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Your JEE Guide

MP Board Class XII · Higher Mathematics

Sample Question Paper 4 · Session 2026-27

Time allowed: 3 hours **Maximum marks: 80**

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This is an original practice paper written to the MPBSE 2027 sample question paper pattern; it is not issued by MPBSE.

General instructions:

1. All questions are compulsory.
2. Sub-questions of question numbers 1 to 5 carry 1 mark each.
3. Question numbers 6 to 15 carry 2 marks each.
4. Question numbers 16 to 19 carry 3 marks each.
5. Question numbers 20 to 23 carry 4 marks each.
6. Internal choices are provided for question numbers 16 to 23.
7. Draw neat and clean labelled diagrams wherever required.

1.	**(i)** *Choose and write the correct option:* The function f: $\mathbb{R} \to \mathbb{R}$, $f(x) = x^3$ is: (a) neither one-one nor onto (b) onto but not one-one (c) one-one but not onto (d) one-one and onto	1
	(ii) The value of $\cos\left(\sin^{-1}\frac{3}{5}\right)$ is: (a) $\frac{5}{4}$ (b) $\frac{4}{5}$ (c) $\frac{3}{5}$ (d) $\frac{3}{4}$	1
	(iii) If $A = \begin{bmatrix} 0 & 1 \\ 0 & 0 \end{bmatrix}$, then A^2 is: (a) the zero matrix O (b) A (c) I (d) 2A	1
	(iv) If $y = e^{3x}$, then $\frac{d^2y}{dx^2}$ is: (a) $6e^{3x}$ (b) $3e^{3x}$ (c) $9e^{3x}$ (d) e^{3x}	1
	(v) $\int_0^1 \frac{dx}{1+x^2}$ equals: (a) $\frac{\pi}{2}$ (b) $\frac{\pi}{4}$ (c) 1 (d) 0	1
	(vi) If $\lvert\vec{a}\rvert = 2$, $\lvert\vec{b}\rvert = 3$ and $\vec{a} \perp \vec{b}$, then $\lvert\vec{a} \times \vec{b}\rvert$ is: (a) 0 (b) 5 (c) 6 (d) 1	1

2.	**(i)** *Fill in the blanks:* The relation R = {(a, b): a = b} on a set A is called the _____ relation.	1
	(ii) $\sin^{-1} x + \cos^{-1} x$ = _____, for x in [–1, 1].	1
	(iii) A square matrix in which every non-diagonal element is zero is called a _____ matrix.	1
	(iv) $\frac{d}{dx}\sqrt{x}$ = _____.	1
	(v) $\int \sin x \, dx$ = _____.	1
	(vi) Two events A and B are mutually exclusive if P(A ∩ B) = _____.	1
3.	**(i)** *Write True or False:* The relation "is parallel to" on the set of lines in a plane is reflexive.	1
	(ii) $\tan^{-1} x$ is defined for every real number x.	1
	(iii) Matrix multiplication is commutative.	1
	(iv) The function sin x is continuous at every real number.	1
	(v) $\int_0^{2a} f(x)\,dx = 2\int_0^a f(x)\,dx$ for every function f.	1
	(vi) The vectors $\hat{i} + \hat{j}$ and $\hat{i} - \hat{j}$ are perpendicular.	1
4.	Match column A with column B:	7

Column A	Column B
(i) $\frac{d}{dx}\cos^{-1} x$	(a) $-\hat{k}$
(ii) $\frac{d}{dx}\sec x$	(b) $-\frac{1}{\sqrt{1-x^2}}$
(iii) $\int \csc^2 x \, dx$	(c) 2
(iv) $\int \sec x \tan x \, dx$	(d) sec x tan x
(v) Order of $y'' + y = 0$	(e) –cot x + C
(vi) $\hat{j} \times \hat{i}$	(f) 1 – P(A)
(vii) P(A′)	(g) sec x + C

5.	**(i)** *Write the answer in one word or one sentence:* If f(x) = x + 1 and g(x) = 2x, write (g ∘ f)(1).	1
	(ii) Write the principal value of $\cos^{-1}\left(-\frac{1}{2}\right)$.	1
	(iii) If A is a 3 × 4 matrix, write the order of its transpose A′.	1
	(iv) If $y = x^2 + 1$, write the value of $\frac{dy}{dx}$ at x = 2.	1

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	(v) Write the value of $\int_0^2 2x\,dx$.	1
	(vi) Write the general solution of the differential equation $\frac{dy}{dx} = 2x$.	1
	(vii) If P(A) = 0.3, write P(not A).	1
6.	Show that f: $\mathbb{R} \to \mathbb{R}$, f(x) = 3 – 4x is one-one.	2
7.	Find the value of $\cos\left(2\sin^{-1}\frac{3}{5}\right)$.	2
8.	Find x and y if $2\begin{bmatrix} x & 5 \\ 7 & y-3 \end{bmatrix} + \begin{bmatrix} 3 & -4 \\ 1 & 2 \end{bmatrix} = \begin{bmatrix} 7 & 6 \\ 15 & 14 \end{bmatrix}$.	2
9.	Using determinants, find the area of the triangle with vertices (1, 0), (6, 0) and (4, 3).	2
10.	Differentiate $\sin^2 x$ with respect to $e^{\cos x}$.	2
11.	Find the maximum value of $f(x) = 10 - (x-1)^2$.	2
12.	Find $\int (\sin x + \cos x)^2\,dx$.	2
13.	Evaluate $\int_0^{\pi/4} \tan^2 x\,dx$.	2
14.	Find λ if the vectors $2\hat{i} + \lambda\hat{j} + \hat{k}$ and $\hat{i} - 2\hat{j} + 3\hat{k}$ are perpendicular.	2
15.	Find the direction cosines of the line joining the points (1, 2, 3) and (3, 4, 4).	2
16.	Show that the relation R = {(a, b): a – b is divisible by 3} on the set of integers $\mathbb{Z}$ is an equivalence relation. **OR** Prove that $2\tan^{-1}\frac{1}{3} + \tan^{-1}\frac{1}{7} = \frac{\pi}{4}$.	3
17.	If $y = (\sin^{-1} x)^2$, show that $(1-x^2)\frac{d^2y}{dx^2} - x\frac{dy}{dx} = 2$. **OR** Find $\frac{dy}{dx}$ if $y = x^{\sin x}$, x > 0.	3
18.	Find $\int x^2 e^x\,dx$. **OR** Find $\int \frac{2x}{(x^2+1)(x^2+3)}\,dx$.	3

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19.	A coin is biased so that a head is three times as likely as a tail. It is tossed twice. Find the probability distribution of the number of tails and its mean. **OR** A and B are independent events with P(A) = 0.3 and P(B) = 0.4. Find P(A ∪ B), P(A | B) and P(A′ ∩ B′).	3
20.	If $A = \begin{bmatrix} 2 & 1 & 1 \\ 1 & 0 & 1 \\ 0 & 1 & 2 \end{bmatrix}$, find A^{-1}. Hence solve 2x + y + z = 7, x + z = 3, y + 2z = 7. **OR** (a) Show that the system x + 2y = 2, 2x + 4y = 3 is inconsistent. *[2]* (b) Solve by the matrix method: 2x + 3y = 13, x − y = −1. *[2]*	4
21.	Two positive numbers x and y have sum 60. Find them if xy^3 is the greatest. **OR** Show that the height of the right circular cylinder of greatest volume that can be inscribed in a sphere of radius R is $\frac{2R}{\sqrt{3}}$.	4
22.	Using integration, find the area of the region bounded by the parabola $y = x^2$ and the line y = 2x + 3. **OR** Find $\int x \tan^{-1} x \, dx$.	4
23.	Solve the differential equation $\frac{dy}{dx} + \frac{3y}{x} = \frac{1}{x^2}$, x > 0. **OR** Solve graphically: Minimise Z = x + 2y subject to 2x + y ≥ 3, x + 2y ≥ 6, x ≥ 0, y ≥ 0.	4

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Answers and Marking Scheme

Marks for each step are shown in brackets. Any correct alternative method gets full credit.

Question 1

(i) **(d)** one-one and onto. *Working:* It is strictly increasing and takes every real value.

(ii) **(b)** $\frac{4}{5}$. *Working:* If $\sin\theta = \frac{3}{5}$ with θ in $\left[-\frac{\pi}{2}, \frac{\pi}{2}\right]$, then $\cos\theta = \frac{4}{5}$.

(iii) **(a)** the zero matrix O. *Working:* Every entry of the product is 0.

(iv) **(c)** $9e^{3x}$. *Working:* Each differentiation multiplies by 3.

(v) **(b)** $\frac{\pi}{4}$. *Working:* $\tan^{-1}1 - \tan^{-1}0$.

(vi) **(c)** 6. *Working:* $|\vec{a}||\vec{b}|\sin 90^\circ$.

Question 2

(i) identity.

(ii) $\frac{\pi}{2}$.

(iii) diagonal.

(iv) $\frac{1}{2\sqrt{x}}$.

(v) –cos x + C.

(vi) 0.

Question 3

(i) True: every line is taken as parallel to itself.

(ii) True.

(iii) False: in general AB ≠ BA.

(iv) True.

(v) False: it holds only when f(2a – x) = f(x).

(vi) True: their dot product is 1 – 1 = 0.

4. (i) – (b) $-\frac{1}{\sqrt{1-x^2}}$; (ii) – (d) sec x tan x; (iii) – (e) –cot x + C; (iv) – (g) sec x + C; (v) – (c) 2; (vi) – (a) $-\hat{k}$; (vii) – (f) 1 – P(A)

Question 5

(i) 4.

(ii) $\frac{2\pi}{3}$.

(iii) 4 × 3.

(iv) 4.

(v) 4.

(vi) $y = x^2 + C$.

(vii) 0.7.

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6. f(a) = f(b) ⇒ 3 − 4a = 3 − 4b (1) ⇒ a = b, so f is one-one (1).

7. With $\theta = \sin^{-1}\frac{3}{5}$, $\cos 2\theta = 1 - 2\sin^2\theta$ (1) $= 1 - \frac{18}{25} = \frac{7}{25}$ (1).

8. Comparing: 2x + 3 = 7, so x = 2 (1); 2(y − 3) + 2 = 14, so y = 9 (1).

9. $\frac{1}{2}\left|\begin{vmatrix}1 & 0 & 1\\ 6 & 0 & 1\\ 4 & 3 & 1\end{vmatrix}\right| = \frac{1}{2}|1(0-3) + 1(18-0)|$ (1) $= \frac{15}{2}$ square units (1).

10. $\frac{d}{dx}\sin^2 x = 2\sin x\cos x$ and $\frac{d}{dx}e^{\cos x} = -\sin x\, e^{\cos x}$ (1). Required derivative $= -\frac{2\cos x}{e^{\cos x}}$ (1).

11. $(x-1)^2 \geq 0$, so f(x) ≤ 10 (1). The maximum value is 10, at x = 1 (1).

12. $(\sin x + \cos x)^2 = 1 + \sin 2x$ (1). Integral $= x - \frac{\cos 2x}{2} + C$ (1).

13. $\tan^2 x = \sec^2 x - 1$, so the integral is $\left[\tan x - x\right]_0^{\pi/4}$ (1) $= 1 - \frac{\pi}{4}$ (1).

14. Dot product = 2 − 2λ + 3 = 0 (1), so $\lambda = \frac{5}{2}$ (1).

15. Direction ratios 2, 2, 1, with $\sqrt{4+4+1} = 3$ (1). Direction cosines $\frac{2}{3}, \frac{2}{3}, \frac{1}{3}$ (1).

16. a − a = 0 is divisible by 3: reflexive (1). If 3 divides a − b, it divides b − a = −(a − b): symmetric (1). If 3 divides a − b and b − c, it divides their sum a − c: transitive (1).

OR $2\tan^{-1}\frac{1}{3} = \tan^{-1}\frac{2/3}{1-1/9} = \tan^{-1}\frac{3}{4}$ (1). $\tan^{-1}\frac{3}{4} + \tan^{-1}\frac{1}{7} = \tan^{-1}\frac{\frac{3}{4}+\frac{1}{7}}{1-\frac{3}{28}} = \tan^{-1}\frac{25/28}{25/28}$ (1) $= \tan^{-1}1 = \frac{\pi}{4}$ (1).

17. $y' = \frac{2\sin^{-1}x}{\sqrt{1-x^2}}$, so $\sqrt{1-x^2}\,y' = 2\sin^{-1}x$ (1). Differentiating: $\sqrt{1-x^2}\,y'' - \frac{x}{\sqrt{1-x^2}}y' = \frac{2}{\sqrt{1-x^2}}$ (1). Multiplying by $\sqrt{1-x^2}$ gives the result (1).

OR log y = sin x log x (1). $\frac{1}{y}\frac{dy}{dx} = \cos x\log x + \frac{\sin x}{x}$ (1). $\frac{dy}{dx} = x^{\sin x}\left(\cos x\log x + \frac{\sin x}{x}\right)$ (1).

18. By parts: $x^2e^x - \int 2xe^x\,dx$ (1). Again by parts: $\int 2xe^x\,dx = 2xe^x - 2e^x$ (1). Integral $= e^x(x^2 - 2x + 2) + C$ (1).

OR Put $t = x^2$: $\int \frac{dt}{(t+1)(t+3)}$ (1). $\frac{1}{(t+1)(t+3)} = \frac{1}{2}\left(\frac{1}{t+1} - \frac{1}{t+3}\right)$ (1). Integral $= \frac{1}{2}\log\frac{x^2+1}{x^2+3} + C$ (1).

19. P(T) = 1/4, P(H) = 3/4 (½). P(X = 0) = 9/16, P(X = 1) = 6/16, P(X = 2) = 1/16 (1½). Mean = 6/16 + 2/16 = 1/2 (1).

OR P(A ∩ B) = 0.12, so P(A ∪ B) = 0.3 + 0.4 − 0.12 = 0.58 (1). P(A | B) = P(A) = 0.3 (1). P(A′ ∩ B′) = 1 − 0.58 = 0.42 (1).

20. |A| = 2(0 − 1) − 1(2 − 0) + 1(1 − 0) = −3 (1). $\operatorname{adj} A = \begin{bmatrix}-1 & -1 & 1\\ -2 & 4 & -1\\ 1 & -2 & -1\end{bmatrix}$, so $A^{-1} = -\frac{1}{3}\operatorname{adj} A$ (1½). $X = A^{-1}B = -\frac{1}{3}\begin{bmatrix}-3\\ -9\\ -6\end{bmatrix}$ (1), so x = 1, y = 3, z = 2 (½).

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OR (a) |A| = 4 − 4 = 0 and $(\operatorname{adj} A)B = \begin{bmatrix} 4 & -2 \\ -2 & 1 \end{bmatrix}\begin{bmatrix} 2 \\ 3 \end{bmatrix} = \begin{bmatrix} 2 \\ -1 \end{bmatrix} \neq O$ (1), so the system has no solution (1). (b) |A| = −5, $\operatorname{adj} A = \begin{bmatrix} -1 & -3 \\ -1 & 2 \end{bmatrix}$ (1). $X = -\frac{1}{5}\begin{bmatrix} -10 \\ -15 \end{bmatrix}$, so x = 2, y = 3 (1).

21. x = 60 − y, so $P = (60 - y)y^3$ (1). $\frac{dP}{dy} = 180y^2 - 4y^3 = 4y^2(45 - y) = 0$ gives y = 45 (1). P′ changes from positive to negative at y = 45, a maximum (1). The numbers are x = 15 and y = 45 (1).

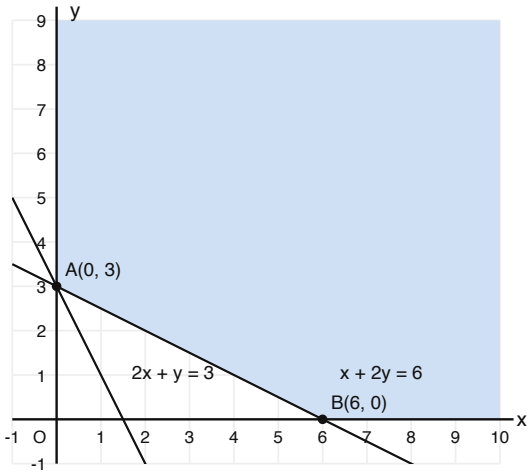
OR With height h and radius r: $r^2 = R^2 - \frac{h^2}{4}$, so $V = \pi\left(R^2 h - \frac{h^3}{4}\right)$ (1). $\frac{dV}{dh} = \pi\left(R^2 - \frac{3h^2}{4}\right) = 0$ gives $h = \frac{2R}{\sqrt{3}}$ (1½). $\frac{d^2V}{dh^2} = -\frac{3\pi h}{2} < 0$, so V is greatest there (1½).

22. $x^2 = 2x + 3$ gives x = −1, 3 (1). Area $= \int_{-1}^{3}(2x + 3 - x^2)\,dx$ (1) $= \left[x^2 + 3x - \frac{x^3}{3}\right]_{-1}^{3} = 9 - \left(-\frac{5}{3}\right)$ (1) $= \frac{32}{3}$ square units (1).

OR By parts: $\frac{x^2}{2}\tan^{-1} x - \int \frac{x^2}{2(1+x^2)}\,dx$ (1½). $\frac{x^2}{1+x^2} = 1 - \frac{1}{1+x^2}$ (1). Integral $= \frac{x^2+1}{2}\tan^{-1} x - \frac{x}{2} + C$ (1½).

23. Linear with $P = \frac{3}{x}$, $Q = \frac{1}{x^2}$ (1). IF $= e^{3\log x} = x^3$ (1). $x^3 y = \int x\,dx = \frac{x^2}{2} + C$ (1), so $y = \frac{1}{2x} + \frac{C}{x^3}$ (1).

OR Feasible region (unbounded) (1½):



Corners A(0, 3) and B(6, 0): Z = 6 at both (1). The half-plane x + 2y < 6 has no point in common with the region, so the minimum is 6, at every point of the segment AB (1½).

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