

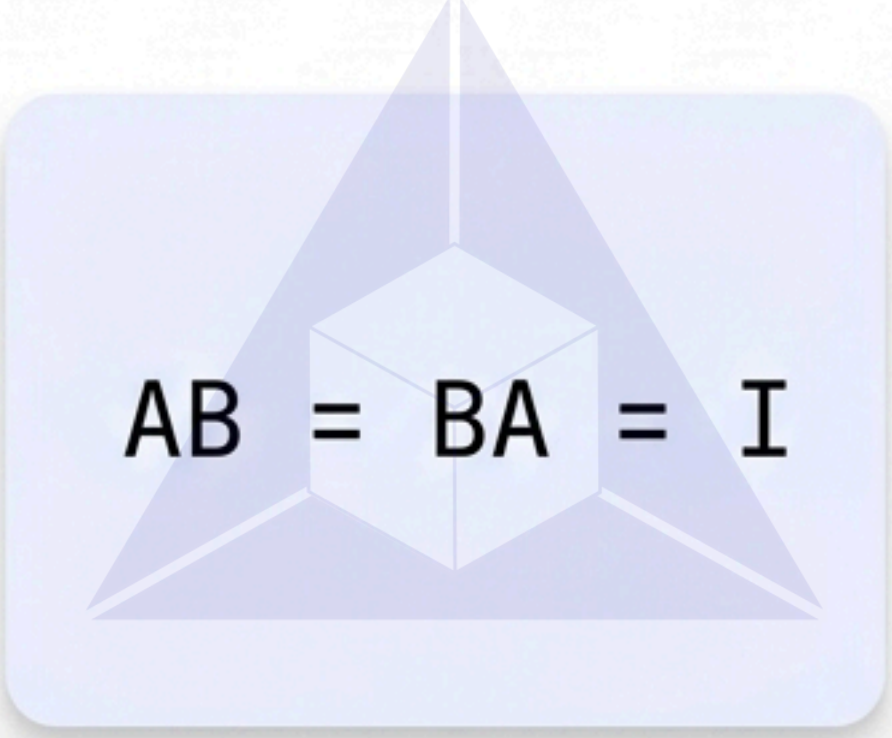
Invertible Matrices

The Algebraic Counterpart to Division

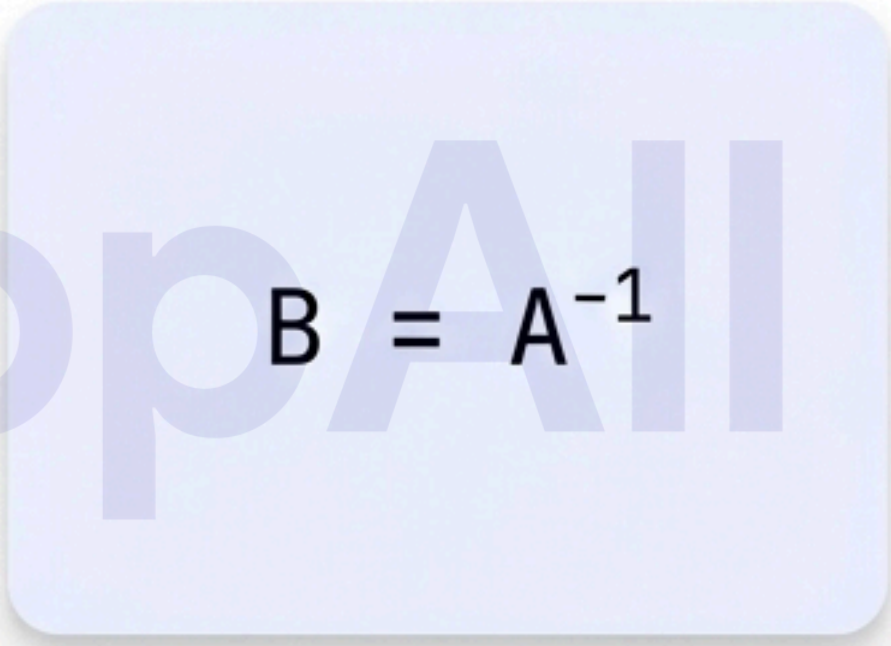
$$A \times A^{-1} = I$$

Defining the Inverse

When two square matrices multiply to yield the Identity matrix (I), they are defined as inverses of each other. I acts as the matrix equivalent of the number 1.


$$AB = BA = I$$

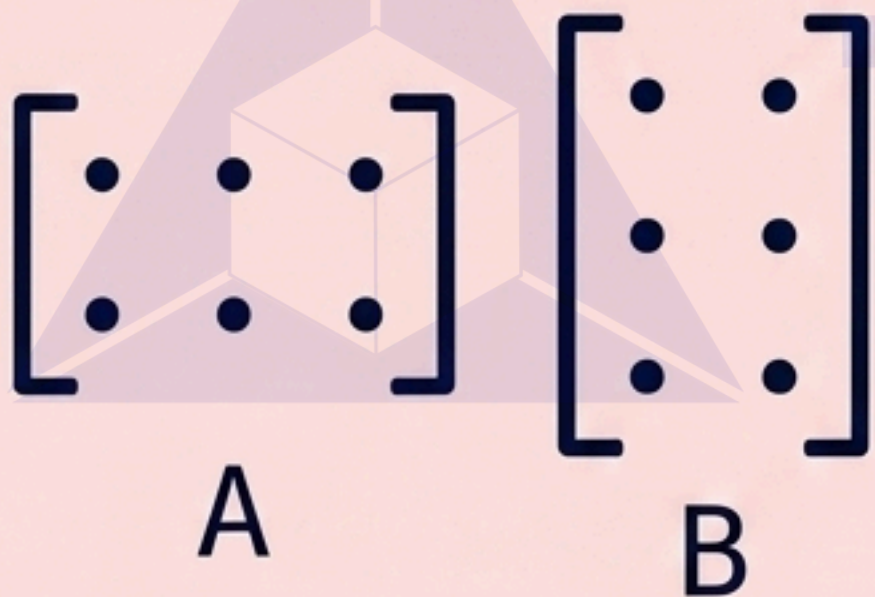



$$B = A^{-1}$$

The Square Matrix Constraint

For both products AB and BA to be defined and equal, the matrices must have identical, symmetric dimensions.

Rectangular (Fails)


$$\begin{bmatrix} \cdot & \cdot & \cdot \\ \cdot & \cdot & \cdot \end{bmatrix} \begin{bmatrix} \cdot & \cdot \\ \cdot & \cdot \\ \cdot & \cdot \end{bmatrix}$$

$A \qquad B$



AB yields 2×2 , but
 BA yields 3×3 .
Commutativity is
impossible.

Square (Valid)


$$\begin{bmatrix} \cdot & \cdot \\ \cdot & \cdot \end{bmatrix} \begin{bmatrix} \cdot & \cdot \\ \cdot & \cdot \end{bmatrix}$$

$A \qquad B$



Both AB and BA
yield a 2×2 matrix.

The Identity Connection

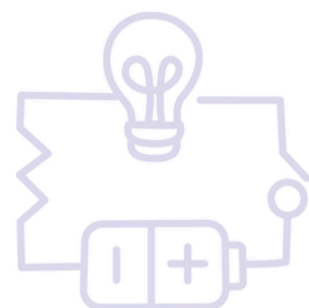
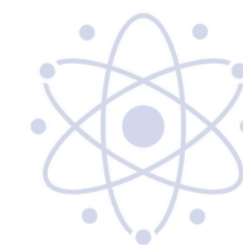
Multiplying a matrix by its inverse from either direction "collapses" the matrix back to the Identity matrix.





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$$E=mc^2$$



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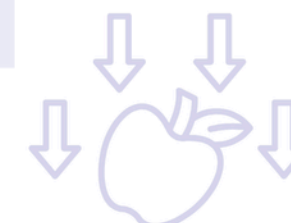
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Theorem: The Inverse is Unique



If a matrix has an inverse, it only has one. Assume a matrix A has two hypothetical inverses, B and C .

$$B = BI \text{ (Identity property)}$$

$$B = B(AC) \text{ (Substitute } I = AC \text{ since } C \text{ is an inverse)}$$

$$B = (BA)C \text{ (Associative property of multiplication)}$$

$$B = IC \text{ (Substitute } BA = I \text{ since } B \text{ is an inverse)}$$

$$B = C \text{ (Identity property)}$$

Therefore, the two inverses are the exact same matrix.

The Reversal Law for Products

When taking the inverse of a product, the inverse distributes to each matrix, but the order of the matrices must be reversed.

$$(AB)^{-1}$$



$$B^{-1}A^{-1}$$

Pitfall: Distributing Inverses

The Trap


$$(AB)^{-1} = A^{-1}B^{-1}$$

Because matrix multiplication is not commutative ($AB \neq BA$), you cannot simply distribute the inverse without swapping.

The Truth


$$(AB)^{-1} = B^{-1}A^{-1}$$

Always apply the Reversal Law.

Key Takeaways



Constraint

Inverse strictly requires a square matrix.

Definition

$$AB = BA = I$$

Uniqueness

The inverse of a matrix is strictly unique.

Product Rule

$$(AB)^{-1} = B^{-1}A^{-1}$$

(Reverses order)



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