Chapter: Section A1: Algebra (Matrices and Determinants)

General Instructions

1. Total Questions: **20**
2. Duration: **60 Minutes**
3. All questions are compulsory.
4. Read each question carefully before answering.
5. Choose the most appropriate answer from the given options.
6. Use of calculator or electronic devices is strictly prohibited.

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1. Let A be a 3×3 matrix such that $det(A) = 2$. If $B = adj(3A^2)$, find the value of $det(B)$.

2. If $A = \begin{bmatrix} 1 & 0 & 0 \\ 2 & 1 & 0 \\ 3 & 2 & 1 \end{bmatrix}$ and U_1, U_2 are column matrices such that $AU_1 = \begin{bmatrix} 1 \\ 0 \\ 0 \end{bmatrix}$ and $AU_2 = \begin{bmatrix} 0 \\ 1 \\ 0 \end{bmatrix}$, find the value of $U_1 + U_2$.

3. Prove that if A and B are square matrices of the same order such that $AB = A$ and $BA = B$, then A and B are idempotent matrices.

4. Let P be a 3×3 matrix such that $P^T = 2P + I$, where P^T is the transpose of P and I is the identity matrix. Find the matrix P.

5. If $A = \begin{bmatrix} 1 & a \\ 0 & 1 \end{bmatrix}$, find the expression for A^n for any positive integer n and use it to find A^{100}.

6. Let A be a 3×3 matrix with real entries such that $A^2 = A + 2I$. If $det(A) = 4$, find the $Trace(A)$.

7. Evaluate the determinant: $\begin{vmatrix} (b+c)^2 & a^2 & a^2 \\ b^2 & (c+a)^2 & b^2 \\ c^2 & c^2 & (a+b)^2 \end{vmatrix}$.

8. If $A = \begin{bmatrix} 0 & 2\beta & \gamma \\ \alpha & \beta & -\gamma \\ \alpha & -\beta & \gamma \end{bmatrix}$ is an orthogonal matrix, find the values of α, β, and γ.

9. Solve for X if $A = \begin{bmatrix} 3 & 2 \\ 7 & 5 \end{bmatrix}$ and $B = \begin{bmatrix} 2 & -1 \\ -4 & 3 \end{bmatrix}$ such that $AX = B$.

10. If $f(x) = \begin{bmatrix} \cos x & -\sin x & 0 \\ \sin x & \cos x & 0 \\ 0 & 0 & 1 \end{bmatrix}$, prove that $f(x)f(y) = f(x+y)$.

11. Let A and B be two 3×3 non-zero real matrices such that $AB = O$. Prove that $det(A) = det(B) = 0$.

12. Find the value of k if the system of equations $x + y + z = 2$, $x + 2y + 3z = 5$, and $x + 3y + kz = 8$ has infinitely many solutions.

13. If A is a square matrix of order 3 such that $|A| = k$, find the value of $|adj(adj(adjA))|$ in terms of k.

14. Let $A = \begin{bmatrix} 1 & -1 & 1 \\ 2 & 1 & -3 \\ 1 & 1 & 1 \end{bmatrix}$ and $10B = \begin{bmatrix} 4 & 2 & 2 \\ -5 & 0 & 5 \\ 1 & -2 & 3 \end{bmatrix}$. If $B = A^{-1}$, find the value of the missing entry in $10B$ (verify the inverse).

15. If $A = \begin{bmatrix} a & b \\ c & d \end{bmatrix}$ satisfies the equation $x^2 - (a+d)x + (ad - bc) = 0$, find A^2.

16. Find the number of 3×3 matrices A whose entries are from the set $\{0, 1, 2\}$ such that the trace of $A^T A$ is 3.

17. If ω is a complex cube root of unity, evaluate: $\begin{vmatrix} 1 & \omega & \omega^2 \\ \omega & \omega^2 & 1 \\ \omega^2 & 1 & \omega \end{vmatrix}$.

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18. Let A be a 2×2 matrix with $A^2 = I$. If A is not I or $-I$, prove that $Trace(A) = 0$ and $det(A) = -1$.

19. If $A = \begin{bmatrix} 1 & 1 \\ 0 & 1 \end{bmatrix}$, find the sum of the series $S = I + A + A^2 + \cdots + A^n$.

20. Find the inverse of the matrix $A = \begin{bmatrix} 1 & 3 & 3 \\ 1 & 4 & 3 \\ 1 & 3 & 4 \end{bmatrix}$.

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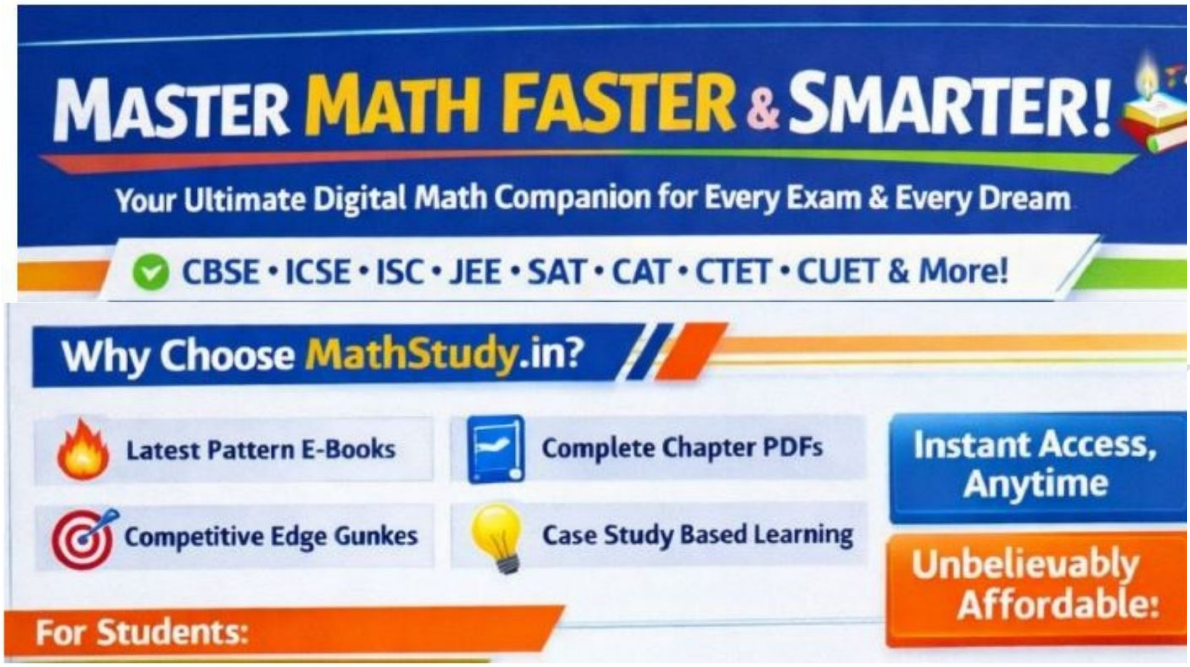

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