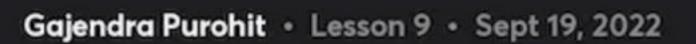


Detailed Course 2.0 on Linear Algebra For IIT JAM' 23





Gajendra Purohit

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System of linear equation

The system of m equations and n variables

$$a_{11}X_1 + a_{12}X_2 \dots + a_{1n}X_n = b_1$$

$$a_{21}x_1 + a_{22}x_2 \dots + a_{2n}x_n = b_2$$

.

$$a_{m1}x_1 + a_{m2}x_2 + a_{mn}x_n = b_m$$

is called system of linear equation

It is denoted by Ax = b



Homogeneous system of linear equation : The system of equation AX = b is called homogeneous iff b = 0.

Non - homogeneous system of linear equation : The system of equation AX = b is called non - homogeneous iff $b \neq 0$.

And [A:b] is augmented matrix

Consistency & inconsistency: Let AX = b be a system of equation it is called consistent if it has a solution otherwise it is called inconsistent system of equation.

Note: Homogeneous system of equation AX = 0 always has a solution. So, AX = 0 is called consistent.

Solution space of homogeneous system: Let AX = 0 be a given homogeneous system then ker(A) is called solution space of this system.

Dimension of solution space: Let $A_{m\times n}$ is a coefficient matrix of system of linear equation. Then dimension of solution space = $\eta(A) = n - \rho(A)$

Note: X = 0 is known as trivial solution and any solution other then X = 0 is known as non-trivial solution

Analysis of solution of the homogeneous system of equation:

Consider the homogeneous system of equation AX = 0 of mequation in n-variables.

 $A = [a_{ij}]$ be $m \times n$ matrix with entries from $a_{ij} \in F$ (F is infinite field)

- (i) If $ker(A) = \{0\}$ then system has trivial solution i.e. if $\eta(A) = 0$ then system has unique (trivial) solution.
- (ii) If $ker(A) \neq \{0\}$ i.e. $\eta(A) \geq 1$ then system has infinite (non-trivial) solution.

(3) If $|A| \neq 0$ then system has unique solution.

- (4) If |A| = 0 the system has infinite solution.
- (5) If number of equation (m) < number of variables then system always has non-trivial solution.
- (6) System has non-trivial solution iff it has infinite many solution.

Q.1 If system of linear equation

$$kx + y + 2z = 0$$

$$x - y - 2z = 0$$

$$x + y + 4z = 0$$

have a unique solution, then k is not equal to

(a) -1

(b) 0

(c) 1

Q.2. Let
$$M = \begin{bmatrix} \alpha & 1 & 1 \\ 1 & \beta & 1 \\ 1 & 1 & \gamma \end{bmatrix}$$
, $\alpha\beta\gamma = 1$, $\alpha,\beta,\gamma \in \mathbb{R}$ and

$$x = \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix} \in R^3$$
. Then Mx = 0 has infinitely many solution

if trace (M) is

(a) 0

(b) 1

(c) 2

Consider the following system of three linear equation in Q.3 three unknown x1, x2, & x3.

$$x_1 + x_2 + x_3 = 0$$

$$x_1 + x_2 + x_3 = 0$$

 $x_1 + kx_2 + 2x_3 = 0$

$$2x_1 + 3x_2 + x_3 = 0$$

If system has infinitely many solution then value of k is

(a) 0

(b) 1

(c) 2

Q.4. Let A be a 5×4 matrix with real entries such that Ax = 0 iff x = 0 where x is a 4×1 vector and 0 is null vector. Then the rank of A is

(a) 4

(b) 5

(c) 2



- Q.5 Consider a homogeneous system of linear equation Ax = 0 where A is an m × n real matrix and n > m. Then which of the following statements are always true?
 - (a) Ax = 0 has a solution
 - (b) Ax = 0 has no non-zero solution.
 - (c) Ax = 0 has a non-zero solution
 - (d) Dimension of the space of all solutions is

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Q.6. Let S be the solution space of system of linear equation

$$x + 2y + 3z = 0$$

$$3x + 4y + 4z = 0$$

$$7x + 10y + 12z = 0$$

Then dimension of S is

(a) 0

(b) 1

(c) 2

d) 3

Non-homogeneous system of equation :A system of equation Ax = b is called non-homogeneous iff $b \neq 0$.

Consistency & inconsistency : A non-homogeneous system Ax = b is called consistency if it has a solution otherwise it is called inconsistent.

Augmented matrix: Let Ax = b be a given system of equation then [A:b] is called augmented matrix.

Necessary and sufficient condition for solution:

Ax = b has a solution iff

- (i) $\rho(A:b) = \rho(A)$
- (ii) b is linear combination of c₁, c₂,, c_n where c_i are column of A.

Note: If $\rho(A:b) \neq \rho(A)$ then Ax = b has no solution.

Analysis of solution of non-homogeneous system of equation:

- (1) Unique solution :Let Ax = b has a unique solution iff $Ker(A) = \{0\}$ i.e. $\eta(A) = 0$ and $\rho(A : b) = \rho(A)$
- (2) Infinite solution : A non-homogeneous system Ax = b has infinite solution iff $\rho(A : b) = \rho(A)$ and $\eta(A) > 0$.

(3) No solution:

If $\rho(A:b) \neq \rho(A)$

Then system AX = b has no solution.

Q.1. Consider the following system

$$x + y + z + w = 4$$

$$x + 2y + 3z + 4w = 5$$

$$x + 3y + 5z + kw = 5$$

If the system has no solution then k is

(a) 4

(b) 5

(c) 7

Q.3. Consider the system

$$2x + ky = 2 - k$$

$$kx + 2y = k$$

$$ky + kz = k - 1$$

in three unknowns and one real parameter k. For which of the following values of k is the system of linear equation consistent?

(a) 1

(b) 2

(c) -1

(d) -2



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