MATHEMATICS · GRADES 10-12

Unit vectors

Difficulty level: Advanced

Mathematics: Grades 10-12

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Overview of the concept

This is how you describe a direction on its own, like the direction a plane is flying or a wind is blowing, without the size getting in the way. A unit vector points the same way as the original, but its length is one, so it carries direction and nothing else. That makes it easy to compare directions, or to build a bigger movement out of a direction and a size. Pilots, sailors, and engineers use it whenever the direction matters on its own, apart from how far or how fast.



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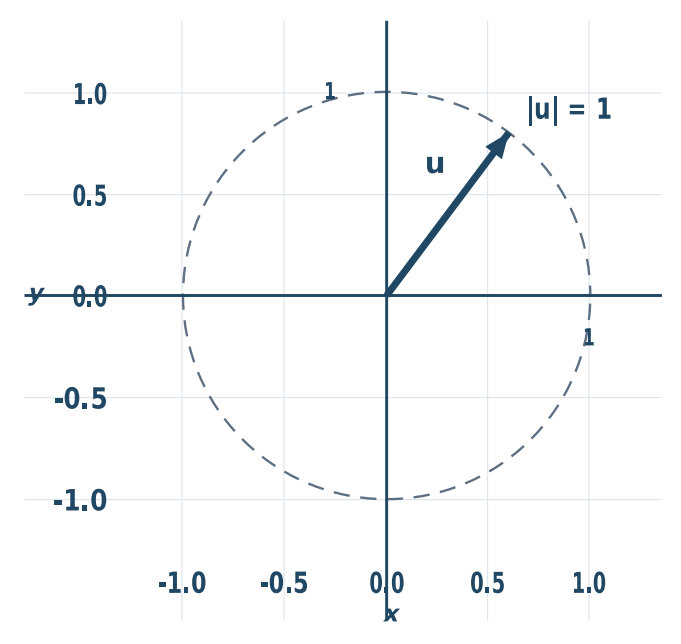
Rule

Unit vectors: a unit vector has length 1 and points in the same direction as the original vector.

Divide each component by the magnitude of the vector (its length) to get it.



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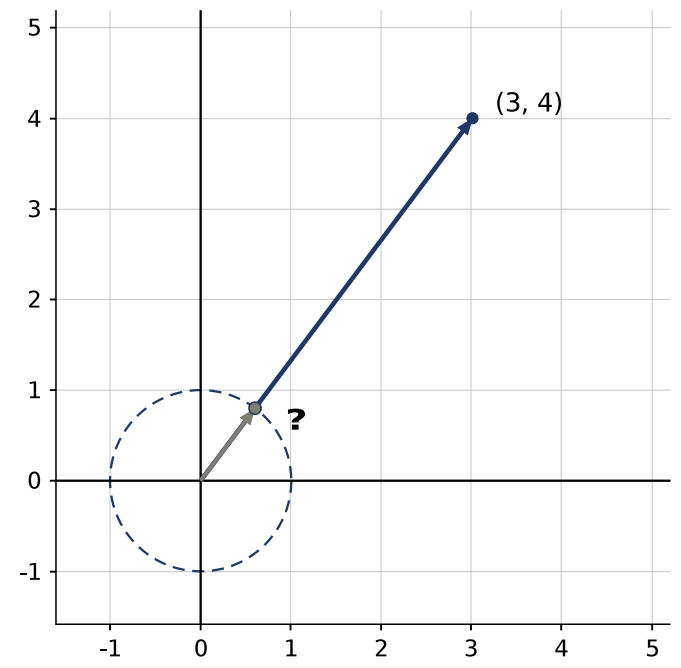
Worked examples

EXAMPLE 1

Q Find the unit vector in the direction of $(3, 4)$.



SOLUTION

First find the magnitude:

$\sqrt{(3^2+4^2)} = \sqrt{25} = 5$

Divide each component by 5: $(\frac{3}{5}, \frac{4}{5})$

Check: $(\frac{3}{5})^2 + (\frac{4}{5})^2 = \frac{9}{25} + \frac{16}{25} = \frac{25}{25} = 1$

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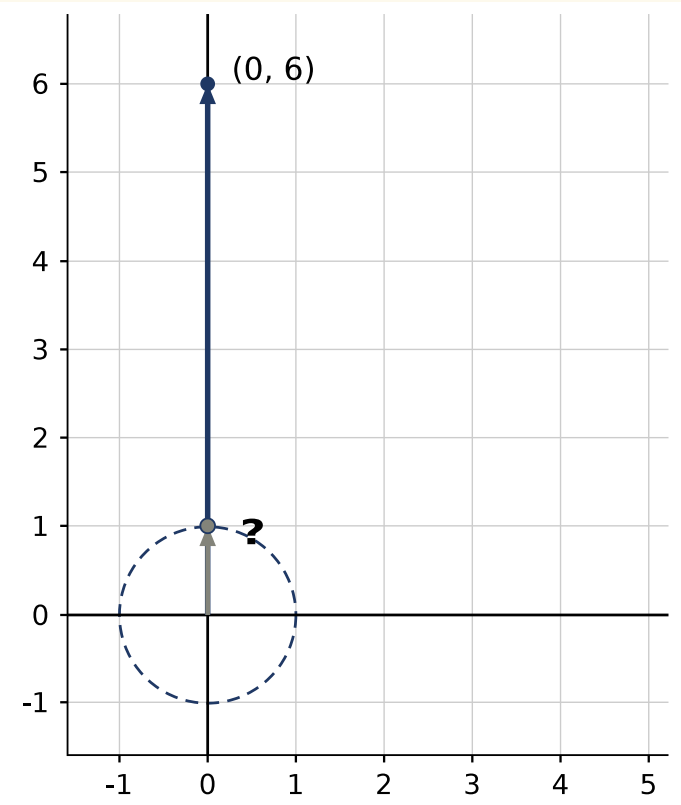
EXAMPLE 2

Q Find the unit vector in the direction of (0, 6).



SOLUTION

Magnitude:

$\sqrt{(0^2+6^2)} = \sqrt{36} = 6$

Divide: $(\frac{0}{6}, \frac{6}{6}) = (0, 1)$

So the unit vector points straight up.

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Practice questions

1 A force points $(6, 8)$. Find the unit vector in its direction.

- **A** $(\frac{4}{5}, \frac{3}{5})$
- **B** $(\frac{3}{5}, \frac{4}{5})$
- **C** $(\frac{6}{5}, \frac{8}{5})$
- **D** $(\frac{3}{4}, \frac{4}{3})$

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2 A velocity points $(1, 0)$. Find the unit vector in its direction.

- **A** $(1, 0)$
- **B** $(0, 1)$
- **C** $(0, 0)$
- **D** $(1, 1)$

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3 A wind blows south, in the direction $(0, -5)$. Give the direction as a unit vector.

- **A** $(0, 1)$
- **B** $(0, -1)$
- **C** $(-1, 0)$
- **D** $(1, 0)$

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4 What is the magnitude of any unit vector?

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5 A vector has magnitude 5. Its unit vector is $(\frac{3}{5}, \frac{4}{5})$. What is the original vector?

- **A** (3, 4)
- **B** $(\frac{3}{5}, \frac{4}{5})$
- **C** (5, 5)
- **D** (15, 20)

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6 A hiker walks in the direction (8, 6). A compass app shows direction only, as a unit vector. What does it show?

- **A** $(\frac{3}{5}, \frac{4}{5})$
- **B** $(\frac{4}{5}, \frac{3}{5})$
- **C** $(\frac{8}{5}, \frac{6}{5})$
- **D** $(\frac{4}{3}, \frac{3}{4})$

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7 Two standard unit vectors point along the axes. What are they?

- **A** (1, 0)
- **B** (0, 1)
- **C** (1, 0) and (0, 1)
- **D** (1, 1)

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8 Which of these is a unit vector?

- **A** $(\frac{3}{5}, \frac{4}{5})$
- **B** (1, 1)
- **C** (2, 0)
- **D** (0, 3)

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9 **A student divides a vector by its magnitude. Why does that give a unit vector?**

- **A** To scale the length to 1 without changing the direction
- **B** To change the direction of the vector
- **C** To make the vector longer
- **D** To turn the vector into zero

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10 **A lift rises straight up. What is the unit vector in the direction of the lift?**

- **A** (1, 0)
- **B** (0, 1)
- **C** (0, 0)
- **D** (1, 1)

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ANSWER KEY

1. $(\frac{3}{5}, \frac{4}{5})$

2. (1, 0)

3. (0, -1)

4. 1

5. (3, 4)

6. $(\frac{4}{5}, \frac{3}{5})$

7. (1, 0) and (0, 1)

8. $(\frac{3}{5}, \frac{4}{5})$

9. To scale the length to 1 without changing the direction

10. (0, 1)

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