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Invertible, then AB is invertible and $(AB)^{-1} = B^{-1}A^{-1}$?

This maths homework is hard! How to prove? Thanks :)

Update: If AB is invertible, is it true that both A and B are invertible?


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 **Best Answer:** Suppose that A and B are both invertible.

Then, since A is invertible, then there exists a matrix A^{-1} such that $AA^{-1} = I$ and $A^{-1}A = I$, where I is the identity matrix.

Similarly, since B is invertible, then there exists a matrix B^{-1} such that $BB^{-1} = I$ and $B^{-1}B = I$.

To show that AB is invertible, all that one has to do is to demonstrate that it has an inverse; that is, we must exhibit a matrix C such that $(AB)C = I$, and $C(AB) = I$.

Selecting $B^{-1}A^{-1}$ to be the matrix C works, because

$(AB)(B^{-1}A^{-1}) = A(BB^{-1})A^{-1} = A(I)A^{-1} = (AI)A^{-1} = AA^{-1} = I$; and
 $(B^{-1}A^{-1})AB = B^{-1}(A^{-1}A)B = B^{-1}(I)B = (B^{-1}I)B = B^{-1}B = I$.

(Here, I've used the facts that matrix multiplication is associative; that a matrix multiplied by its inverse yields the identity matrix; and that the identity matrix times any matrix is the other matrix.)

So AB is invertible and $B^{-1}A^{-1}$ is the inverse of AB; in other words, $B^{-1}A^{-1} = (AB)^{-1}$.

If AB is invertible, then yes, it will be true that both A and B are invertible.

Suppose that AB is invertible. Then there exists a matrix C such that $(AB)C = I$ and $C(AB) = I$.

Since $(AB)C = I$ and matrix multiplication is associative, then $A(BC) = I$. Thus, BC is an inverse for the matrix A. (To show that a square matrix has an inverse, it is enough to show that the multiplication works on one side only--if it does, then it will always work the other way also. That is to say, in this case, knowing that $A(BC) = I$, we can also conclude that $(BC)A = I$.)

Also, since $C(AB) = I$, then $(CA)B = I$. Thus, CA is an inverse for the matrix B.

Since A and B both have inverses, then both are invertible.

[TheMathemagician](#) · 6 years ago



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The proof that if A and B are invertible, then AB is invertible can be done more elegantly if you know these two results:

- I. $\det(AB) = (\det(A))(\det(B))$.
- II. A matrix B is invertible if and only if $\det(B) \neq 0$.

Proof. Suppose that both A and B are invertible. Then $\det(A) \neq 0$ and $\det(B) \neq 0$. Now by I, $\det(AB) \neq 0$, so by II AB is invertible.

Tony · 6 years ago



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

Reza · 6 years ago



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Matrices: Prove that A and B are both invertible, then AB is invertible and $(AB)^{-1} = B^{-1} A^{-1}$ ✓



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