Compute the product using (a) the definition where A**x** is the linear combination of the columns of A using the corresponding entries in **x** as weights, and (b) the row-vector rule for computing A**x**. If a product is undefined, explain why.

$$\begin{bmatrix} -9 & 8 \\ 3 & 4 \\ 0 & 5 \end{bmatrix} \begin{bmatrix} 9 \\ -9 \\ 10 \end{bmatrix}$$

(a) Compute the product using the definition where A**x** is the linear combination of the columns of A using the corresponding entries in **x** as weights. If the product is undefined, explain why. Select the correct choice below and, if necessary, fill in any answer boxes to complete your choice.

- **A.** A**x** = ☐
- **B.** The matrix-vector A**x** is not defined because the number of rows in matrix A does not match the number of entries in the vector **x**.
- **C.** The matrix-vector A**x** is not defined because the number of columns in matrix A does not match the number of entries in the vector **x**.

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Do Homework - Homework 2 Winter 2024

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Math 18 (1) Brenton Dunn 01/16/24 9:55 PM

Homework: **Homework 2 Winter 2024**

Question 2, 1.4.6

HW Score: 0%, 0 of 25 points

Points: 0 of 1

Save

Question list

Use the definition of A**x** to write the matrix equation as a vector equation.

$$\begin{bmatrix} 6 & -8 \\ -4 & -9 \\ -7 & 5 \\ -7 & -2 \end{bmatrix} \begin{bmatrix} -5 \\ -5 \end{bmatrix} = \begin{bmatrix} 10 \\ 65 \\ 10 \\ 45 \end{bmatrix}$$

The matrix equation written as a vector equation is $\square$.

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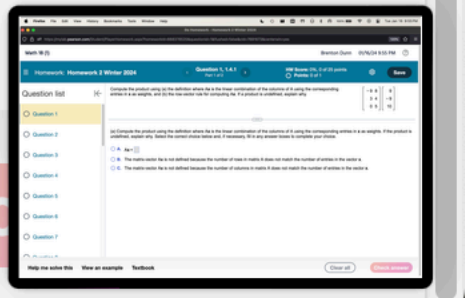

Write the system first as a vector equation and then as a matrix equation.

$$\begin{aligned} 3x_1 + x_2 - 3x_3 &= 7 \\ 9x_2 + 6x_3 &= 0 \end{aligned}$$

Write the system as a vector equation where the first equation of the system corresponds to the first row. Select the correct choice below and fill in any answer boxes to complete your choice.

- **A.** $\square \begin{bmatrix} x_1 & x_2 & x_3 \end{bmatrix} = \square$
- **B.** $x_1 \square + x_2 \square + x_3 \square = \square$
- **C.** $\square \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix} = \square$

Question list

Question 1

Question 2

Question 3

Question 4

Question 5

Question 6

Question 7

Question 8

Let $A = \begin{bmatrix} 1 & -4 & -3 \\ -4 & 4 & 0 \\ 3 & 0 & 3 \end{bmatrix}$ and $\mathbf{b} = \begin{bmatrix} b_1 \\ b_2 \\ b_3 \end{bmatrix}$. Show that the equation $A\mathbf{x} = \mathbf{b}$ does not have a solution for all possible $\mathbf{b}$, and describe the set of all $\mathbf{b}$ for which $A\mathbf{x} = \mathbf{b}$ does have a solution.

How can it be shown that the equation $A\mathbf{x} = \mathbf{b}$ does not have a solution for all possible $\mathbf{b}$? Choose the correct answer below.

- **A.** Find a vector $\mathbf{b}$ for which the solution to $A\mathbf{x} = \mathbf{b}$ is the zero vector.
- **B.** Find a vector $\mathbf{x}$ for which $A\mathbf{x} = \mathbf{b}$ is the zero vector.
- **C.** Row reduce the augmented matrix $\begin{bmatrix} A & \mathbf{b} \end{bmatrix}$ to demonstrate that $\begin{bmatrix} A & \mathbf{b} \end{bmatrix}$ has a pivot position in every row.
- **D.** Row reduce the matrix A to demonstrate that A does not have a pivot position in every row.
- **E.** Row reduce the matrix A to demonstrate that A has a pivot position in every row.

Question list
Question 1
Question 2
Question 3
Question 4
Question 5
Question 6
Question 7
Question 8

Let $\mathbf{v}_1 = \begin{bmatrix} 0 \\ 0 \\ -2 \end{bmatrix}$, $\mathbf{v}_2 = \begin{bmatrix} 0 \\ -2 \\ -6 \end{bmatrix}$, and $\mathbf{v}_3 = \begin{bmatrix} 6 \\ -5 \\ -4 \end{bmatrix}$. Does $\{\mathbf{v}_1, \mathbf{v}_2, \mathbf{v}_3\}$ span $\mathbb{R}^3$? Why or why not?

Choose the correct answer below.

- **A.** Yes. When the given vectors are written as the columns of a matrix A, A has a pivot position in every row.
- **B.** Yes. Any vector in $\mathbb{R}^3$ except the zero vector can be written as a linear combination of these three vectors.
- **C.** No. When the given vectors are written as the columns of a matrix A, A has a pivot position in only two rows.
- **D.** No. The set of given vectors spans a plane in $\mathbb{R}^3$. Any of the three vectors can be written as a linear combination of the other two.

Help me solve this View an example Textbook Clear all

Question list
Question 1
Question 2
Question 3
Question 4
Question 5
Question 6
Question 7
Question 8

Let $\mathbf{u} = \begin{bmatrix} 6 \\ 5 \\ -6 \end{bmatrix}$, $\mathbf{v} = \begin{bmatrix} 2 \\ -6 \\ -4 \end{bmatrix}$, and $\mathbf{w} = \begin{bmatrix} 10 \\ 62 \\ 4 \end{bmatrix}$. It can be shown that $4\mathbf{u} - 7\mathbf{v} - \mathbf{w} = 0$. Use this fact (and no row operations) to find x_1 and x_2 that satisfy the equation $\begin{bmatrix} 6 & 2 \\ 5 & -6 \\ -6 & -4 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix} = \begin{bmatrix} 10 \\ 62 \\ 4 \end{bmatrix}$.

$x_1 = \square$
$x_2 = \square$
(Simplify your answers.)

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Question list

Question 3

Question 4

Question 5

Question 6

Question 7

Question 8

Question 9

Question 10

Could a set of three vectors in $\mathbb{R}^4$ span all of $\mathbb{R}^4$? Explain. What about n vectors in $\mathbb{R}^m$ when n is less than m?

Could a set of three vectors in $\mathbb{R}^4$ span all of $\mathbb{R}^4$? Explain. Choose the correct answer below.

A. Yes. A set of n vectors in $\mathbb{R}^m$ can span $\mathbb{R}^m$ when $n < m$. There is a sufficient number of rows in the matrix A formed by the vectors to have enough pivot points to show that the vectors span $\mathbb{R}^m$.

B. No. There is no way for any number of vectors in $\mathbb{R}^4$ to span all of $\mathbb{R}^4$.

C. Yes. Any number of vectors in $\mathbb{R}^4$ will span all of $\mathbb{R}^4$.

D. No. The matrix A whose columns are the three vectors has four rows. To have a pivot in each row, A would have to have at least four columns (one for each pivot).

Textbook

Clear all

Suppose A is a 4×3 matrix and $\mathbf{b}$ is a vector in $\mathbb{R}^4$ with the property that $A\mathbf{x} = \mathbf{b}$ has a unique solution. What can you say about the reduced echelon form of A? Justify your answer.

Choose the correct answer below.

- **A.** The first 3 rows will have a pivot position and the last row will be all zeros. If a row had more than one 1, then there would be an infinite number of solutions for $\mathbf{a}_m x_m = b_m$.
- **B.** There will be a pivot position in each row. If a row did not have a pivot position then the equation $A\mathbf{x} = \mathbf{b}$ would be inconsistent.
- **C.** The first row will have a pivot position and all other rows will be all zeros. There is only one equation to solve, so there is only one solution.
- **D.** The first term of the first row will be a 1 and all other terms will be 0. There is only one variable x_m, so there is only one possible solution.

Write the solution set of the given homogeneous system in parametric vector form.

$$\begin{aligned} 2x_1 + 2x_2 + 4x_3 &= 0 \\ -6x_1 - 6x_2 - 12x_3 &= 0 \\ -3x_2 + 6x_3 &= 0 \end{aligned}$$

where the solution set is $\mathbf{x} = \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix}$

$\mathbf{x} = x_3 \square$

(Type an integer or simplified fraction for each matrix element.)

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Describe all solutions of $A\mathbf{x} = \mathbf{0}$ in parametric vector form, where A is row equivalent to the given matrix.

$$\begin{bmatrix} 3 & -12 & 15 \\ -1 & 4 & -5 \end{bmatrix}$$

$\mathbf{x} = x_2 \square + x_3 \square$

(Type an integer or fraction for each matrix element.)

Let A be a 3×3 matrix with two pivot positions. Use this information to answer parts (a) and (b) below.

a. Does the equation $A\mathbf{x} = \mathbf{0}$ have a nontrivial solution?

- **A.** Yes. Since A has 2 pivots, there is one free variable. So $A\mathbf{x} = \mathbf{0}$ has a nontrivial solution.
- **B.** No. Since A has 2 pivots, there are no free variables. With no free variables, $A\mathbf{x} = \mathbf{0}$ has only the trivial solution.
- **C.** No. Since A has 2 pivots, there is one free variable. Since there is at least one free variable, $A\mathbf{x} = \mathbf{0}$ has only the trivial solution.
- **D.** Yes. Since A has 2 pivots, there is one free variable. The solution set of $A\mathbf{x} = \mathbf{0}$ does not contain the trivial solution if there is at least one free variable.

Math 18 (1) Brenton Dunn 01/16/24 9:56 PM

Homework: **Homework 2 Winter 2024**

Question 12, 1.5.45

HW Score: 0%, 0 of 25 points
Points: 0 of 1

Save

Question list
Question 9
Question 10
Question 11
Question 12
Question 13
Question 14
Question 15
Question 16

Given $A = \begin{bmatrix} -2 & -8 \\ 7 & 28 \\ -3 & -12 \end{bmatrix}$, find one nontrivial solution of $A\mathbf{x} = \mathbf{0}$ by inspection. [Hint: Think of the equation $A\mathbf{x} = \mathbf{0}$ written as a vector equation.]

$\mathbf{x} = \square$

(Type an integer or simplified fraction for each matrix element.)

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Construct a 3×3 nonzero matrix A such that the vector $\begin{bmatrix} 1 \\ 1 \\ -1 \end{bmatrix}$ is a solution of $A\mathbf{x} = \mathbf{0}$.

A = $\square$

Suppose A is a 3×3 matrix and $\mathbf{y}$ is a vector in $\mathbb{R}^3$ such that the equation $A\mathbf{x} = \mathbf{y}$ does not have a solution. Does there exist a vector $\mathbf{z}$ in $\mathbb{R}^3$ such that the equation $A\mathbf{x} = \mathbf{z}$ has a unique solution?

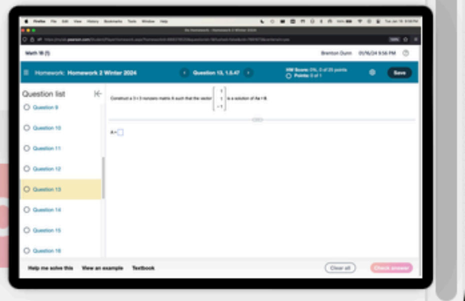
Choose the correct answer.

A. No. Since $A\mathbf{x} = \mathbf{y}$ has no solution, then A cannot have a pivot in every row. So the equation $A\mathbf{x} = \mathbf{z}$ has at most two basic variables and at least one free variable for any $\mathbf{z}$. Thus the solution set for $A\mathbf{x} = \mathbf{z}$ is either empty or has infinitely many elements.

B. Yes. Since $A\mathbf{x} = \mathbf{y}$ has no solution, then A cannot have a pivot in every row. The free variable(s) can be set equal to values such that there are infinitely many solutions for $A\mathbf{x} = \mathbf{z}$ for any given $\mathbf{z}$.

C. Yes. Since $A\mathbf{x} = \mathbf{y}$ has no solution, then A cannot have a pivot in every row. So there is at least one free variable. The free variable(s) can be set equal to values such that there is a unique solution for $A\mathbf{x} = \mathbf{z}$ for any given $\mathbf{z}$.

D. No. Since $A\mathbf{x} = \mathbf{y}$ has no solution, then A cannot have a pivot in every row. Since A is 3×3, it has at most two pivot positions. So the equation $A\mathbf{x} = \mathbf{z}$ has at most two basic variables and at least one free variable for any $\mathbf{z}$. Thus there is no solution for $A\mathbf{x} = \mathbf{z}$.



Determine if the columns of the matrix form a linearly independent set.
Justify your answer.

$$\begin{bmatrix} -4 & -3 & 0 \\ 0 & -1 & 7 \\ 1 & 1 & -7 \\ 2 & 1 & -14 \end{bmatrix}$$

Select the correct choice below and fill in the answer box within your choice.
(Type an integer or simplified fraction for each matrix element.)

A. If A is the given matrix, then the augmented matrix ☐ represents the equation $A\mathbf{x} = \mathbf{0}$. The reduced echelon form of this matrix indicates that $A\mathbf{x} = \mathbf{0}$ has more than one solution. Therefore, the columns of A form a linearly independent set.

B. If A is the given matrix, then the augmented matrix ☐ represents the equation $A\mathbf{x} = \mathbf{0}$. The reduced echelon form of this matrix indicates that $A\mathbf{x} = \mathbf{0}$ has only the trivial solution. Therefore, the columns of A form a linearly independent set.

C. If A is the given matrix, then the augmented matrix ☐ represents the equation $A\mathbf{x} = \mathbf{0}$. The reduced echelon form of this matrix indicates that $A\mathbf{x} = \mathbf{0}$ has more than one solution. Therefore, the columns of A do not form a linearly independent set.

D. If A is the given matrix, then the augmented matrix ☐ represents the equation $A\mathbf{x} = \mathbf{0}$. The reduced echelon form of this matrix indicates that $A\mathbf{x} = \mathbf{0}$ has only the trivial solution. Therefore, the columns of A do not form a linearly independent set.

Determine if the columns of the matrix form a linearly independent set. Justify your answer.

$$\begin{bmatrix} 1 & -3 & 3 \\ -3 & 9 & 3 \end{bmatrix}$$

Choose the correct answer below.

- **A.** The columns of the matrix do form a linearly independent set because there are more entries in each vector than there are vectors in the set.
- **B.** The columns of the matrix do form a linearly independent set because the set contains more vectors than there are entries in each vector.
- **C.** The columns of the matrix do not form a linearly independent set because there are more entries in each vector than there are vectors in the set.
- **D.** The columns of the matrix do not form a linearly independent set because the set contains more vectors than there are entries in each vector.

Question list

Question 12

Question 13

Question 14

Question 15

Question 16

Question 17

Question 18

Question 19

Find the value(s) of h for which the vectors are linearly dependent. Justify your answer.

$$\begin{bmatrix} 2 \\ -2 \\ -4 \end{bmatrix}, \begin{bmatrix} -4 \\ 2 \\ 7 \end{bmatrix}, \begin{bmatrix} -2 \\ 2 \\ h \end{bmatrix}$$

The value(s) of h which makes the vectors linearly dependent is(are) ☐ because this will cause ▼ to be a ▼ variable.

(Use a comma to separate answers as needed.)

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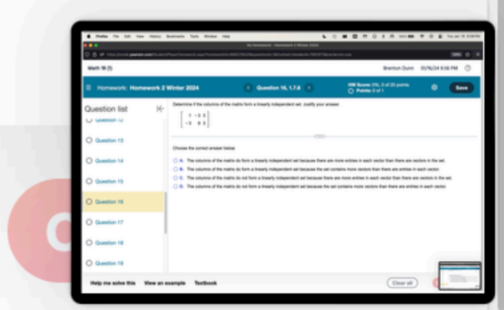

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Homework: **Homework 2 Winter 2024**

Question 18, 1.7.16

HW Score: 0%, 0 of 25 points
Points: 0 of 1

Save

Question list

Question 12

Question 13

Question 14

Question 15

Question 16

Question 17

Question 18

Question 19

Determine by inspection whether the vectors are linearly independent. Justify your answer.

$$\begin{bmatrix} 6 \\ -12 \\ 3 \end{bmatrix}, \begin{bmatrix} 4 \\ -8 \\ 2 \end{bmatrix}$$

Select the correct choice below and, if necessary, fill in the answer box to complete your choice.

A. The set of vectors is linearly dependent because ☐ times the first vector is equal to the second vector.
(Type an integer or a simplified fraction.)

B. The set of vectors is linearly dependent because neither vector is the zero vector.

C. The set of vectors is linearly independent because neither vector is a multiple of the other vector.

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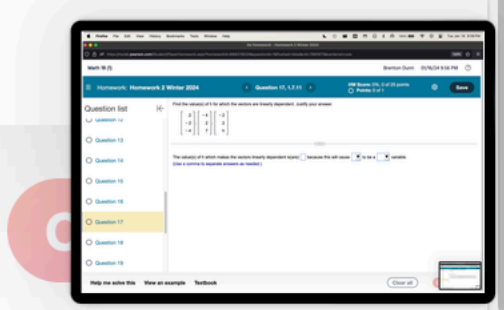
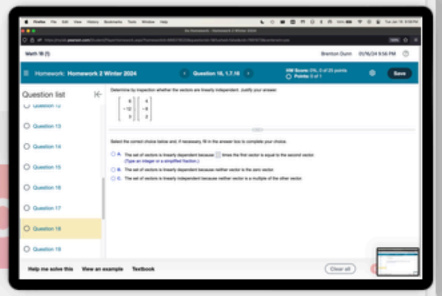


Determine by inspection whether the vectors are linearly independent. Justify your answer.

$$\begin{bmatrix} 3 \\ 6 \\ -1 \end{bmatrix}, \begin{bmatrix} 0 \\ 0 \\ 0 \end{bmatrix}, \begin{bmatrix} -4 \\ 3 \\ 4 \end{bmatrix}$$

Choose the correct answer below.

- **A.** The set of vectors is linearly dependent because ☐ times the first vector is equal to the third vector.
(Type an integer or a simplified fraction.)
- **B.** The set of vectors is linearly independent because ☐ times the first vector is equal to the second vector.
(Type an integer or a simplified fraction.)
- **C.** The set of vectors is linearly dependent because one of the vectors is the zero vector.
- **D.** The set of vectors is linearly independent because none of the vectors are multiples of the other vectors.



Question list
Question 17
Question 18
Question 19
Question 20
Question 21
Question 22
Question 23

Determine by inspection whether the vectors are linearly independent. Justify your answer.

$$\begin{bmatrix} 8 \\ -12 \\ -4 \end{bmatrix}, \begin{bmatrix} -2 \\ 3 \\ -1 \end{bmatrix}$$

Choose the correct answer below.

- **A.** The set is linearly independent because neither vector is a multiple of the other vector. Two of the entries in the first vector are -4 times the corresponding entry in the second vector. But this multiple does not work for the third entries.
- **B.** The set is linearly independent because the first vector is a multiple of the other vector. The entries in the first vector are -4 times the corresponding entry in the second vector.
- **C.** The set is linearly dependent because neither vector is a multiple of the other vector. Two of the entries in the first vector are -4 times the corresponding entry in the second vector. But this multiple does not work for the third entries.
- **D.** The set is linearly dependent because the first vector is a multiple of the other vector. The entries in the first vector are -4 times the corresponding entry in the second vector.

Help me solve this View an example Textbook Clear all

Question list
Question 17
Question 18
Question 19
Question 20
Question 21
Question 22
Question 23

Describe the possible echelon forms of the following matrix.

A is a 6×2 matrix, $A = \begin{bmatrix} \mathbf{a}_1 & \mathbf{a}_2 \end{bmatrix}$, and $\mathbf{a}_2$ is not a multiple of $\mathbf{a}_1$.

Select all that apply. (Note that leading entries marked with an X may have any nonzero value and starred entries (*) may have any value including zero.)

- [ ] **A.** $\begin{bmatrix} X & * \\ 0 & X \\ 0 & 0 \\ 0 & 0 \\ 0 & 0 \\ 0 & 0 \end{bmatrix}$
- [ ] **B.** $\begin{bmatrix} X & * & 0 & 0 & 0 & 0 \\ 0 & X & 0 & 0 & 0 & 0 \end{bmatrix}$
- [ ] **C.** $\begin{bmatrix} 0 & X \\ 0 & 0 \\ 0 & 0 \\ 0 & 0 \\ 0 & 0 \\ 0 & 0 \end{bmatrix}$
- [ ] **D.** $\begin{bmatrix} X & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 \end{bmatrix}$

Suppose A is a 5×7 matrix. How many pivot columns must A have if its columns span $\mathbb{R}^5$? Why?

Select the correct choice below and, if necessary, fill in the answer box to complete your choice.

A. The matrix must have ☐ pivot columns. The statements "A has a pivot position in every row" and "the columns of A span $\mathbb{R}^5$" are logically equivalent.

B. The matrix must have ☐ pivot columns. Otherwise, the equation $A\mathbf{x} = \mathbf{0}$ would have a free variable, in which case the columns of A would not span $\mathbb{R}^5$.

C. The matrix must have ☐ pivot columns. If A had fewer pivot columns, then the equation $A\mathbf{x} = \mathbf{0}$ would have only the trivial solution.

D. The columns of a 5×7 matrix cannot span $\mathbb{R}^5$ because having more columns than rows makes the columns of the matrix dependent.

(a) Fill in the blank in the following statement.

If A is an $m \times n$ matrix, then the columns of A are linearly independent if and only if A has _______ pivot columns.

(b) Explain why the statement in (a) is true.

(a) Fill in the blank.

If A is an $m \times n$ matrix, then the columns of A are linearly independent if and only if A has ▼ pivot columns.

The statement is either true in all cases or false. If false, construct a specific example to show that the statement is not always true.

If $\mathbf{v}_1, \ldots, \mathbf{v}_4$ are in $\mathbb{R}^4$ and $\mathbf{v}_3 = 2\mathbf{v}_1 + \mathbf{v}_2$, then $\{\mathbf{v}_1, \mathbf{v}_2, \mathbf{v}_3, \mathbf{v}_4\}$ is linearly dependent.

Select the correct choice below and, if necessary, fill in the answer boxes to complete your choice.

- **A.** True. The vector $\mathbf{v}_3$ is a linear combination of $\mathbf{v}_1$ and $\mathbf{v}_2$, so at least one of the vectors in the set is a linear combination of the others and set is linearly dependent.
- **B.** True. If $c_1 = 2$, $c_2 = 1$, $c_3 = 1$, and $c_4 = 0$, then $c_1\mathbf{v}_1 + \cdots + c_4\mathbf{v}_4 = \mathbf{0}$. The set of vectors is linearly dependent.
- **C.** True. Because $\mathbf{v}_3 = 2\mathbf{v}_1 + \mathbf{v}_2$, $\mathbf{v}_4$ must be the zero vector. Thus, the set of vectors is linearly dependent.
- **D.** False. If $\mathbf{v}_1 = \square$, $\mathbf{v}_2 = \square$, $\mathbf{v}_3 = \square$, and $\mathbf{v}_4 = \begin{bmatrix} 1 \\ 2 \\ 1 \\ 2 \end{bmatrix}$, then $\mathbf{v}_3 = 2\mathbf{v}_1 + \mathbf{v}_2$ and $\{\mathbf{v}_1, \mathbf{v}_2, \mathbf{v}_3, \mathbf{v}_4\}$ is linearly independent.

Question list
Question 18
Question 19
Question 20
Question 21
Question 22
Question 23
Question 24
Question 25

The following statement is either true (in all cases) or false (for at least one example). If false, construct a specific example to show that the statement is not always true. Such an example is called a counterexample to the statement. If a statement is true, give a justification.

If $\mathbf{v}_1$ and $\mathbf{v}_2$ are in $\mathbb{R}^4$ and $\mathbf{v}_2$ is not a scalar multiple of $\mathbf{v}_1$, then $\{\mathbf{v}_1, \mathbf{v}_2\}$ is linearly independent.

Choose the correct answer below.

- **A.** The statement is false. The vector $\mathbf{v}_1$ could be the zero vector.
- **B.** The statement is true. A set of vectors is linearly independent if and only if none of the vectors are a scalar multiple of another vector.
- **C.** The statement is false. The vector $\mathbf{v}_1$ could be equal to the vector $\mathbf{v}_2$.
- **D.** The statement is false. The vector $\mathbf{v}_1$ could be a scalar multiple of vector $\mathbf{v}_2$.

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