6. Subspaces

Introduction to vector spaces and subspaces

at the bottom, and then a plane through the origin, or a line

You've got the idea.

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Subspaces are subsets of vector spaces that are by themselves vector spaces.

Example 6.1 Subspaces of $\mathbb{R}^2$ (it turns out that this is the complete list):

- $\{\mathbf{0}\}$ (the set containing only the origin),
- any line through the origin,
- the whole plane $\mathbb{R}^2$.

Example 6.2 Subspaces of $\mathbb{R}^3$ (again, the complete list):

- $\{\mathbf{0}\}$,
- any line through the origin,
- any plane through the origin,
- the whole space $\mathbb{R}^3$.

Example problem

1/1 point (graded)

The set of linear combinations of the vectors $\begin{pmatrix} 1 \\ 3 \\ 0 \end{pmatrix}$ and $\begin{pmatrix} 1 \\ 4 \\ 5 \end{pmatrix}$ is a subspace of $\mathbb{R}^3$.

0. The zero vector is obtained by taking the zero combination:

$$0\begin{pmatrix} 1 \\ 3 \\ 0 \end{pmatrix} + 0\begin{pmatrix} 1 \\ 4 \\ 5 \end{pmatrix} = \begin{pmatrix} 0 \\ 0 \\ 0 \end{pmatrix}$$

1. If a vector $\mathbf{v}$ can be written as a linear combination of the two vectors:

$$\mathbf{v} = a \begin{pmatrix} 1 \\ 3 \\ 0 \end{pmatrix} + b \begin{pmatrix} 1 \\ 4 \\ 5 \end{pmatrix},$$

then so can $c\mathbf{v}$:

$$c\mathbf{v} = ca \begin{pmatrix} 1 \\ 3 \\ 0 \end{pmatrix} + cb \begin{pmatrix} 1 \\ 4 \\ 5 \end{pmatrix}.$$

2. If two vectors $\mathbf{v}$ and $\mathbf{w}$ can be written as a linear combination of the two vectors:

$$\mathbf{v} = a_1 \begin{pmatrix} 1 \\ 3 \\ 0 \end{pmatrix} + b_1 \begin{pmatrix} 1 \\ 4 \\ 5 \end{pmatrix}, \qquad \mathbf{w} = a_2 \begin{pmatrix} 1 \\ 3 \\ 0 \end{pmatrix} + b_2 \begin{pmatrix} 1 \\ 4 \\ 5 \end{pmatrix}$$

then so can $\mathbf{v} + \mathbf{w}$:

$$\mathbf{v} + \mathbf{w} = (a_1 + a_2) \begin{pmatrix} 1 \\ 3 \\ 0 \end{pmatrix} + (b_1 + b_2) \begin{pmatrix} 1 \\ 4 \\ 5 \end{pmatrix}.$$

This vector space is what kind of subspace of $\mathbb{R}^3$?

- ○ The point $\{\mathbf{0}\}$
- ○ A line through the origin.
- ◉ A plane through the origin. ✔
- ○ The whole space $\mathbb{R}^3$.

Solution:

The linear combinations of the two vectors $\begin{pmatrix} 1 \\ 3 \\ 0 \end{pmatrix}$ and $\begin{pmatrix} 1 \\ 4 \\ 5 \end{pmatrix}$ forms a plane in $\mathbb{R}^3$, because these two vectors do not lie on the same line through the origin.

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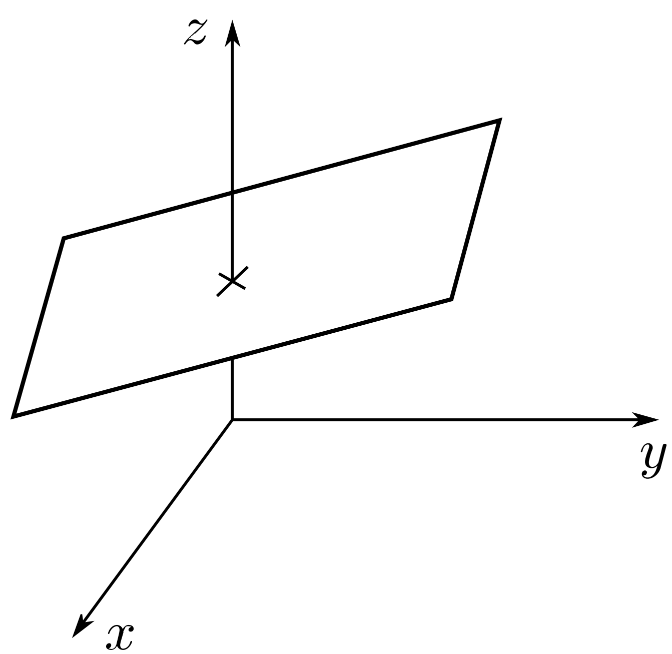
Answers are displayed within the problem

Subspaces concept check

1/1 point (graded)

Is the plane below a subspace of $\mathbb{R}^3$?



Yes.

No. ✔

Cannot be determined without more information.

Solution:

The plane in the image above is not a subspace of $\mathbb{R}^3$ because it is not passing through the origin.

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