

ADVANCED MATH CLASSES

@ Think Academy, Najafgarh

(For Half Yearly Exam. Paper)

Class : XII

Syllabus : Chapter 1 to 8

MATHEMATICS-041

For 2026-27 Exams

Maximum Marks : 80

Time : 3 Hours

General Instructions :

- All questions are compulsory.
- This question paper consists of **38 questions** divided into **five sections A, B, C, D and E**.
- Section A comprises of **20 questions of one mark** each (from Q01 - 20).
Section B comprises of **05 questions of two marks** each (from Q21 - 25).
Section C comprises of **06 questions of three marks** each (from Q26 - 31).
Section D comprises of **04 questions of five marks** each (from Q32 - 35).
Section E comprises of **03 Case-study** based question with **sub-parts** (from Q36 - 38).
- There is no overall choice. However, **internal choice** has been provided in
 - **02 Questions of Section B**
 - **03 Questions of Section C**
 - **02 Questions of Section D**
 - **02 Questions of Section E**

You have to attempt only one of the alternatives in all such questions.

SECTION A

(Question numbers 01 to 20 carry **1 mark** each.)

Followings are **multiple choice questions**. Select the correct options (from **Q01 to 18**).

Q01. If A and B are square matrices of the same order and I is the identity matrix of the same order, then which of the following statements is/are always true?

- $(A + I)(A - I) = A^2 - I$
- $(A + B)(A - B) = A^2 - AB + BA - B^2$
- $(A - B)^2 = A^2 - 2AB + B^2$
- If $A^2 = I$, then $A = I$ or $A = -I$

- Only (i) and (ii)
- Only (ii) and (iii)
- Only (i), (ii) and (iv)
- All (i), (ii), (iii) and (iv)

Q02. If $\begin{vmatrix} a & 1 & 2 \\ 2 & a & 0 \\ -1 & 3 & 1 \end{vmatrix} = 25$, then the sum of all possible values of 'a' is

- 2
- 2
- 15
- 5

Q03. The number of points of discontinuities of the greatest integer function $f(x) = [x]$, $0 < x < 4$ is

- one points
- two points
- three points
- infinite points

Q04. If U is $\begin{pmatrix} 1 & 2 & 2 \\ -2 & -1 & -1 \\ 1 & -4 & -3 \end{pmatrix}$, then the value of the element of $P = \begin{pmatrix} 3 & 2 & 0 \end{pmatrix} U \begin{pmatrix} 3 \\ 2 \\ 0 \end{pmatrix}$ is

- 4
- 5
- $\frac{3}{2}$
- $\frac{5}{2}$

- Q05.** If $\int_0^a \frac{1}{\sqrt{1-x^2}} dx = \frac{\pi}{6}$, then the value of $(2a) =$
- (a) $\frac{1}{2}$ (b) $\frac{\sqrt{3}}{2}$ (c) 1 (d) -1
- Q06.** The domain of $f(x) = \cot^{-1}(2026x + 2027)$ is $x \in$
- (a) $[-1, 1]$ (b) $\left[-\frac{2027}{2026}, \frac{2027}{2026}\right]$ (c) $[2026, 2027]$ (d) $(-\infty, \infty)$
- Q07.** $\int \sqrt{1+e^x} dx =$
- (a) $\sqrt{1+e^x} + \log \left| \frac{\sqrt{1+e^x} - 1}{\sqrt{1+e^x} + 1} \right| + C$ (b) $\sqrt{1+e^x} + \log \left| \frac{\sqrt{1+e^x} + 1}{\sqrt{1+e^x} - 1} \right| + C$
- (c) $2\sqrt{1+e^x} - \log \left| \frac{\sqrt{1+e^x} + 1}{\sqrt{1+e^x} - 1} \right| + C$ (d) $2\sqrt{1+e^x} + \log \left| \frac{1 - \sqrt{1+e^x}}{1 + \sqrt{1+e^x}} \right| + C$
- Q08.** Govt. of India is promoting E20 fuel, a blend containing 20% ethanol and 80% petrol, to reduce dependence on fossil fuels. Suppose a relation R is defined on the set A of fuel-based vehicles as $R = \{(a, b) : a \text{ and } b \text{ are compatible with the same E20 fuel standard}\}$. Which one of the following statements is correct?
- (a) R is reflexive and transitive only, but not symmetric
 (b) R is symmetric only but neither reflexive nor transitive
 (c) R is reflexive, symmetric and transitive
 (d) R is neither reflexive, symmetric nor transitive
- Q09.** Let A be a non-zero skew-symmetric matrix of order n ($n \geq 2$), and let I denote the identity matrix of the same order. Which of the following statements is always true?
- (a) $|A| = 0$, for all positive integers n
 (b) $|I - A| = |I + A|$, for any integer $n \geq 2$
 (c) The matrix $A^2 + I$ is skew-symmetric
 (d) If n is even, then $(I + A)$ must be a singular matrix
- Q10.** Using the standard principal-value ranges of inverse trigonometric functions, which one of the following statements is correct?
- (a) $\sin^{-1}\left(-\frac{\sqrt{2}}{2}\right) = \frac{3\pi}{4}$ (b) $\sec^{-1} 2 = -\frac{\pi}{3}$
- (c) $\cot^{-1} \sqrt{3} = \frac{\pi}{3}$ (d) $\operatorname{cosec}^{-1}\left(-\frac{2}{\sqrt{3}}\right) = -\frac{\pi}{3}$
- Q11.** Value of $\frac{d}{dx} \left(x + \frac{x^3}{3} + \frac{x^5}{5} + \dots \right)$ is
- (a) $\frac{1}{1-x^2}$ (b) $\frac{1}{1+x^2}$ (c) $-\frac{1}{1-x^2}$ (d) $-\frac{1}{1+x^2}$
- Q12.** If $y = \log \frac{\cos x - \sin x}{\cos x + \sin x}$, then $\frac{dy}{dx}$ is equal to
- (a) $2 \sec 2x$ (b) $-2 \operatorname{cosec} 2x$ (c) $-2 \sec 2x$ (d) $2 \operatorname{cosec} 2x$

Q13. If $\Delta_1 = \begin{vmatrix} 2 & 0 & 0 \\ 0 & 3 & 0 \\ 0 & 0 & 4 \end{vmatrix}$ and $\Delta_2 = \begin{vmatrix} 0 & 0 & 4 \\ 0 & 3 & 0 \\ 4 & 0 & 0 \end{vmatrix}$, then

- (a) $\Delta_1 = \Delta_2$ (b) $\Delta_2 = -2\Delta_1$ (c) $\Delta_1 = -\Delta_2$ (d) $\Delta_1 = 2\Delta_2$

Q14. Let $I = \int_0^1 \left(\frac{x}{1+x^2} \right) dx$. Then $I =$

- (a) $\int_0^1 \left(\frac{1-x}{2-x+x^2} \right) dx$ (b) $\int_0^1 \left(\frac{1+x}{1+x^2} \right) dx$ (c) $\int_0^1 \left(\frac{x}{2-x} \right) dx$ (d) $\int_0^1 \left(\frac{1-x}{2-2x+x^2} \right) dx$

Q15. If $2^{-x} + 2^{-y} = e$, then $\frac{dy}{dx}$ is

- (a) 2^{y-x} (b) $-(2^{x-y})$ (c) $-(2^{y-x})$ (d) 2^{x-y}

Q16. For $f(x) = x - \frac{1}{x}$; ($x \neq 0$)

- (a) local maximum value is 2
(b) local minimum value is -2
(c) local minimum value < local maximum value
(d) no local maximum and no local minimum

Q17. Let $\int \frac{dx}{1+\sin x} = f(x) + C$. Then $f(x) =$

- (a) $\tan\left(\frac{\pi}{4} - \frac{x}{2}\right)$ (b) $-\tan\left(\frac{\pi}{4} - \frac{x}{2}\right)$
(c) $-2\tan\left(\frac{\pi}{4} - \frac{x}{2}\right) + C$ (d) $2\tan\left(\frac{\pi}{4} - \frac{x}{2}\right)$

Q18. Let A and B be invertible square matrices of the same order. Consider the following statements.

- (i) $(AB)^{-1} = A^{-1}B^{-1}$ (ii) $(AB)^{-1} = B^{-1}A^{-1}$
(iii) $(A^{-1})^{-1} = A$ (iv) If $A^2 = I$, then $A^{-1} = A$

Which of the above statements are correct?

- (a) (i) and (iii) only (b) (ii) and (iii) only (c) (ii), (iii) and (iv) only
(d) (i), (ii) and (iv) only

Followings are Assertion (A) - Reason (R) based questions (from Q19 to 20).

Read the following statements carefully to mark the correct option out of the options given below.

- (a) A is true, R is true; R is a correct explanation for A.
(b) A is true, R is true; R is not a correct explanation for A.
(c) A is true, R is false.
(d) A is false, R is true.

Q19. Assertion (A) : When $x \in [0, 1]$, then the range of $y = 2\sin^{-1} x$ is given by $[0, \pi]$.

Reason (R) : $y = \sin^{-1} x$ is defined only for all $x \in [0, 1]$.

Q20. Assertion (A) : A relation R on the set $\{1, 2, 3\}$ defined as $R = \{(1,1), (2,1), (2,2), (3,3)\}$ is an identity as well as reflexive relation.

Reason (R) : An identity relation is always a reflexive relation.

SECTION B

(Question numbers 21 to 25 carry 2 marks each.)

Q21. (a) Find the value of $\sec^{-1} x - \sin^{-1} \left(-\frac{1}{x} \right)$, if $x^2 + 4x + 4 = 0$.

OR

(b) If $\sin^{-1}\left(\frac{\sin x + \cos x}{\sqrt{2}}\right) = \frac{\pi}{2}$, find the value of $(4x)$.

Q22. If A is a skew-symmetric matrix of order 3, then prove that $|A| = 0$.

Q23. (a) Show that the function f given by $f(x) = \tan^{-1}(\sin x + \cos x)$ is strictly decreasing for all $x \in \left(\frac{\pi}{4}, \frac{\pi}{2}\right)$.

OR

(b) Show that $f(x) = e^x - e^{-x} + x - \tan^{-1} x$ is strictly increasing in its domain.

Q24. A relation R on set $A = \{1, 2, 3, 4, 5, 6\}$ is defined as $R = \{(x, y) : |x^2 - y^2| < 10\}$.

Check whether the relation R is reflexive. Is it a symmetric relation?

Q25. If $A = \begin{pmatrix} \cos \alpha & \sin \alpha \\ -\sin \alpha & \cos \alpha \end{pmatrix}$, where $\alpha \in \left(0, \frac{\pi}{2}\right)$ and $A + A^T = \sqrt{2} I_2$; then determine the value of $(\sin 2\alpha - \tan \alpha)$.

SECTION C

(Question numbers 26 to 31 carry 3 marks each.)

Q26. (a) If $A = \begin{bmatrix} 1 & -1 & 1 \\ 2 & -1 & 0 \\ 1 & 0 & 0 \end{bmatrix}$, find A^2 and show that $A^2 = A^{-1}$.

OR

(b) Given $A = \begin{bmatrix} 5 & 0 & 4 \\ 2 & 3 & 2 \\ 1 & 2 & 1 \end{bmatrix}$, $B^{-1} = \begin{bmatrix} 1 & 3 & 3 \\ 1 & 4 & 3 \\ 1 & 3 & 4 \end{bmatrix}$, compute $(AB)^{-1}$.

Q27. Determine the values of 'a' and 'b' such that the following function is continuous at $x = 0$:

$$f(x) = \begin{cases} \frac{x + \sin x}{\sin(a+1)x}, & \text{if } -\pi < x < 0 \\ 2, & \text{if } x = 0 \\ 2\frac{e^{\sin bx} - 1}{bx}, & \text{if } x > 0 \end{cases}.$$

Q28. (a) Find the derivative of the function $f(x) = \cos^{-1}\left[\sin\sqrt{\frac{1+x}{2}}\right] + x^x$ w. r. t. x , at $x = 1$.

OR

(b) If $x = \cos t + \log \tan\left(\frac{t}{2}\right)$, $y = \sin t$, then find the value of $\frac{d^2y}{dt^2}$ and $\frac{d^2y}{dx^2}$ both, at $t = \frac{\pi}{4}$.

Q29. The volume of a wooden block in the shape of a cube increases at a constant rate as the air becomes moist during the rainy season. Show that the rate of change of its surface area varies inversely as the length of edge of the cube.

Q30. (a) Find the range of the function $f(x) = \tan^{-1} x + \frac{1}{2} \sin^{-1} x$.

OR

(b) Simplify : $\sin^{-1}\left(\frac{3\sin x + 2\cos x}{\sqrt{13}}\right)$.

Q31. Find $\int_0^1 \log(1+x^2) dx$.

SECTION D

(Question numbers 32 to 35 carry 5 marks each.)

Q32. (a) Find $\int \frac{\cos x dx}{1 + \cos x + \sin x}$.

OR

(b) Find $\int \frac{1}{x} \sqrt{\frac{x+a}{x-a}} dx$.

Q33. 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 $y = 0$.

Q34. A bakery produces three types of cake boxes: A, B and C. Each box requires specific quantities of flour, sugar, and butter (in grams) as given below:

Box A: Requires 200 g of flour, 100 g of sugar, and 50 g of butter.

Box B: Requires 100 g of flour, 200 g of sugar, and 100 g of butter.

Box C: Requires 100 g of flour, 100 g of sugar, and 200 g of butter.

On a weekend, the baker uses a total of 1100 g of flour, 1000 g of sugar, and 1100 g of butter.

Let x , y and z represent the number of boxes of type A, B and C produced, respectively.

(i) Use matrices to represent the system of linear equations for above information.

(ii) Find the determinant of the coefficient matrix to show that the system has a unique solution.

(iii) Solve the system using the matrix method to find x , y and z .

Q35. (a) Show that $f: \mathbb{R}_+ \rightarrow [-5, \infty)$ given by $f(x) = 4x^2 + 4x - 5$ is both one-one and onto where $\mathbb{R}_+ = [0, \infty)$. Also, find $p \in \mathbb{R}_+$, such that $f(p) = 3$.

OR

(b) A relation R on set $A = \{-4, -3, -2, -1, 0, 1, 2, 3, 4\}$ be defined as $R = \{(x, y) : x + y \text{ is an integer divisible by } 2\}$. Show that R is an equivalence relation.

Also, write the equivalence class $[2]$.

SECTION E

This section contains **three Case-study based questions** (from Q36 to 38).

This section contains **three Case-study / Passage based questions**.

First two questions have **three sub-parts** (i), (ii) and (iii) of **marks 1, 1 and 2** respectively.

Third question has **two sub-parts** of **2 marks** each.

Q36. In May 2026, the National Testing Agency (NTA) conducted the NEET-UG examination. Soon after the examination, reports of a possible paper leak created uncertainty and stress among students. Many students who had prepared for months felt disturbed by the situation. To ensure fairness and equal opportunity, NTA decided to conduct a Re-NEET examination.

For analyzing the relationship between students and their examination attempts, consider a set S of students and define different relations as given below in the sub-parts, based on their scores and performance in the Re-NEET examination. Answer the following questions.

(i) Suppose S is the set of all students appearing for the Re-NEET examination. Define a relation R on S by $xRy \Leftrightarrow$ students x and y appeared for the Re-NEET examination on the same date. Is the relation R reflexive? Justify.

(ii) Let R_1 be a relation on the set S defined by

$xR_1y \Leftrightarrow$ students x and y obtained the same score in the Re-NEET.

Determine whether R_1 is symmetric? Justify.

(iii) (a) Let R_2 be a relation on S defined by $xR_2y \Leftrightarrow |M_x - M_y| \leq 10$, where M_x and M_y are the marks obtained by students x and y respectively, in the Re-NEET examination. Examine if R_2 is reflexive, symmetric and transitive. Hence, state if R_2 is an equivalence relation.

OR

(iii) (b) Suppose four students A, B, C, D received ranks 1, 2, 3, 4 respectively, in the Re-NEET examination. Define a function $f: S \rightarrow T$, where $S = \{A, B, C, D\}$ and $T = \{1, 2, 3, 4\}$ such that $f(A) = 1$, $f(B) = 2$, $f(C) = 3$ and $f(D) = 4$. Check whether the function f is one-one. Justify your answer.

- Q37.** Following intense seasonal flooding and displacement in a flood-affected district in Assam, the National Disaster Response Force (NDRF) set up an emergency water distribution station.



To ensure continuous gravity-fed water filtration, engineers installed an inverted right circular conical reservoir (vertex pointing downwards). The semi-vertical angle α of the conical tank satisfies $\tan \alpha = \frac{1}{2}$. Purified water is pumped into the reservoir at a steady rate of $6 \text{ m}^3/\text{min}$.

Based on the above information, answer the following questions.

- (i) Express the volume V of water in the tank purely as a function of the water height (h), and find the volume when the water level reaches $h = 4 \text{ m}$.
- (ii) Find the rate of change of the volume of water with respect to the water depth (h), when it is given that $h = 4 \text{ m}$.
- (iii) (a) At the instant when the water depth is 4 m , determine the rate at which the water level is rising.

OR

(iii) (b) The inside surface of the tank in contact with water is coated with a waterproof food-grade resin. Find the rate at which the wet surface area is expanding at the instant when the water depth is 4 m .

- Q38.** Let $A = [a_{ij}]$ be a square matrix of order m . Then the transpose of matrix A is $A^T = [a_{ji}]$.

- If A is a symmetric matrix, then $A = A^T$.
- If A is a skew symmetric matrix, then $A = -A^T$.

Using the information given above, answer the following questions.

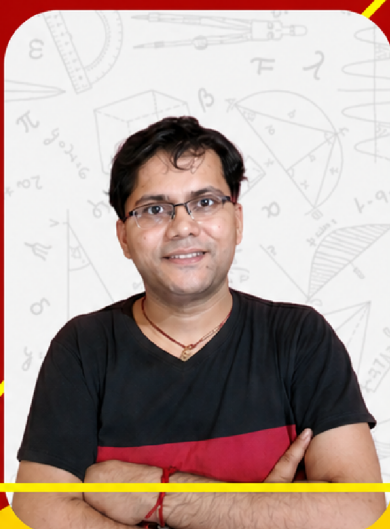
(i) For $A = \begin{pmatrix} 1 & -1 & 2 \\ 0 & -2 & 3 \\ -3 & 4 & 0 \end{pmatrix}$, check if $A + A^T$ is symmetric or skew symmetric.

(ii) If $B = \begin{pmatrix} 0 & 2x-1 & 3 \\ 5 & 0 & y+2 \\ -3 & 4 & 0 \end{pmatrix}$ is a skew symmetric matrix, then find the values of x and y .

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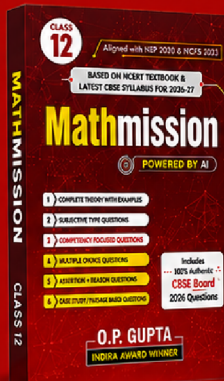
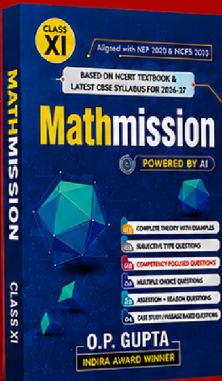
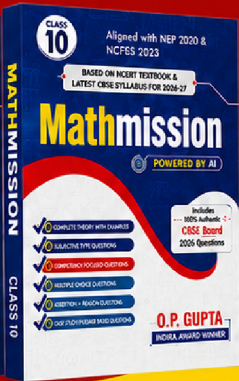
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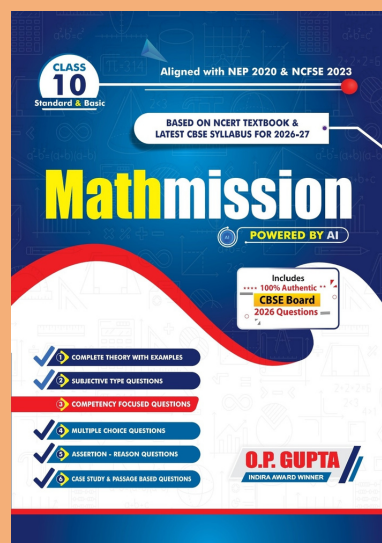
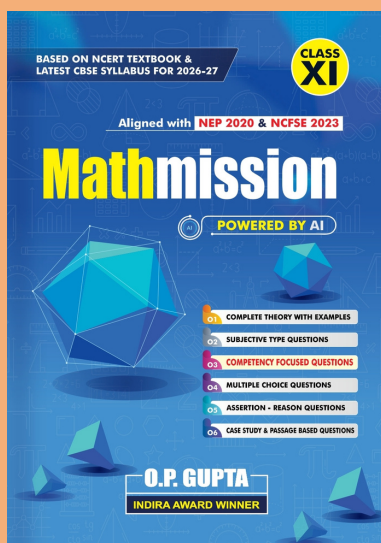
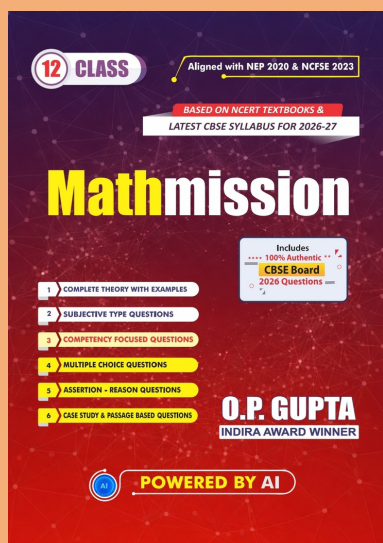
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