Linear Transformations - Part II

Detailed Course 2.0 on Linear Algebra For IIT JAM' 23

Gajendra Purohit • Lesson 5 • Sept 15, 2022


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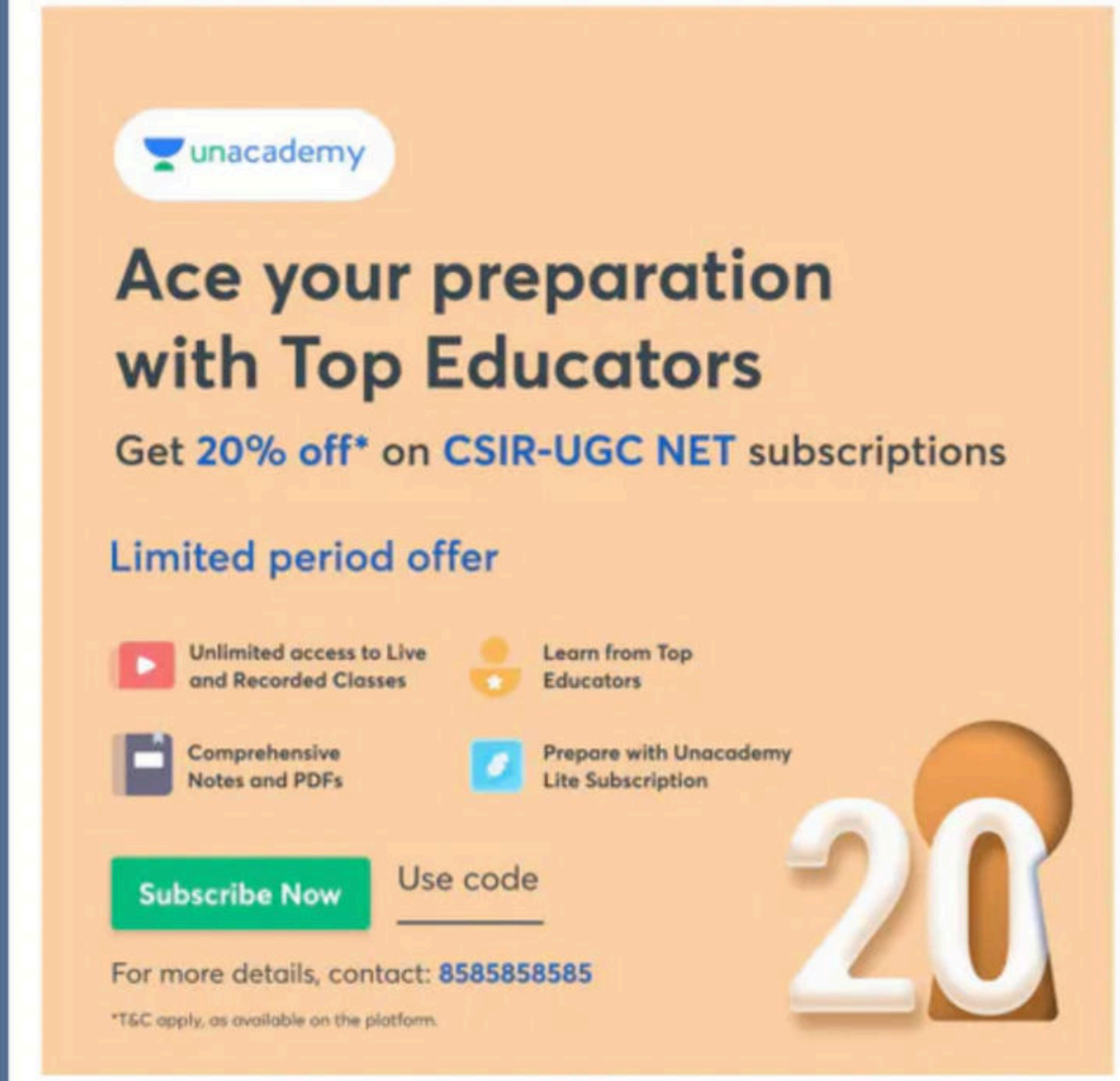
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Orthogonal matrix : A be a matrix A is called orthogonal matrix if $AA^T = A^TA = I$

Note :

(1) $AA^T = I$

$|AA^T| = 1 \Rightarrow |A|\,|A^T| = 1$

$\Rightarrow |A|^2 = 1 \Rightarrow |A| = \pm 1$

Determinant of an othrogonal matrix is ± 1 and $A^T = A^{-1}$.

(2) Sum of square of elements of each row or column are 1 and sum of the product of element of any row or column with corresponding elements of any other (column) is always zero.

Q.1. Number of orthogonal matrix of order n whose entries are 0 & 1 only

(a) n

(b) n!

(c) n – 1

(d) None of these

Property :

(1) If A is orthogonal then kA is orthogonal if $k = \pm 1$

Example : If A is orthogonal then 3A is not orthogonal.

(2) If A & B are orthogonal then A + B cannot orthogonal but AB is always orthogonal.

(3) If A is orthogonal then A^n is orthogonal.

Q.2. If A is orthogonal matrix then which of the following are true?

(a) 2A is orthogonal

(b) A^2 is orthogonal

(c) –A is orthogonal

(d) None of these

Q.3. The number of orthogonal matrix of order 5 whose entries are 0 & 1 only

(a) 5^2 (b) 5!

(c) 120 (d) 0

Unitary matrix : A matrix A is said to be unitory if

$AA^{\theta} = A^{\theta}A = I$

Q4. The matrix $M=\begin{bmatrix}\cos\alpha & \sin\alpha \\ i\sin\alpha & i\cos\alpha\end{bmatrix}$ is a unitary matrix when α is

(a) $(2n+1)\frac{\pi}{2}, n\in Z$ (b) $(3n+1)\frac{\pi}{3}, n\in Z$

(c) $(4n+1)\frac{\pi}{4}, n\in Z$ (d) $(5n+1)\frac{\pi}{5}, n\in Z$

Q.5. If A and B are orthogonal matrix then which of the following is true?

(a) $A + B$ is orthogonal (b) AB is orthogonal

(c) 2A is orthogonal (d) B^2 is orthogonal

Q.6. Let $\underline{u}$ be a real $n \times 1$ vector satisfying $\underline{u}'\underline{u} = 1$ where $\underline{u}'$ is the transpose of $\underline{u}$. Define $A = I - 2\underline{u}\underline{u}'$ where I is the nth order identity matrix. Which of the following statements are true?

(a) A is singular

(b) $A^2 = A$

(c) Trace $(A) = n - 2$

(d) $A^2 = I$

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Permutation Matrix :

A matrix whose entries are either 0 or 1 and each row sum and each column sum is 1 then this matrix is called permutation matrix.

Properties :

(1) Number of permutation matrix of order n are n!.

(2) Permutation $\sigma \in S_n$ corresponding to permutation matrix.

Let $I = [c_1\ c_2\ \ldots\ c_n]$ is a identity matrix where c_i are column and $A = [c_{\sigma(1)}, c_{\sigma(2)}\ \ldots\ c_{\sigma(n)}]$ is permutation matrix then permutation

$$\sigma = \begin{pmatrix} 1 & 2 & 3 & \cdots & n \\ \sigma(1) & \sigma(2) & \sigma(3) & \ldots. & \sigma(n) \end{pmatrix}.$$

(3) Permutation matrix corresponding to permutation $\sigma \in S_r$

$$\sigma = \begin{pmatrix} 1 & 2 & 3 & \cdots & n \\ \sigma(1) & \sigma(2) & \sigma(3) & .... & \sigma(n) \end{pmatrix}$$ i

permutation then $A = [c_{\sigma(1)} \quad c_{\sigma(2)} \quad ..... \quad c_{\sigma(n)}]$ is a permutation matrix.

(4) Trace of permutation matrix is number of self inverse element in permutation .

(5) **Determinant of matrix** : Let A be a matrix corresponding to permutation $\sigma \in S_n$.

Then $\det(A) = |A| = (-1)^d$

Where d is number of transposition.

(6) Every permutation matrix is orthogonal/unitary matrix.

(7) If $\sigma \in S_n$ be a permutation and $O(\sigma) = k$, then $A^k = I$

Let $\sigma = (1\ 2\ 3\ 4) \in S_4$

Q.7. Let $\sigma = \begin{pmatrix} 1 & 2 & 3 & 4 & 5 \\ 3 & 1 & 2 & 5 & 4 \end{pmatrix}$ and matrix A is denoted to the one whose i^{th} column is the $\sigma(i)^{th}$ column of the identity matrix I. Which of the following is true?

(a) $A^2 = A$ (b) $A^{-4} = A$

(c) $A^{-5} = A$ (d) $A = A^{-1}$

Q.8. Let $\sigma = \begin{pmatrix} 1 & 2 & 3 & 4 & 5 \\ 3 & 1 & 2 & 5 & 4 \end{pmatrix}\begin{pmatrix} 5 & 6 & 7 \\ 6 & 5 & 7 \end{pmatrix}$ and matrix A is denoted to the one whose i^{th} column is the $\sigma(i)^{th}$ column of the identity matrix I. Which of the following is true?

(a) A is involutory matrix (b) $|A| = 1$

(c) $Tr(A) = 1$ (d) $A^2 = A^{-1}$

Q.9. Let $A=\begin{bmatrix} 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 \end{bmatrix}_{6\times 6}$. Then which of the following is true?

(a) A is involutory matrix

(b) $|A| = 1$

(c) A is idempotent matrix

(d) $|A| = 0$

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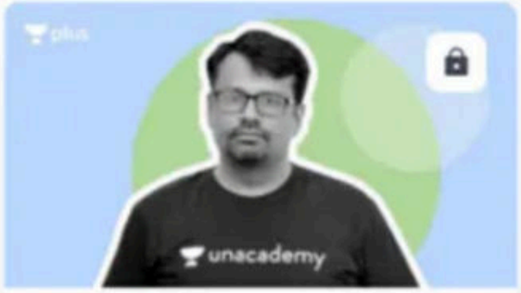

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- Studied at **M.Sc., NET, PhD(Algebra), MBA(Finance), BEd**
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