

Vectors in the plane

Lesson #22

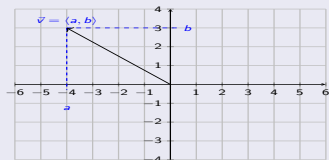
MAT 1375 Precalculus

New York City College of Technology CUNY



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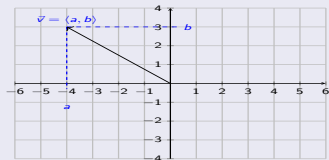
Vector in the plane



A **vector** is a geometric object that is given by a **direction** and **magnitude**.

Vectors in the plane

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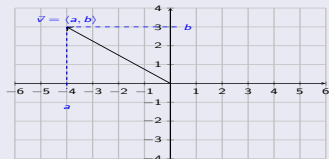
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For a vector in the plane, we write the vector in coordinates:

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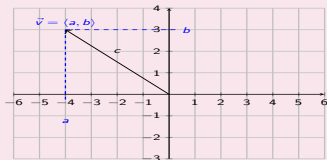
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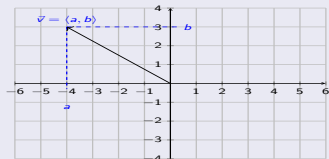
Magnitude of a vector in the plane

The **magnitude** of $\vec{v} = \langle a, b \rangle$ is



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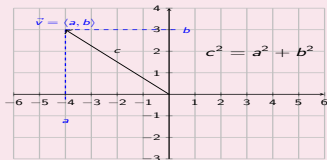
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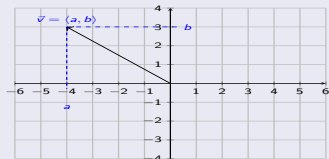
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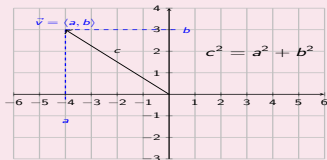
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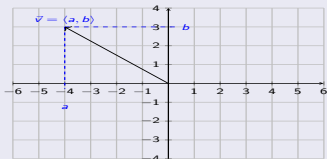
$$\|\vec{v}\| = \|\langle a, b \rangle\| = \sqrt{a^2 + b^2}$$

Find the magnitude of the vector.

- 1 $\vec{v} = \langle 4, -2 \rangle$
- 2 $\vec{v} = \langle -3, -3 \rangle$
- 3 $\vec{v} = \langle -5, 5\sqrt{3} \rangle$

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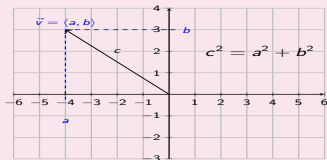
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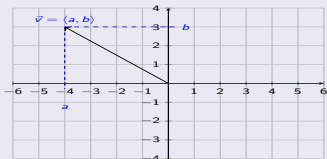
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 $= \sqrt{16 + 4} = \sqrt{20} = \sqrt{4 \cdot 5} = 2\sqrt{5}$
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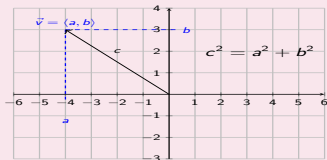
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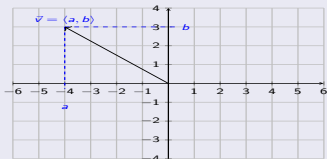
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 $\Rightarrow \|\langle -3, -3 \rangle\| = \sqrt{(-3)^2 + (-3)^2}$
 $= \sqrt{9 + 9} = \sqrt{18} = \sqrt{9 \cdot 2} = 3\sqrt{2}$
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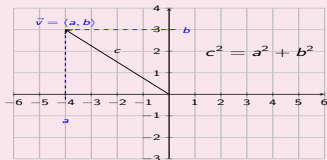
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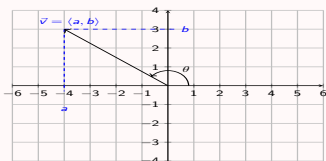
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 $\Rightarrow \|\langle -5, 5\sqrt{3} \rangle\| = \sqrt{(-5)^2 + (5\sqrt{3})^2}$
 $= \sqrt{25 + 25 \cdot 3} = \sqrt{100} = 10$

Magnitude and direction angle of a vector

Direction angle of a vector in the plane

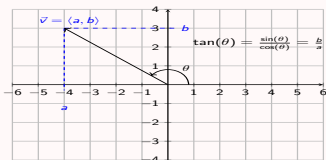
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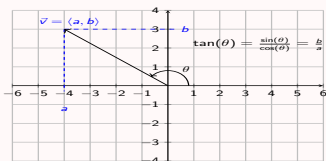


$$\theta = \arctan\left(\frac{b}{a}\right)$$

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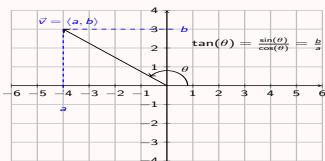
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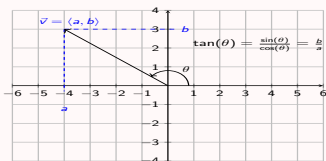
1 $\vec{v} = \langle 3, 2 \rangle$

$$\theta = \arctan\left(\frac{2}{3}\right) \approx 33.69^\circ$$

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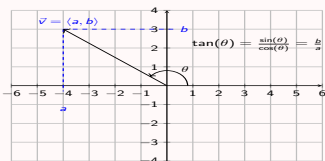
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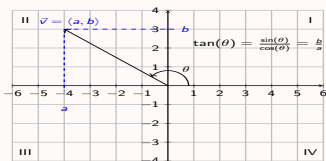
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Magnitude and direction angle of a vector

Direction angle of a vector in the plane

The **direction angle** of $\vec{v} = \langle a, b \rangle$ is



$$\theta = \arctan\left(\frac{b}{a}\right) \quad \text{if in I or IV}$$

$$\theta = \arctan\left(\frac{b}{a}\right) + 180^\circ \quad \text{if in II or III}$$

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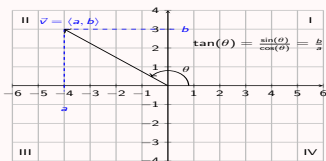
② $\vec{v} = \langle -3, -2 \rangle$ in quadrant III

$$\begin{aligned} \theta &= \arctan\left(\frac{-2}{-3}\right) + 180^\circ \\ &\approx 33.69^\circ + 180^\circ \approx 213.69^\circ \end{aligned}$$

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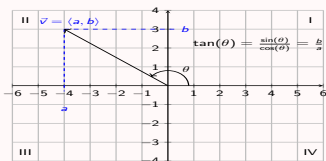
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1 $\vec{v} = \langle 4, 3 \rangle$ in quadrant I

$$\|\vec{v}\| = \sqrt{16 + 9} = \sqrt{25} = 5$$

$$\theta = \arctan\left(\frac{3}{4}\right) \approx 36.87^\circ$$

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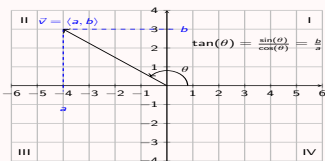
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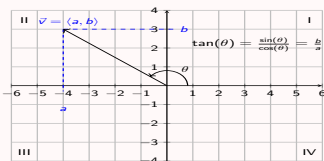
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- $\vec{v} = \langle -2, 2 \rangle$ in quadrant II
 $\|\vec{v}\| = \sqrt{4 + 4} = \sqrt{8} = 2\sqrt{2}$
 $\theta = \arctan\left(\frac{2}{-2}\right) + 180^\circ = -45^\circ + 180^\circ = 135^\circ$
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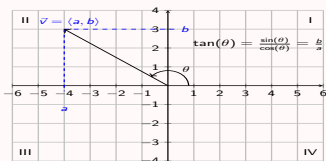
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4 $\vec{v} = \langle 7, -7\sqrt{3} \rangle$ in quadrant IV

$$\|\vec{v}\| = \sqrt{49 + 49 \cdot 3} = \sqrt{196} = 14$$

$$\theta = \arctan\left(\frac{-7\sqrt{3}}{7}\right) = -60^\circ$$

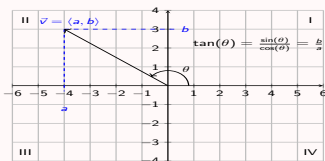
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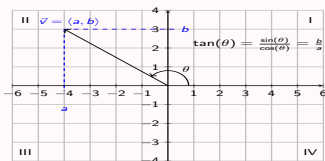
$$\theta = \arctan\left(\frac{1}{-\sqrt{3}}\right) + 180^\circ = -30^\circ + 180^\circ = 150^\circ$$

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Find the direction angle of the vector.

1 $\vec{v} = \langle 3, 2 \rangle$

$$\theta = \arctan\left(\frac{2}{3}\right) \approx 33.69^\circ$$

2 $\vec{v} = \langle -3, -2 \rangle$ in quadrant III

$$\theta = \arctan\left(\frac{-2}{-3}\right) + 180^\circ$$
$$\approx 33.69^\circ + 180^\circ \approx 213.69^\circ$$

Find the magnitude and direction angle.

1 $\vec{v} = \langle 4, 3 \rangle$ in quadrant I

$$\|\vec{v}\| = \sqrt{16 + 9} = \sqrt{25} = 5$$

$$\theta = \arctan\left(\frac{3}{4}\right) \approx 36.87^\circ$$

2 $\vec{v} = \langle -2, 2 \rangle$ in quadrant II

$$\|\vec{v}\| = \sqrt{4 + 4} = \sqrt{8} = 2\sqrt{2}$$

$$\theta = \arctan\left(\frac{2}{-2}\right) + 180^\circ = -45^\circ + 180^\circ = 135^\circ$$

3 $\vec{v} = \langle -5, -5 \rangle$ in quadrant III

$$\|\vec{v}\| = \sqrt{25 + 25} = \sqrt{50} = 5\sqrt{2}$$

$$\theta = \arctan\left(\frac{-5}{-5}\right) + 180^\circ = 45^\circ + 180^\circ = 225^\circ$$

4 $\vec{v} = \langle 7, -7\sqrt{3} \rangle$ in quadrant IV

$$\|\vec{v}\| = \sqrt{49 + 49 \cdot 3} = \sqrt{196} = 14$$

$$\theta = \arctan\left(\frac{-7\sqrt{3}}{7}\right) = -60^\circ$$

5 $\vec{v} = \langle -\sqrt{3}, 1 \rangle$ in quadrant II

$$\|\vec{v}\| = \sqrt{3 + 1} = \sqrt{4} = 2$$

$$\theta = \arctan\left(\frac{1}{-\sqrt{3}}\right) + 180^\circ = -30^\circ + 180^\circ = 150^\circ$$

6 $\vec{v} = \langle -10, -6 \rangle$ in quadrant III

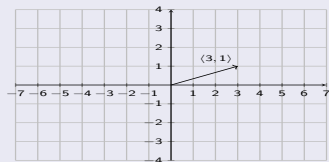
$$\|\vec{v}\| = \sqrt{100 + 36} = \sqrt{136} = 2\sqrt{34}$$

$$\theta = \arctan\left(\frac{-6}{-10}\right) + 180^\circ \approx 30.96^\circ + 180^\circ \approx 210.96^\circ$$

Scalar multiplication and vector addition

Scalar multiplication

Vector addition

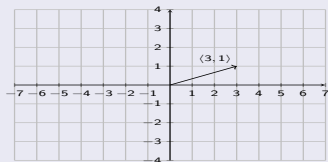


$$r \cdot \langle a, b \rangle = \langle r \cdot a, r \cdot b \rangle$$

Scalar multiplication and vector addition

Scalar multiplication

Vector addition



$$r \cdot \langle a, b \rangle = \langle r \cdot a, r \cdot b \rangle$$

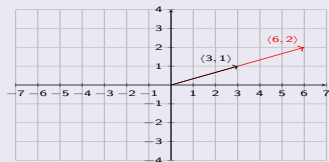
Multiply the scalar with the vector.

1 $2 \cdot \langle 3, 1 \rangle =$

Scalar multiplication and vector addition

Scalar multiplication

Vector addition



$$r \cdot \langle a, b \rangle = \langle r \cdot a, r \cdot b \rangle$$

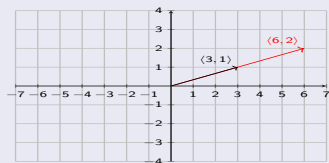
Multiply the scalar with the vector.

$$1 \quad 2 \cdot \langle 3, 1 \rangle = \langle 6, 2 \rangle$$

Scalar multiplication and vector addition

Scalar multiplication

Vector addition



$$r \cdot \langle a, b \rangle = \langle r \cdot a, r \cdot b \rangle$$

Multiply the scalar with the vector.

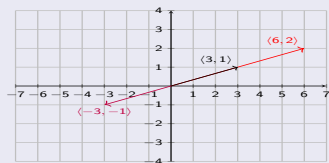
1 $2 \cdot \langle 3, 1 \rangle = \langle 6, 2 \rangle$

2 $-1 \cdot \langle 3, 1 \rangle =$

Scalar multiplication and vector addition

Scalar multiplication

Vector addition



$$r \cdot \langle a, b \rangle = \langle r \cdot a, r \cdot b \rangle$$

Multiply the scalar with the vector.

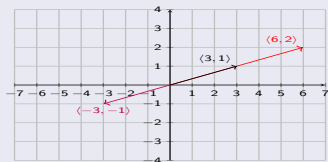
① $2 \cdot \langle 3, 1 \rangle = \langle 6, 2 \rangle$

② $-1 \cdot \langle 3, 1 \rangle = \langle -3, -1 \rangle$

Scalar multiplication and vector addition

Scalar multiplication

Vector addition



$$r \cdot \langle a, b \rangle = \langle r \cdot a, r \cdot b \rangle$$

Multiply the scalar with the vector.

1 $2 \cdot \langle 3, 1 \rangle = \langle 6, 2 \rangle$

2 $-1 \cdot \langle 3, 1 \rangle = \langle -3, -1 \rangle$

3 $5 \cdot \langle -7, 3 \rangle =$

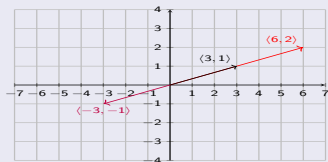
4 $\frac{1}{4} \cdot \langle 6, -7 \rangle =$

5 $-\frac{3}{8} \cdot \langle -\frac{5}{6}, \frac{11}{9} \rangle =$

Scalar multiplication and vector addition

Scalar multiplication

Vector addition



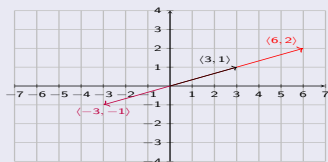
$$r \cdot \langle a, b \rangle = \langle r \cdot a, r \cdot b \rangle$$

Multiply the scalar with the vector.

- 1 $2 \cdot \langle 3, 1 \rangle = \langle 6, 2 \rangle$
- 2 $-1 \cdot \langle 3, 1 \rangle = \langle -3, -1 \rangle$
- 3 $5 \cdot \langle -7, 3 \rangle = \langle -35, 15 \rangle$
- 4 $\frac{1}{4} \cdot \langle 6, -7 \rangle = \langle \frac{6}{4}, -\frac{7}{4} \rangle = \langle \frac{3}{2}, -\frac{7}{4} \rangle$
- 5 $-\frac{3}{8} \cdot \langle -\frac{5}{6}, \frac{11}{9} \rangle = \langle \frac{15}{48}, -\frac{33}{72} \rangle$
 $= \langle \frac{5}{16}, -\frac{11}{24} \rangle$

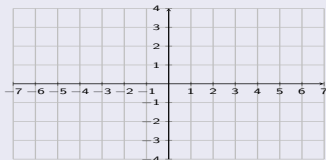
Scalar multiplication and vector addition

Scalar multiplication



$$r \cdot \langle a, b \rangle = \langle r \cdot a, r \cdot b \rangle$$

Vector addition



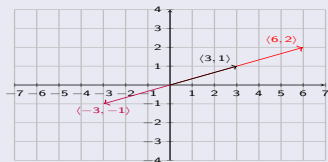
$$\langle a, b \rangle + \langle c, d \rangle = \langle a + c, b + d \rangle$$

Multiply the scalar with the vector.

- 1 $2 \cdot \langle 3, 1 \rangle = \langle 6, 2 \rangle$
- 2 $-1 \cdot \langle 3, 1 \rangle = \langle -3, -1 \rangle$
- 3 $5 \cdot \langle -7, 3 \rangle = \langle -35, 15 \rangle$
- 4 $\frac{1}{4} \cdot \langle 6, -7 \rangle = \langle \frac{6}{4}, -\frac{7}{4} \rangle = \langle \frac{3}{2}, -\frac{7}{4} \rangle$
- 5 $-\frac{3}{8} \cdot \langle -\frac{5}{6}, \frac{11}{9} \rangle = \langle \frac{15}{48}, -\frac{33}{72} \rangle$
 $= \langle \frac{5}{16}, -\frac{11}{24} \rangle$

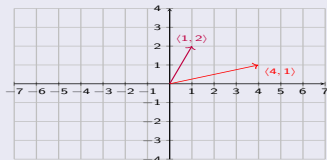
Scalar multiplication and vector addition

Scalar multiplication



$$r \cdot \langle a, b \rangle = \langle r \cdot a, r \cdot b \rangle$$

Vector addition



$$\langle a, b \rangle + \langle c, d \rangle = \langle a + c, b + d \rangle$$

Multiply the scalar with the vector.

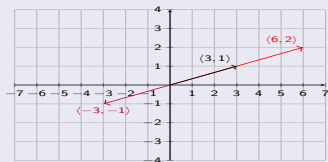
- 1 $2 \cdot \langle 3, 1 \rangle = \langle 6, 2 \rangle$
- 2 $-1 \cdot \langle 3, 1 \rangle = \langle -3, -1 \rangle$
- 3 $5 \cdot \langle -7, 3 \rangle = \langle -35, 15 \rangle$
- 4 $\frac{1}{4} \cdot \langle 6, -7 \rangle = \langle \frac{6}{4}, -\frac{7}{4} \rangle = \langle \frac{3}{2}, -\frac{7}{4} \rangle$
- 5 $-\frac{3}{8} \cdot \langle -\frac{5}{6}, \frac{11}{9} \rangle = \langle \frac{15}{48}, -\frac{33}{72} \rangle$
 $= \langle \frac{5}{16}, -\frac{11}{24} \rangle$

Add the vectors.

- 1 $\langle 4, 1 \rangle + \langle 1, 2 \rangle =$

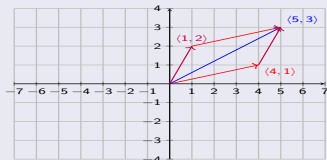
Scalar multiplication and vector addition

Scalar multiplication



$$r \cdot \langle a, b \rangle = \langle r \cdot a, r \cdot b \rangle$$

Vector addition



$$\langle a, b \rangle + \langle c, d \rangle = \langle a + c, b + d \rangle$$

Multiply the scalar with the vector.

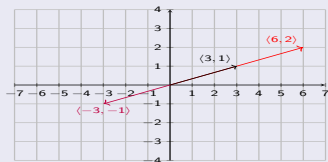
- 1 $2 \cdot \langle 3, 1 \rangle = \langle 6, 2 \rangle$
- 2 $-1 \cdot \langle 3, 1 \rangle = \langle -3, -1 \rangle$
- 3 $5 \cdot \langle -7, 3 \rangle = \langle -35, 15 \rangle$
- 4 $\frac{1}{4} \cdot \langle 6, -7 \rangle = \langle \frac{6}{4}, -\frac{7}{4} \rangle = \langle \frac{3}{2}, -\frac{7}{4} \rangle$
- 5 $-\frac{3}{8} \cdot \langle -\frac{5}{6}, \frac{11}{9} \rangle = \langle \frac{15}{48}, -\frac{33}{72} \rangle$
 $= \langle \frac{5}{16}, -\frac{11}{24} \rangle$

Add the vectors.

- 1 $\langle 4, 1 \rangle + \langle 1, 2 \rangle = \langle 5, 3 \rangle$

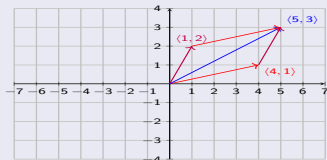
Scalar multiplication and vector addition

Scalar multiplication



$$r \cdot \langle a, b \rangle = \langle r \cdot a, r \cdot b \rangle$$

Vector addition



$$\langle a, b \rangle + \langle c, d \rangle = \langle a + c, b + d \rangle$$

Multiply the scalar with the vector.

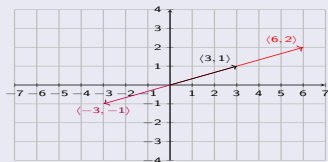
- 1 $2 \cdot \langle 3, 1 \rangle = \langle 6, 2 \rangle$
- 2 $-1 \cdot \langle 3, 1 \rangle = \langle -3, -1 \rangle$
- 3 $5 \cdot \langle -7, 3 \rangle = \langle -35, 15 \rangle$
- 4 $\frac{1}{4} \cdot \langle 6, -7 \rangle = \langle \frac{6}{4}, -\frac{7}{4} \rangle = \langle \frac{3}{2}, -\frac{7}{4} \rangle$
- 5 $-\frac{3}{8} \cdot \langle -\frac{5}{6}, \frac{11}{9} \rangle = \langle \frac{15}{48}, -\frac{33}{72} \rangle$
 $= \langle \frac{5}{16}, -\frac{11}{24} \rangle$

Add the vectors.

- 1 $\langle 4, 1 \rangle + \langle 1, 2 \rangle = \langle 5, 3 \rangle$
- 2 $\langle 6, -2 \rangle + \langle 7, 5 \rangle =$
- 3 $\langle -2, -4 \rangle + \langle -6, 4 \rangle =$
- 4 $\langle 3, -1 \rangle - \langle -5, 3 \rangle =$

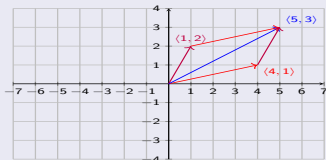
Scalar multiplication and vector addition

Scalar multiplication



$$r \cdot \langle a, b \rangle = \langle r \cdot a, r \cdot b \rangle$$

Vector addition



$$\langle a, b \rangle + \langle c, d \rangle = \langle a + c, b + d \rangle$$

Multiply the scalar with the vector.

- 1 $2 \cdot \langle 3, 1 \rangle = \langle 6, 2 \rangle$
- 2 $-1 \cdot \langle 3, 1 \rangle = \langle -3, -1 \rangle$
- 3 $5 \cdot \langle -7, 3 \rangle = \langle -35, 15 \rangle$
- 4 $\frac{1}{4} \cdot \langle 6, -7 \rangle = \langle \frac{6}{4}, -\frac{7}{4} \rangle = \langle \frac{3}{2}, -\frac{7}{4} \rangle$
- 5 $-\frac{3}{8} \cdot \langle -\frac{5}{6}, \frac{11}{9} \rangle = \langle \frac{15}{48}, -\frac{33}{72} \rangle$
 $= \langle \frac{5}{16}, -\frac{11}{24} \rangle$

Add the vectors.

- 1 $\langle 4, 1 \rangle + \langle 1, 2 \rangle = \langle 5, 3 \rangle$
- 2 $\langle 6, -2 \rangle + \langle 7, 5 \rangle = \langle 13, 3 \rangle$
- 3 $\langle -2, -4 \rangle + \langle -6, 4 \rangle = \langle -8, 0 \rangle$
- 4 $\langle 3, -1 \rangle - \langle -5, 3 \rangle = \langle 8, -4 \rangle$

Scalar multiplication and vector addition - exercises

Evaluate the expression.

1 $\langle -8, -5 \rangle - 2 \cdot \langle -4, 9 \rangle$

2 $(-3) \cdot \langle 2, 4 \rangle + 5 \cdot \langle 7, -3 \rangle$

3 $\vec{v} = \langle 6, -8 \rangle, \vec{w} = \langle -4, -9 \rangle$
Find $4 \cdot \vec{v} - 7 \cdot \vec{w}$

4 $-\frac{2}{9} \cdot \langle -\frac{5}{6}, \frac{8}{7} \rangle + \frac{1}{7} \cdot \langle \frac{11}{4}, -\frac{2}{3} \rangle$

Scalar multiplication and vector addition - exercises

Evaluate the expression.

$$\begin{aligned} 1 \quad & \langle -8, -5 \rangle - 2 \cdot \langle -4, 9 \rangle \\ & = \langle -8 - 2 \cdot (-4), -5 - 2 \cdot 9 \rangle \\ & = \langle -8 + 8, -5 - 18 \rangle \\ & = \langle 0, -23 \rangle \end{aligned}$$

$$2 \quad (-3) \cdot \langle 2, 4 \rangle + 5 \cdot \langle 7, -3 \rangle$$

$$3 \quad \vec{v} = \langle 6, -8 \rangle, \vec{w} = \langle -4, -9 \rangle$$

Find $4 \cdot \vec{v} - 7 \cdot \vec{w}$

$$4 \quad -\frac{2}{9} \cdot \langle -\frac{5}{6}, \frac{8}{7} \rangle + \frac{1}{7} \cdot \langle \frac{11}{4}, -\frac{2}{3} \rangle$$

Scalar multiplication and vector addition - exercises

Evaluate the expression.

$$\begin{aligned} 1 \quad & \langle -8, -5 \rangle - 2 \cdot \langle -4, 9 \rangle \\ & = \langle -8 - 2 \cdot (-4), -5 - 2 \cdot 9 \rangle \\ & = \langle -8 + 8, -5 - 18 \rangle \\ & = \langle 0, -23 \rangle \end{aligned}$$

$$\begin{aligned} 2 \quad & (-3) \cdot \langle 2, 4 \rangle + 5 \cdot \langle 7, -3 \rangle \\ & = \langle -6, -12 \rangle + \langle 35, -15 \rangle \\ & = \langle 29, -27 \rangle \end{aligned}$$

$$\begin{aligned} 3 \quad & \vec{v} = \langle 6, -8 \rangle, \vec{w} = \langle -4, -9 \rangle \\ & \text{Find } 4 \cdot \vec{v} - 7 \cdot \vec{w} \end{aligned}$$

$$4 \quad -\frac{2}{9} \cdot \left\langle -\frac{5}{6}, \frac{8}{7} \right\rangle + \frac{1}{7} \cdot \left\langle \frac{11}{4}, -\frac{2}{3} \right\rangle$$

Scalar multiplication and vector addition - exercises

Evaluate the expression.

$$\begin{aligned} 1 \quad & \langle -8, -5 \rangle - 2 \cdot \langle -4, 9 \rangle \\ & = \langle -8 - 2 \cdot (-4), -5 - 2 \cdot 9 \rangle \\ & = \langle -8 + 8, -5 - 18 \rangle \\ & = \langle 0, -23 \rangle \end{aligned}$$

$$\begin{aligned} 2 \quad & (-3) \cdot \langle 2, 4 \rangle + 5 \cdot \langle 7, -3 \rangle \\ & = \langle -6, -12 \rangle + \langle 35, -15 \rangle \\ & = \langle 29, -27 \rangle \end{aligned}$$

$$\begin{aligned} 3 \quad & \vec{v} = \langle 6, -8 \rangle, \vec{w} = \langle -4, -9 \rangle \\ & \text{Find } 4 \cdot \vec{v} - 7 \cdot \vec{w} \\ & = 4 \cdot \langle 6, -8 \rangle - 7 \cdot \langle -4, -9 \rangle \\ & = \langle 24, -32 \rangle + \langle 28, 63 \rangle \\ & = \langle 52, 31 \rangle \end{aligned}$$

$$4 \quad -\frac{2}{9} \cdot \langle -\frac{5}{6}, \frac{8}{7} \rangle + \frac{1}{7} \cdot \langle \frac{11}{4}, -\frac{2}{3} \rangle$$

Scalar multiplication and vector addition - exercises

Evaluate the expression.

$$\begin{aligned} 1 \quad & \langle -8, -5 \rangle - 2 \cdot \langle -4, 9 \rangle \\ & = \langle -8 - 2 \cdot (-4), -5 - 2 \cdot 9 \rangle \\ & = \langle -8 + 8, -5 - 18 \rangle \\ & = \langle 0, -23 \rangle \end{aligned}$$

$$\begin{aligned} 2 \quad & (-3) \cdot \langle 2, 4 \rangle + 5 \cdot \langle 7, -3 \rangle \\ & = \langle -6, -12 \rangle + \langle 35, -15 \rangle \\ & = \langle 29, -27 \rangle \end{aligned}$$

$$\begin{aligned} 3 \quad & \vec{v} = \langle 6, -8 \rangle, \vec{w} = \langle -4, -9 \rangle \\ & \text{Find } 4 \cdot \vec{v} - 7 \cdot \vec{w} \\ & = 4 \cdot \langle 6, -8 \rangle - 7 \cdot \langle -4, -9 \rangle \\ & = \langle 24, -32 \rangle + \langle 28, 63 \rangle \\ & = \langle 52, 31 \rangle \end{aligned}$$

$$\begin{aligned} 4 \quad & -\frac{2}{9} \cdot \langle -\frac{5}{6}, \frac{8}{7} \rangle + \frac{1}{7} \cdot \langle \frac{11}{4}, -\frac{2}{3} \rangle \\ & = \langle \frac{5}{27}, -\frac{16}{63} \rangle + \langle \frac{11}{28}, -\frac{2}{21} \rangle \\ & = \langle \frac{5 \cdot 28 + 11 \cdot 27}{27 \cdot 28}, \frac{-16 - 2 \cdot 3}{63} \rangle \\ & = \langle \frac{437}{756}, -\frac{22}{63} \rangle \end{aligned}$$

Scalar multiplication and vector addition - exercises

Evaluate the expression.

$$\begin{aligned} ① \quad & \langle -8, -5 \rangle - 2 \cdot \langle -4, 9 \rangle \\ &= \langle -8 - 2 \cdot (-4), -5 - 2 \cdot 9 \rangle \\ &= \langle -8 + 8, -5 - 18 \rangle \\ &= \langle 0, -23 \rangle \end{aligned}$$

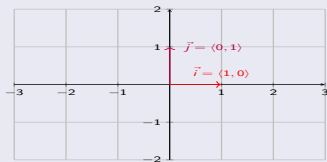
$$\begin{aligned} ② \quad & (-3) \cdot \langle 2, 4 \rangle + 5 \cdot \langle 7, -3 \rangle \\ &= \langle -6, -12 \rangle + \langle 35, -15 \rangle \\ &= \langle 29, -27 \rangle \end{aligned}$$

$$\begin{aligned} ③ \quad & \vec{v} = \langle 6, -8 \rangle, \vec{w} = \langle -4, -9 \rangle \\ & \text{Find } 4 \cdot \vec{v} - 7 \cdot \vec{w} \\ &= 4 \cdot \langle 6, -8 \rangle - 7 \cdot \langle -4, -9 \rangle \\ &= \langle 24, -32 \rangle + \langle 28, 63 \rangle \\ &= \langle 52, 31 \rangle \end{aligned}$$

$$\begin{aligned} ④ \quad & -\frac{2}{9} \cdot \left\langle -\frac{5}{6}, \frac{8}{7} \right\rangle + \frac{1}{7} \cdot \left\langle \frac{11}{4}, -\frac{2}{3} \right\rangle \\ &= \left\langle \frac{5}{27}, -\frac{16}{63} \right\rangle + \left\langle \frac{11}{28}, -\frac{2}{21} \right\rangle \\ &= \left\langle \frac{5 \cdot 28 + 11 \cdot 27}{27 \cdot 28}, \frac{-16 - 2 \cdot 3}{63} \right\rangle \\ &= \left\langle \frac{437}{756}, -\frac{22}{63} \right\rangle \end{aligned}$$

Standard unit vectors

Denote by $\vec{i} = \langle 1, 0 \rangle$ and $\vec{j} = \langle 0, 1 \rangle$.



Scalar multiplication and vector addition - exercises

Evaluate the expression.

$$\begin{aligned} 1 \quad & \langle -8, -5 \rangle - 2 \cdot \langle -4, 9 \rangle \\ &= \langle -8 - 2 \cdot (-4), -5 - 2 \cdot 9 \rangle \\ &= \langle -8 + 8, -5 - 18 \rangle \\ &= \langle 0, -23 \rangle \end{aligned}$$

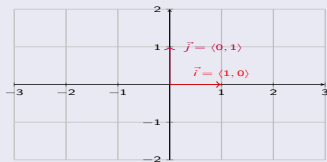
$$\begin{aligned} 2 \quad & (-3) \cdot \langle 2, 4 \rangle + 5 \cdot \langle 7, -3 \rangle \\ &= \langle -6, -12 \rangle + \langle 35, -15 \rangle \\ &= \langle 29, -27 \rangle \end{aligned}$$

$$\begin{aligned} 3 \quad & \vec{v} = \langle 6, -8 \rangle, \vec{w} = \langle -4, -9 \rangle \\ & \text{Find } 4 \cdot \vec{v} - 7 \cdot \vec{w} \\ &= 4 \cdot \langle 6, -8 \rangle - 7 \cdot \langle -4, -9 \rangle \\ &= \langle 24, -32 \rangle + \langle 28, 63 \rangle \\ &= \langle 52, 31 \rangle \end{aligned}$$

$$\begin{aligned} 4 \quad & -\frac{2}{9} \cdot \left\langle -\frac{5}{6}, \frac{8}{7} \right\rangle + \frac{1}{7} \cdot \left\langle \frac{11}{4}, -\frac{2}{3} \right\rangle \\ &= \left\langle \frac{5}{27}, -\frac{16}{63} \right\rangle + \left\langle \frac{11}{28}, -\frac{2}{21} \right\rangle \\ &= \left\langle \frac{5 \cdot 28 + 11 \cdot 27}{27 \cdot 28}, \frac{-16 - 2 \cdot 3}{63} \right\rangle \\ &= \left\langle \frac{437}{756}, -\frac{22}{63} \right\rangle \end{aligned}$$

Standard unit vectors

Denote by $\vec{i} = \langle 1, 0 \rangle$ and $\vec{j} = \langle 0, 1 \rangle$.



$$5 \quad 2\vec{i} + (-7)\vec{j} + (-6)\vec{i} + 9\vec{j}$$

$$6 \quad -3\vec{i} - 2\vec{j} + 8\vec{i} - 4\vec{j}$$

Scalar multiplication and vector addition - exercises

Evaluate the expression.

$$\begin{aligned} 1 \quad & \langle -8, -5 \rangle - 2 \cdot \langle -4, 9 \rangle \\ & = \langle -8 - 2 \cdot (-4), -5 - 2 \cdot 9 \rangle \\ & = \langle -8 + 8, -5 - 18 \rangle \\ & = \langle 0, -23 \rangle \end{aligned}$$

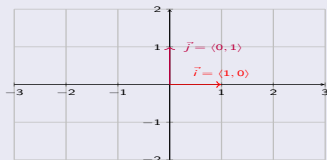
$$\begin{aligned} 2 \quad & (-3) \cdot \langle 2, 4 \rangle + 5 \cdot \langle 7, -3 \rangle \\ & = \langle -6, -12 \rangle + \langle 35, -15 \rangle \\ & = \langle 29, -27 \rangle \end{aligned}$$

$$\begin{aligned} 3 \quad & \vec{v} = \langle 6, -8 \rangle, \vec{w} = \langle -4, -9 \rangle \\ & \text{Find } 4 \cdot \vec{v} - 7 \cdot \vec{w} \\ & = 4 \cdot \langle 6, -8 \rangle - 7 \cdot \langle -4, -9 \rangle \\ & = \langle 24, -32 \rangle + \langle 28, 63 \rangle \\ & = \langle 52, 31 \rangle \end{aligned}$$

$$\begin{aligned} 4 \quad & -\frac{2}{9} \cdot \langle -\frac{5}{6}, \frac{8}{7} \rangle + \frac{1}{7} \cdot \langle \frac{11}{4}, -\frac{2}{3} \rangle \\ & = \langle \frac{5}{27}, -\frac{16}{63} \rangle + \langle \frac{11}{28}, -\frac{2}{21} \rangle \\ & = \langle \frac{5 \cdot 28 + 11 \cdot 27}{27 \cdot 28}, \frac{-16 - 2 \cdot 3}{63} \rangle \\ & = \langle \frac{437}{756}, -\frac{22}{63} \rangle \end{aligned}$$

Standard unit vectors

Denote by $\vec{i} = \langle 1, 0 \rangle$ and $\vec{j} = \langle 0, 1 \rangle$.



$$\begin{aligned} 5 \quad & 2\vec{i} + (-7)\vec{j} + (-6)\vec{i} + 9\vec{j} \\ & = -4\vec{i} + 2\vec{j} \\ & = -4 \cdot \langle 1, 0 \rangle + 2 \cdot \langle 0, 1 \rangle \\ & = \langle -4, 2 \rangle \\ 6 \quad & -3\vec{i} - 2\vec{j} + 8\vec{i} - 4\vec{j} \end{aligned}$$

Scalar multiplication and vector addition - exercises

Evaluate the expression.

$$\begin{aligned} 1 \quad & \langle -8, -5 \rangle - 2 \cdot \langle -4, 9 \rangle \\ & = \langle -8 - 2 \cdot (-4), -5 - 2 \cdot 9 \rangle \\ & = \langle -8 + 8, -5 - 18 \rangle \\ & = \langle 0, -23 \rangle \end{aligned}$$

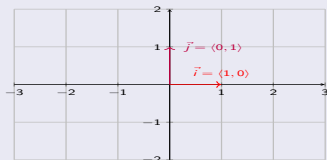
$$\begin{aligned} 2 \quad & (-3) \cdot \langle 2, 4 \rangle + 5 \cdot \langle 7, -3 \rangle \\ & = \langle -6, -12 \rangle + \langle 35, -15 \rangle \\ & = \langle 29, -27 \rangle \end{aligned}$$

$$\begin{aligned} 3 \quad & \vec{v} = \langle 6, -8 \rangle, \vec{w} = \langle -4, -9 \rangle \\ & \text{Find } 4 \cdot \vec{v} - 7 \cdot \vec{w} \\ & = 4 \cdot \langle 6, -8 \rangle - 7 \cdot \langle -4, -9 \rangle \\ & = \langle 24, -32 \rangle + \langle 28, 63 \rangle \\ & = \langle 52, 31 \rangle \end{aligned}$$

$$\begin{aligned} 4 \quad & -\frac{2}{9} \cdot \left\langle -\frac{5}{6}, \frac{8}{7} \right\rangle + \frac{1}{7} \cdot \left\langle \frac{11}{4}, -\frac{2}{3} \right\rangle \\ & = \left\langle \frac{5}{27}, -\frac{16}{63} \right\rangle + \left\langle \frac{11}{28}, -\frac{2}{21} \right\rangle \\ & = \left\langle \frac{5 \cdot 28 + 11 \cdot 27}{27 \cdot 28}, \frac{-16 \cdot 2 \cdot 3}{63} \right\rangle \\ & = \left\langle \frac{437}{756}, -\frac{22}{63} \right\rangle \end{aligned}$$

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Definition

A unit vector \vec{u} is a vector with magnitude 1.

$$\|\vec{u}\| = 1$$

Recall: $\|\langle a, b \rangle\| = \sqrt{a^2 + b^2}$

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Rescaling any vector $\vec{v} = \langle a, b \rangle$ by its magnitude gives a unit vector \vec{u} in the same direction as \vec{v} .

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Find the unit vector in the same direction as the given vectors.

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2 $\vec{v} = \langle -5, 12 \rangle$

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 $\Rightarrow \|\vec{v}\| = \sqrt{4^2 + (-2)^2}$
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 $= \langle \frac{4}{2\sqrt{5}}, \frac{-2}{2\sqrt{5}} \rangle = \langle \frac{2}{\sqrt{5}}, \frac{-1}{\sqrt{5}} \rangle$
 $= \langle \frac{2\sqrt{5}}{5}, \frac{-\sqrt{5}}{5} \rangle$

