MATHEMATICS · GRADES 10-12

Vector projections introduction

Difficulty level: Advanced

Mathematics: Grades 10-12

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Overview of the concept

This is how you find the part of one movement that runs along another direction, like how much of a pull on a rope actually helps drag a sled forward, by splitting it into along and across pieces. A pull on a rope is not all useful, because part of it lifts the sled and only part of it drags it forward. The projection is the forward part, the piece that actually does the job in that direction. That is how you work out how much of a force counts in the direction you care about, whether you are pulling a sled or pushing a cart.



Rule

Vector projections: the projection of one vector onto another is the part of the first vector that runs along the second.

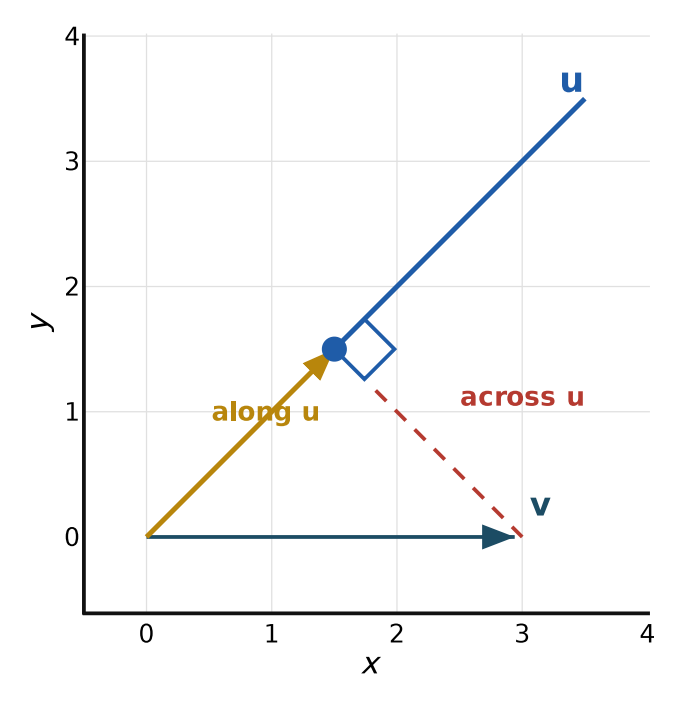
$$\text{Projection} = \frac{a \cdot b}{|b|^2} \times b.$$

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Worked examples

EXAMPLE 1

Q Find the projection of (3, 0) onto (1, 1).



SOLUTION

Dot product (multiply the matching numbers, then add): $3 \times 1 + 0 \times 1 = 3$

Magnitude squared (the length of (1, 1), squared): $1^2 + 1^2 = 2$

Scalar part (the number to multiply by): $\frac{3}{2}$

Projection vector = $\frac{3}{2} \times (1, 1) = (\frac{3}{2}, \frac{3}{2})$

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EXAMPLE 2

Q Find the projection of (0, 4) onto (1, 0).

SOLUTION

Dot product: $0 \times 1 + 4 \times 0 = 0$

Scalar part: $\frac{0}{1} = 0$

Projection vector = (0, 0): nothing lies along the x direction.

Practice questions

1 A force (4, 0) acts on a ramp (1, 1). What is the projection of (4, 0) onto (1, 1)?

- **A** (2, 2)
- **B** (4, 4)
- **C** (2, 0)
- **D** (0, 2)

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2 A velocity $(0, 3)$ acts on a slope $(1, 1)$. What is the projection of $(0, 3)$ onto $(1, 1)$?

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

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3 A boat is pushed by a current of $(2, 0)$. The river runs in the direction $(1, 1)$. What part of the current runs along the river?

- **A** $(1, 1)$
- **B** $(2, 2)$
- **C** $(2, 0)$
- **D** $(0, 1)$

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4 A force of (4, 2) pulls a sled. The slope runs in the direction (1, 1). What is the part of the force that acts along the slope?

- **A** (6, 6)
- **B** (4, 2)
- **C** (3, 3)
- **D** (3, 0)

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5 A car drives with velocity (4, 0) along a straight road east, in the direction (1, 0). What is the projection of the car's velocity onto the road?

- **A** (0, 4)
- **B** (4, 4)
- **C** (1, 0)
- **D** (4, 0)

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6 A boat sails with velocity (2, 2). The river flows east, in the direction (1, 0). How much of the boat's velocity is along the river?

- **A** (0, 2)
- **B** (2, 2)
- **C** (2, 0)
- **D** (1, 0)

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7 A lift rises with velocity (3, 4). The shaft runs straight up, in the direction (0, 1). What is the projection of the lift's velocity onto the shaft?

- **A** (4, 0)
- **B** (0, 4)
- **C** (3, 4)
- **D** (0, 3)

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8 A drone flies with velocity (1, 1). Its path runs east, in the direction (1, 0). What is the projection of the drone's velocity onto its path?

- **A** (1, 0)
- **B** (0, 1)
- **C** (1, 1)
- **D** (2, 0)

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9 A force of (5, 5) acts on a ramp running in the direction (1, 1). What is its projection onto the ramp?

- **A** (1, 1)
- **B** (5, 0)
- **C** (0, 5)
- **D** (5, 5)

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10 **A lift rises with velocity (0, 5) in a shaft running straight up, in the direction (0, 1). What is the projection of the lift's velocity onto the shaft?**

A (5, 0)

B (0, 1)

C (0, 5)

D (5, 5)

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ANSWER KEY

1. (2, 2)

2. $(\frac{3}{2}, \frac{3}{2})$

3. (1, 1)

4. (3, 3)

5. (4, 0)

6. (2, 0)

7. (0, 4)

8. (1, 0)

9. (5, 5)

10. (0, 5)

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