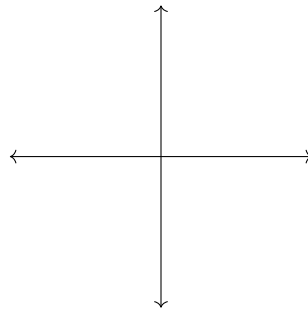


Section V.3

Observation V.3.1 Any single non-zero vector/number x in \mathbb{R}^1 spans \mathbb{R}^1 , since $\mathbb{R}^1 = \{cx \mid c \in \mathbb{R}\}$.



Activity V.3.2 (*~5 min*) How many vectors are required to span \mathbb{R}^2 ? Sketch a drawing in the xy plane to support your answer.



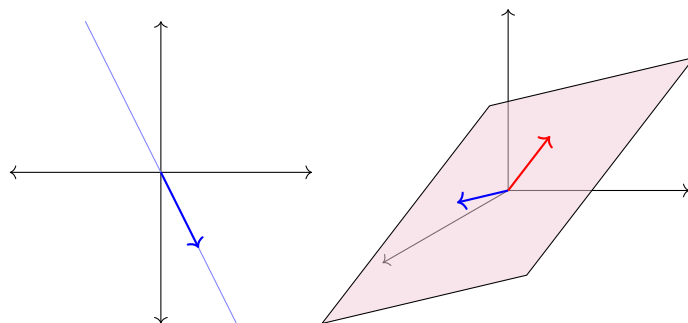
- (a) 1
- (b) 2
- (c) 3
- (d) 4
- (e) Infinitely Many

Activity V.3.3 (*~5 min*) How many vectors are required to span \mathbb{R}^3 ?



- (a) 1
- (b) 2
- (c) 3
- (d) 4
- (e) Infinitely Many

Fact V.3.4 At least n vectors are required to span \mathbb{R}^n .



Activity V.3.5 (*~15 min*) Choose any vector $\begin{bmatrix} ? \\ ? \\ ? \end{bmatrix}$ in \mathbb{R}^3 that is not in $\text{span} \left\{ \begin{bmatrix} 1 \\ -1 \\ 0 \end{bmatrix}, \begin{bmatrix} -2 \\ 0 \\ 1 \end{bmatrix} \right\}$ by using technology to verify that $\text{RREF} \left[\begin{array}{cc|c} 1 & -2 & ? \\ -1 & 0 & ? \\ 0 & 1 & ? \end{array} \right] = \left[\begin{array}{cc|c} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{array} \right]$. (Why does this work?)

Fact V.3.6 The set $\{\vec{v}_1, \dots, \vec{v}_m\}$ fails to span all of \mathbb{R}^n exactly when $\text{RREF}[\vec{v}_1 \dots \vec{v}_m]$ has a non-pivot row of zeros.

$$\begin{aligned} & \begin{bmatrix} 1 & -2 \\ -1 & 0 \\ 0 & 1 \end{bmatrix} \sim \begin{bmatrix} 1 & 0 \\ 0 & 1 \\ 0 & 0 \end{bmatrix} \\ \Rightarrow & \left[\begin{array}{cc|c} 1 & -2 & a \\ -1 & 0 & b \\ 0 & 1 & c \end{array} \right] \sim \left[\begin{array}{cc|c} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{array} \right] \text{ for some choice of vector } \begin{bmatrix} a \\ b \\ c \end{bmatrix} \end{aligned}$$

Activity V.3.7 (*~5 min*) Consider the set of vectors $S = \left\{ \begin{bmatrix} 2 \\ 3 \\ 0 \\ -1 \end{bmatrix}, \begin{bmatrix} 1 \\ -4 \\ 3 \\ 0 \end{bmatrix}, \begin{bmatrix} 2 \\ 0 \\ 0 \\ 3 \end{bmatrix}, \begin{bmatrix} 0 \\ 3 \\ 5 \\ 7 \end{bmatrix}, \begin{bmatrix} 3 \\ 13 \\ 7 \\ 16 \end{bmatrix} \right\}$. Does $\mathbb{R}^4 = \text{span } S$?

Activity V.3.8 (*~10 min*) Consider the set of third-degree polynomials

$$S = \{2x^3 + 3x^2 - 1, 2x^3 + 3, 3x^3 + 13x^2 + 7x + 16, -x^3 + 10x^2 + 7x + 14, 4x^3 + 3x^2 + 2\}.$$

Does $\mathcal{P}^3 = \text{span } S$? (Hint: first rewrite the question so it is about Euclidean vectors.)

Activity V.3.9 (*~5 min*) Consider the set of matrices

$$S = \left\{ \begin{bmatrix} 1 & 3 \\ 0 & 1 \end{bmatrix}, \begin{bmatrix} 1 & -1 \\ 1 & 0 \end{bmatrix}, \begin{bmatrix} 1 & 0 \\ 0 & 2 \end{bmatrix} \right\}$$

Does $M_{2,2} = \text{span } S$?

Activity V.3.10 (*~5 min*) Let $\vec{v}_1, \vec{v}_2, \vec{v}_3 \in \mathbb{R}^7$ be three vectors, and suppose \vec{w} is another vector with $\vec{w} \in \text{span}\{\vec{v}_1, \vec{v}_2, \vec{v}_3\}$. What can you conclude about $\text{span}\{\vec{w}, \vec{v}_1, \vec{v}_2, \vec{v}_3\}$?

- (a) $\text{span}\{\vec{w}, \vec{v}_1, \vec{v}_2, \vec{v}_3\}$ is larger than $\text{span}\{\vec{v}_1, \vec{v}_2, \vec{v}_3\}$.
- (b) $\text{span}\{\vec{w}, \vec{v}_1, \vec{v}_2, \vec{v}_3\} = \text{span}\{\vec{v}_1, \vec{v}_2, \vec{v}_3\}$.
- (c) $\text{span}\{\vec{w}, \vec{v}_1, \vec{v}_2, \vec{v}_3\}$ is smaller than $\text{span}\{\vec{v}_1, \vec{v}_2, \vec{v}_3\}$.