



Matrix Representation - Part I

Detailed Course 2.0 on Linear Algebra For IIT JAM' 23



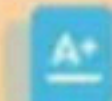
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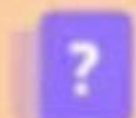
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Rank of matrix : If A is matrix then a non-negative integer is said to be rank of A . if \exists a non-singular submatrix of order r of A and all matrix of order greater than r are singular.

Note :

- (1) A matrix $A_{n \times n}$ is a non-singular iff $\text{rank}(A) = n$
- (2) Rank of matrix is denoted by $\rho(A)$
- (3) If $|A| \neq 0$ then $\rho(A) = n$ where n is order of A

Elementary Transformation : Those transformation that does not effect on rank of matrix are called elementary transformation.

There are 3 elementary row (column) transformation.

Elementary matrix : A matrix obtained by a single elementary operation over identity matrix is known as elementary matrix.

Q.1. Find elementary matrix

(a) $\begin{bmatrix} 0 & 1 \\ 1 & 0 \end{bmatrix}$

(b) $\begin{bmatrix} 1 & 0 & 0 \\ 0 & 0 & 1 \\ 0 & 1 & 0 \end{bmatrix}$

(c) $\begin{bmatrix} 1 & 2 & 3 \\ 0 & 1 & 0 \\ 1 & 0 & 0 \end{bmatrix}$

(d) $\begin{bmatrix} 3 & 2 & 0 \\ 1 & 2 & 0 \\ 1 & 2 & 2 \end{bmatrix}$

Note :

- (1) Every elementary matrix is non-singular.
- (2) Every permutation matrix is elementary matrix.

Q.2. Let $A = \begin{bmatrix} 1 & 2 & 3 & 4 \\ 5 & 6 & 7 & 8 \\ 9 & 10 & 11 & 12 \\ 151 & 262 & 373 & 484 \end{bmatrix}$.

Then Rank(A) is

(a) 1

(b) 2

(c) 3

(d) 4

Q.3. Let $A = \begin{bmatrix} 1 & 1 & 1 & \dots & 1 \\ 1 & 2 & 2 & \dots & 2 \\ 1 & 2 & 3 & \dots & 3 \\ 1 & 2 & 3 & \dots & 4 \\ \vdots & & & & \\ 1 & 2 & 3 & \dots & n \end{bmatrix}$, then $\rho(A)$ is

(a) 0

(b) 1

(c) 2

(d) n

Property :

1. A matrix is of Rank zero iff A is null matrix i.e. if A is non-null matrix then $\rho(A) \geq 1$
2. Rank of idempotent matrix of order n are always less than n except identity matrix.
3. Rank of involutory matrix of order n are always n because determinant of involutory matrix are non-zero.
4. Rank of orthogonal matrix of order n is n.
5. Rank of nilpotent matrix of order n are always less than n.



Q.4. Let $S = \{A = [a_{ij}]_{n \times n} \mid A^k = 0 \text{ \& } \rho(A) = n, \text{ for some } k\}$
then cardinality of S is

(a) ϕ

(b) 1

(c) 2

(d) n

(6) Let A be a matrix of order $m \times n$ then

$$\rho(A) \leq \min\{m, n\}$$

(7) Let A & B are matrix of order $m \times n$ & $n \times p$, then $\rho(A) + \rho(B) - n \leq \rho(AB) \leq \min\{\rho(A), \rho(B)\}$

(8) Let A and A^T are matrix then $\rho(A) = \rho(A^T)$

(9) $\rho(A + B) \leq \rho(A) + \rho(B)$

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Q.5. Let $A = [a_1 \ a_2 \ \dots \ a_n]^T_{1 \times n}$ and $B = [b_1 \ b_2 \ \dots \ b_n]_{1 \times n}$ both are non-zero matrix then $\rho(AB)$ is

(a) 1

(b) n

(c) $n + 1$

(d) $n - 1$

Q.6 Let A be a 3×4 matrix and B be a 4×3 matrix with real entries such that AB is non-singular. Consider the following statements :

P : Nullity of A is 0.

Q : BA is a non-singular matrix.

Then

- (a) both P and Q are true
- (b) P is true and Q is false
- (c) P is false and Q is true
- (d) Both P and Q are false

Q.7. Let A be an $n \times n$ matrix such that the first 3 rows of A are linearly independent and the first 5 columns of A are linearly independent. Which of the following statements are true?

(a) A has at least 5 linearly independent rows

(b) $3 \leq \text{rank } A \leq 5$

(c) $\text{Rank } A \geq 5$

(d) $\text{Rank } A^2 \geq 5$

Q.8. What is the rank of the matrix

$$\begin{pmatrix} 1 & 1 & 1 & 1 & 1 \\ 1 & 2 & 2 & 2 & 2 \\ 1 & 2 & 3 & 3 & 3 \\ 1 & 2 & 3 & 4 & 4 \\ 1 & 2 & 3 & 4 & 5 \end{pmatrix}.$$

(a) 2

(b) 3

(c) 4

(d) 5

Q.9 Let J denote the matrix of order $n \times n$ with all entries 1

and let B be a $(3n) \times (3n)$ matrix given by $B = \begin{pmatrix} 0 & 0 & J \\ 0 & J & 0 \\ J & 0 & 0 \end{pmatrix}$

. Then the rank of B is

- | | |
|----------|--------------|
| (a) $2n$ | (b) $3n - 1$ |
| (c) 2 | (d) 3 |

Q.10. Let A be an $n \times m$ matrix with each entry equal to $+1$, -1 or 0 such that every column has exactly one $+1$ and exactly one -1 . We can conclude that

- | | |
|---------------------------------|--------------------------|
| (a) $\text{Rank } A \leq n - 1$ | (b) $\text{Rank } A = m$ |
| (c) $n \leq m$ | (d) $n - 1 \leq m$ |

Q.11 Let A and B be $n \times n$ real matrices such that $AB = BA = 0$ and $A + B$ is invertible.

Which of the following are always true?

- (a) $\text{Rank}(A) = \text{rank}(B)$
- (b) $\text{Rank}(A) + \text{rank}(B) = n$
- (c) $\text{Nullity}(A) + \text{nullity}(B) = n$
- (d) $A - B$ is invertible



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Educator highlights

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