion-Reasoning Based Questions

Questions 19 and 20 are Assertion-Reasoning based questions. In these questions, a statement of Assertion (A) is followed by a statement of Reason (R). Choose the correct answer from the following options:

- (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 but R is false.
 - (d) A is false but R is true.
19. **Assertion (A):** The function $f(x) = \sin x$ has a local maxima at $x = \pi/2$ in $(0, \pi)$.
Reason (R): For a continuous function, a local maxima occurs at a critical point c if $f'(c) = 0$ or $f'(c)$ is undefined.
Correct Option: (b) Both A and R are true but R is not the correct explanation of A.
20. **Assertion (A):** The optimal solution of a LPP (if it exists) must lie at a corner point of the feasible region. **Reason (R):** The feasible region is formed by a set of linear inequalities, and its vertices correspond to the optimal solutions.
Correct Option: (c) A is true but R is false.

SECTION B (10 Marks)

This section comprises 5 questions of 2 marks each.

21. If $x = a(\theta + \sin \theta)$ and $y = a(1 - \cos \theta)$, find $\frac{dy}{dx}$.

Answer: $\frac{dy}{dx} = \frac{\sin \theta}{1 + \cos \theta}$ or $\tan(\frac{\theta}{2})$

22. Find the angle between the two vectors \vec{a} and \vec{b} with magnitudes $\sqrt{3}$ and 2, respectively, having $\vec{a} \cdot \vec{b} = \sqrt{6}$.

Answer: $\theta = 30^\circ$ or $\frac{\pi}{6}$

OR

Find the direction ratios of the line perpendicular to the lines $\frac{x-1}{2} = \frac{y-2}{3} = \frac{z+3}{4}$ and $\frac{x-2}{3} = \frac{y-4}{4} = \frac{z-5}{5}$.

Answer: Direction ratios are $(-1, 2, -1)$ or $(1, -2, 1)$

23. Evaluate $\int \frac{x \sin^{-1}(x)}{\sqrt{1-x^2}} dx$.

Answer: $x - \sqrt{1-x^2} \sin^{-1}(x) + C$

OR

Evaluate $\int_0^{\pi/4} \tan^2 x \, dx$.

Answer: $1 - \frac{\pi}{4}$

24. If $A = \begin{bmatrix} 2 & -3 \\ 4 & 5 \end{bmatrix}$, find $A^2 - 7A + 22I$.

Answer: $\begin{bmatrix} 0 & 0 \\ 0 & 0 \end{bmatrix}$ (Zero Matrix)

25. A die is thrown three times. Find the probability of getting exactly one six.

Answer: $\frac{25}{72}$

SECTION C (18 Marks)

This section comprises 6 questions of 3 marks each.

26. Show that the relation R in the set $A = \{x \in \mathbb{Z} : 0 \leq x \leq 12\}$ given by $R = \{(a, b) : |a - b| \text{ is a multiple of } 4\}$ is an equivalence relation.

Answer: Proof: R is reflexive, symmetric, and transitive. Equivalence classes: $\{0, 4, 8, 12\}$, $\{1, 5, 9\}$, $\{2, 6, 10\}$

27. Find the points on the curve $\frac{x^2}{9} + \frac{y^2}{16} = 1$ at which the tangents are parallel to the x -axis.

Answer: $(0, 4)$ and $(0, -4)$

OR

A balloon, which always remains spherical, has a variable radius. Find the rate at which its volume is increasing with respect to its radius when the radius is 10 cm.

Answer: $400\pi \text{ cm}^3/\text{cm}$

28. Find the general solution of the differential equation $\frac{dy}{dx} = \frac{x^2 + y^2}{2xy}$.

Answer: $x^2 - y^2 = Cx$

OR

Find the particular solution of the differential equation $x \frac{dy}{dx} + 2y = x^2 \log x$, given that $y(1) = 0$.

Answer: $y = \frac{x^2}{4} \left(\log x - \frac{1}{4} \right) + \frac{1}{16x^2}$ or $y = \frac{x^2}{4} \log x - \frac{x^2}{16} + \frac{1}{16x^2}$

29. Find the distance of the point $(2, 3, -5)$ from the plane $\vec{r} \cdot (\hat{i} + 2\hat{j} - 2\hat{k}) = 9$.

Answer: Distance = $\frac{5}{3}$ units

OR

Find the value of λ such that the vectors $\vec{a} = \hat{i} + 3\hat{j} + \hat{k}$, $\vec{b} = 2\hat{i} - \hat{j} - \hat{k}$ and $\vec{c} = \lambda\hat{i} + 7\hat{j} + 3\hat{k}$ are coplanar.

Answer: $\lambda = 1$

30. Find the inverse of the matrix $A = \begin{bmatrix} 2 & -1 \\ 3 & 4 \end{bmatrix}$ using Elementary Column Operations.

Answer: $A^{-1} = \frac{1}{11} \begin{bmatrix} 4 & 1 \\ -3 & 2 \end{bmatrix}$

31. Find the corner points of the feasible region determined by the following constraints:
 $x + y \leq 4$, $2x + y \leq 5$, $x \geq 0$, $y \geq 0$.
Answer: Corner points: $(0, 0)$, $(2.5, 0)$, $(1, 3)$, $(0, 4)$
-

SECTION D (20 Marks)

This section comprises 4 questions of 5 marks each.

33. Find the area of the region bounded by $y = x^2$ and $y = |x|$.
Answer: $\frac{1}{3}$ square units

OR

Find the area of the smaller region bounded by the ellipse $\frac{x^2}{9} + \frac{y^2}{4} = 1$ and the line $\frac{x}{3} + \frac{y}{2} = 1$.
Answer: $\frac{3}{2}(\pi - 2)$ square units

34. Solve the following system of linear equations using the matrix method:

$$2x - 3y + 5z = 11$$

$$3x + 2y - 4z = -5$$

$$x + y - 2z = -3$$

Answer: $x = 1$, $y = 2$, $z = 3$

35. Show that of all the rectangles inscribed in a given fixed circle, the square has the maximum area.
Answer: Proof using maxima-minima.

OR

Evaluate $\int_0^a \frac{\sqrt{x}}{\sqrt{x} + \sqrt{a-x}} dx$.

Answer: $\frac{a}{2}$

36. Find the coordinates of the foot of the perpendicular drawn from the point $A(1, 8, 4)$ to the line $\frac{x-1}{2} = \frac{y-3}{1} = \frac{z-4}{3}$. Also, find the perpendicular distance.
Answer: Foot = $(3, 4, 7)$, Distance = $\sqrt{21}$ units
-

SECTION E (12 Marks)

This section comprises 3 case study based questions of 4 marks each.

37. Case Study 1: Geometric Mean and Dot Product

In a Physics experiment, forces are applied to a particle. The forces are represented by vectors $\vec{F}_1 = 2\hat{i} + 3\hat{j} + 4\hat{k}$ and $\vec{F}_2 = \hat{i} + 2\hat{j} + \hat{k}$. The particle is displaced from point $A(1, 1, 1)$ to $B(2, 3, 5)$.

Based on the given information, answer the following questions:

(a) Find the resultant force vector, $\vec{F} = \vec{F}_1 + \vec{F}_2$. (1 Mark)

Answer: $\vec{F} = 3\hat{i} + 5\hat{j} + 5\hat{k}$

(b) Find the displacement vector, \vec{d} . (1 Mark)

Answer: $\vec{d} = \hat{i} + 2\hat{j} + 4\hat{k}$

(c) Calculate the work done by the resultant force, given by $W = \vec{F} \cdot \vec{d}$. (2 Marks)

Answer: $W = 33$ units

OR

(d) Find the vector component of \vec{F}_1 along \vec{F}_2 . (2 Marks)

Answer: Component = $\frac{12}{6}(\hat{i} + 2\hat{j} + \hat{k}) = 2(\hat{i} + 2\hat{j} + \hat{k})$

38. Case Study 2: Inspection and Conditional Probability

A manufacturing plant has three machines M_1, M_2, M_3 . The production rates are 25%, 35%, 40% respectively. Past data shows that 2%, 4%, 5% of the items produced by M_1, M_2, M_3 are defective, respectively. An item is selected at random from the total production.

Based on the given information, answer the following questions:

(a) Find the probability that the item was produced by machine M_3 . (1 Mark)

Answer: $P(M_3) = 0.4$ or $\frac{2}{5}$

(b) Find the probability that the item is defective. (3 Marks)

Answer: $P(D) = 0.039$ or $\frac{39}{1000}$

OR

(c) If the item selected is found to be defective, find the probability that it was produced by machine M_2 . (3 Marks)

Answer: $P(M_2|D) = \frac{0.014}{0.039} = \frac{14}{39}$

39. Case Study 3: Area Under Curve and Limits

A physical quantity is modeled by the function $f(x) = \begin{cases} x^2, & 0 \leq x \leq 1 \\ 2-x, & 1 < x \leq 2 \end{cases}$. This function describes the shape of a profile section in engineering design over the interval $[0, 2]$.

Based on the given information, answer the following questions:

(a) Check if the function $f(x)$ is continuous at $x = 1$. (1 Mark)

Answer: Yes, the function is continuous at $x = 1$.

(b) Calculate the total area under the curve $f(x)$ over the interval $[0, 2]$. (3 Marks)

Answer: Area = $\frac{5}{6}$ square units

OR

(c) Find the value of $\int_0^2 xf(x) dx$. (3 Marks)

Answer: $\frac{5}{4}$