

LECTURES IN MATH III: LINEAR ALGEBRA

Lecture 1. The Inverse of a matrix

The inverse of a matrix plays a very significant role in solving certain system of linear equations. There are 3 ways in finding the inverse of a matrix

1. By definition of inverse of a matrix. If A is an $n \times n$ matrix, then the inverse of A is the matrix A^{-1} , such that

$$AA^{-1} = I_n \quad \text{or} \quad A^{-1}A = I_n.$$

- ✓ If there exists a matrix A^{-1} , then A is called nonsingular or invertible.
- ✓ If there exists no such matrix A^{-1} , then A is called singular or noninvertible.

1. For any 2×2 matrix,

$$A = \begin{bmatrix} a & b \\ c & d \end{bmatrix}$$

its inverse can be determined by the formula

$$A^{-1} = \frac{1}{ad - bc} \begin{bmatrix} d & -b \\ -c & a \end{bmatrix}.$$

3. Gauss-Jordan Reduction for finding the inverse of a matrix.

Let A be an $n \times n$ matrix.

a. Adjoin the identity $n \times n$ matrix I_n to A to form the matrix $[A : I_n]$.

b. Compute the reduced row echelon form of $[A : I_n]$.

- ✓ If the reduced row echelon form is of type $[I_n : A^{-1}]$, then A^{-1} is the inverse of A .
- ✓ If the reduced row echelon form is not of the type $[I_n : A^{-1}]$, in that the first $n \times n$ submatrix is not I_n , then A has no inverse.

Properties of Matrix Inverse

Let A and B be invertible matrices and r be a nonzero scalar.

1. $(A^{-1})^{-1} = A$
2. $(rA)^{-1} = (1/r) A^{-1}$
3. $(AB)^{-1} = B^{-1} A^{-1}$
4. $(A^T)^{-1} = (A^{-1})^T$
5. $(A^{-T})^{-1} = (A^{-1})^T$

Note: Proofs of these properties will be left to students as exercises.

Example 1: Find the inverse of A , if

$$A = \begin{bmatrix} 1 & 1 \\ 3 & 4 \end{bmatrix}.$$

Solution 1: By definition of inverse of a matrix, using either $AA^{-1} = I_n$ or

$$\text{Let } A^{-1} = \begin{bmatrix} a & b \\ c & d \end{bmatrix}$$

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