MATHEMATICS · GRADES 10-12

# Parallel and perpendicular vectors

### Difficulty level: Advanced

### Mathematics: Grades 10-12

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## *Overview of the concept*

This is how you check whether two forces pull in the same direction, like two people pushing a car together, or at right angles, like a boat crossing a river current. Two people pushing together add their strength, while a boat crossing a current is pushed sideways at the same time as it moves forward. A pilot landing in a crosswind has to allow for a wind pushing at right angles to the runway. Knowing how forces line up tells you how they combine, and that is what decides where things actually go.



## *Rule*

**Two vectors are parallel if one is a scalar multiple of the other: $a = k \times b$.**

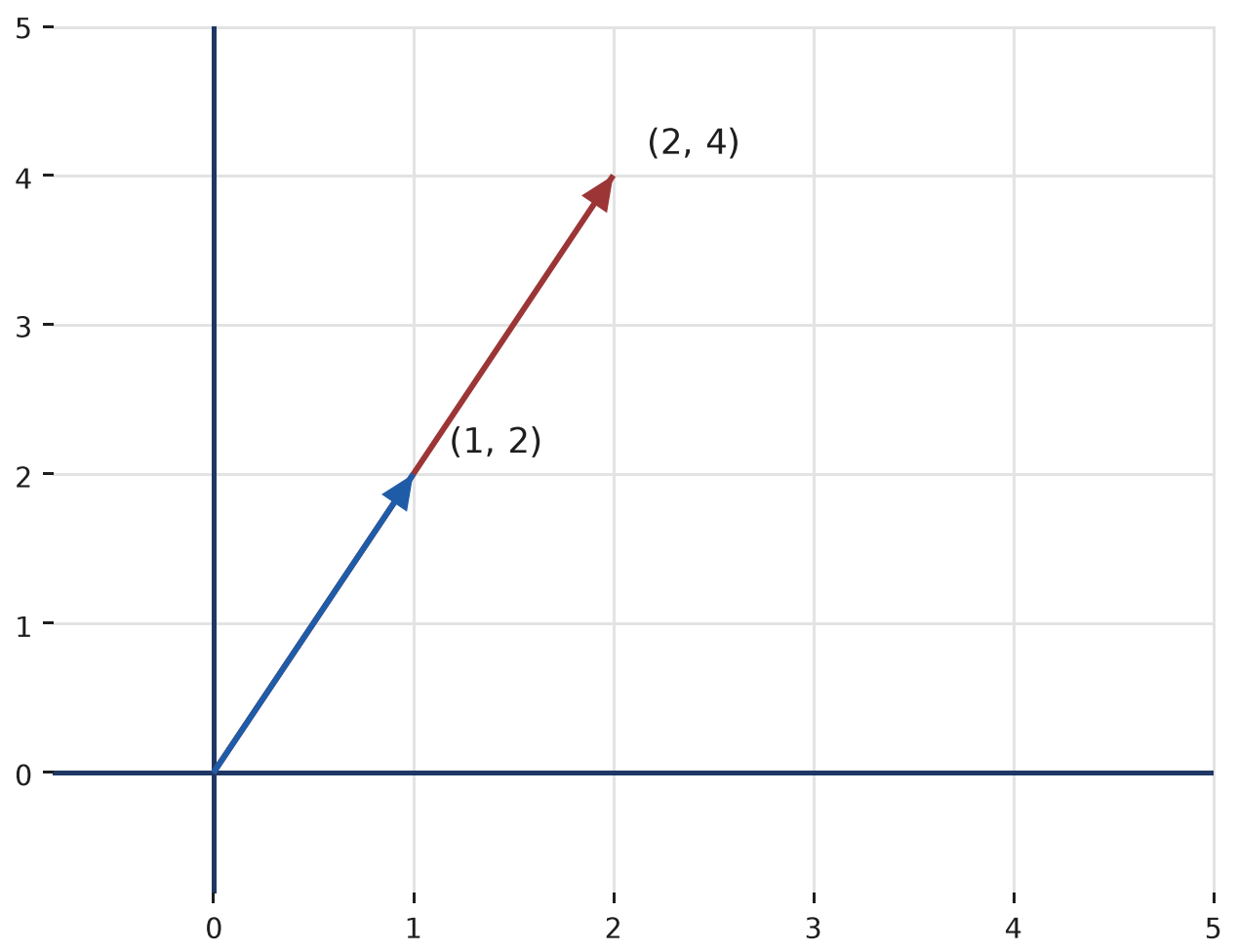
Two vectors are perpendicular if their dot product is 0: $a \cdot b = 0$.

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## Worked examples

EXAMPLE 1

**Q** Are (2, 4) and (1, 2) parallel?




**SOLUTION**

See whether one vector is just a scaled copy of the other: (2, 4) = 2 × (1, 2)

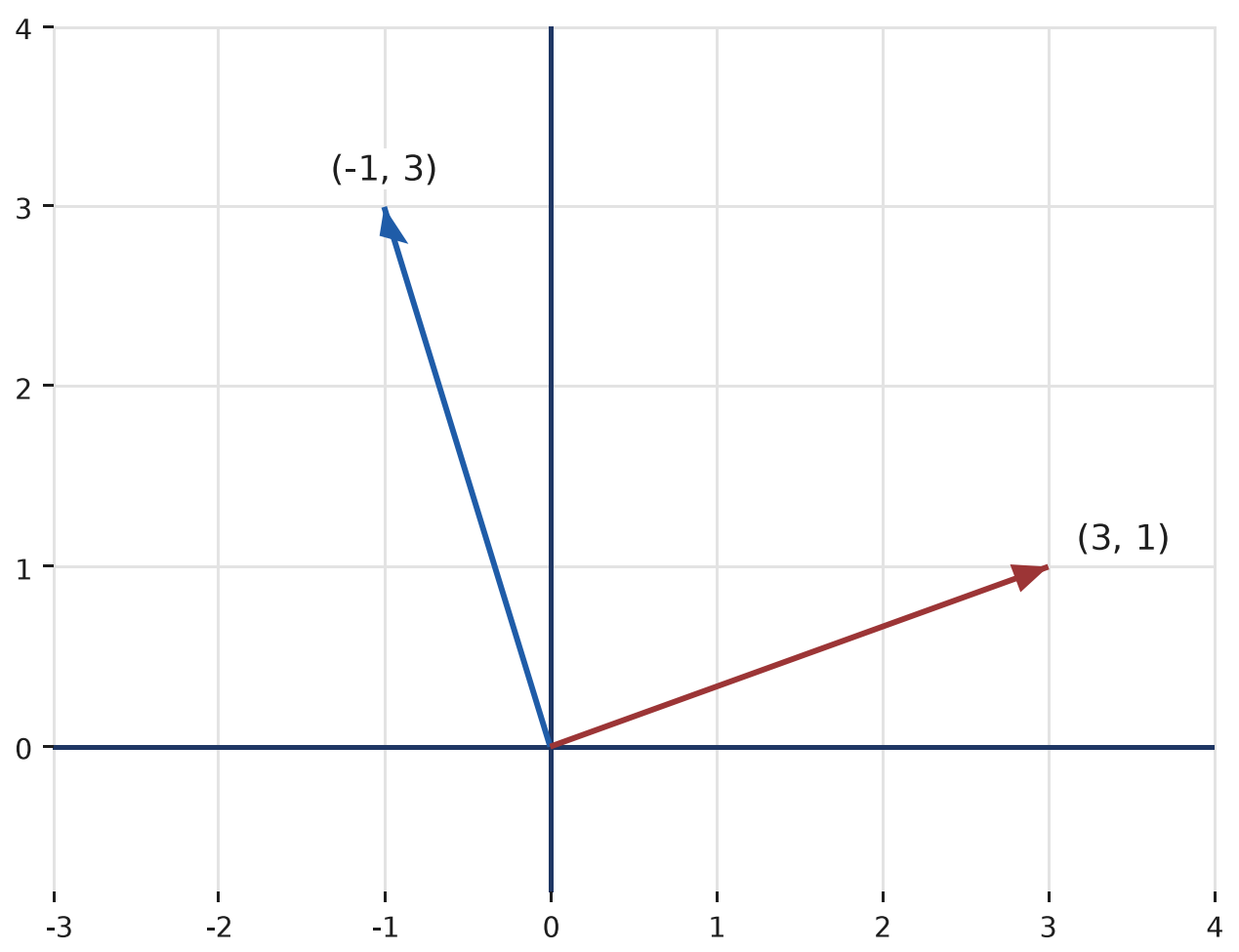
Yes, the multiple is 2.

So they are parallel.

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EXAMPLE 2

## Q Are (3, 1) and (-1, 3) perpendicular?




### SOLUTION

Perpendicular vectors have dot product 0.

Dot product: $3 \times (-1) + 1 \times 3 = 0$

So they are perpendicular.

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## Practice questions

**1** Two forces push a box in the directions (1, 3) and (2, 6). Are they parallel?

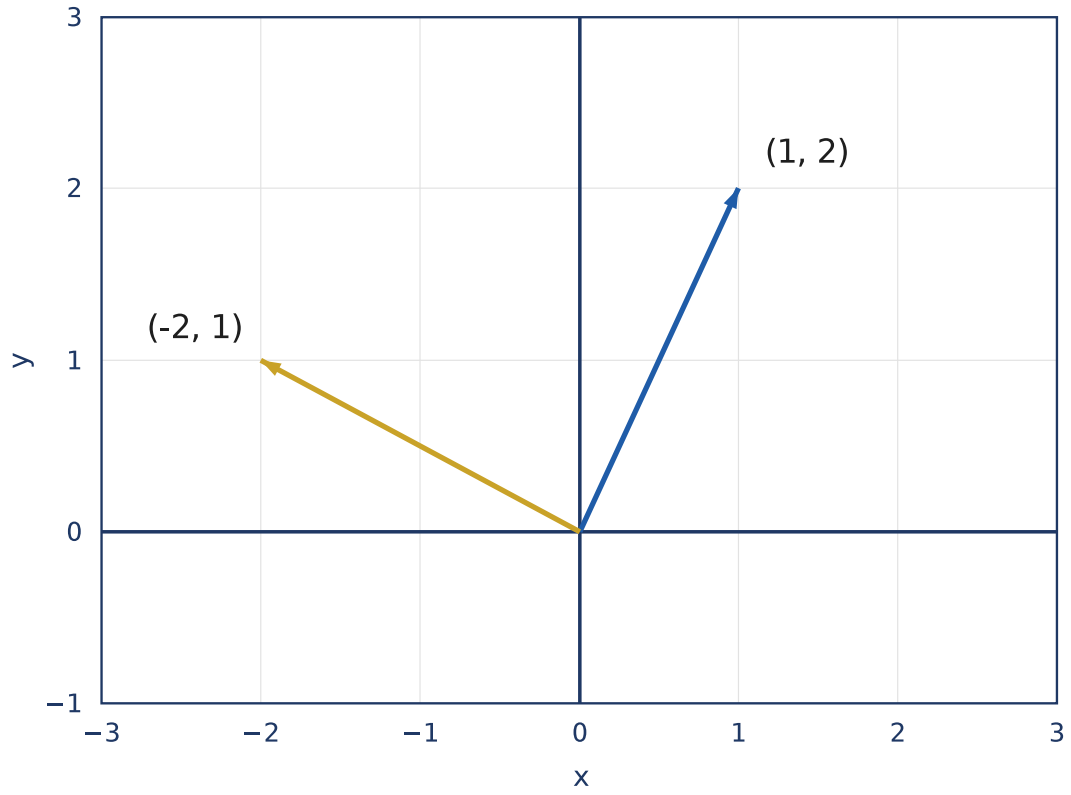
A Yes

B No

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**2** **A drone flies in the direction (1, 2) and a wind blows in the direction (-2, 1). Are they perpendicular?**




A Yes

B No

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**3** Two boats sail in the directions (2, 1) and (3, 2). Are they parallel?

A Yes

B No

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**4** A ladder leans in the direction (4, 0) and the ground runs in the direction (0, 5). Are they perpendicular?

A Yes

B No

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**5** A student wants to check if two vectors point the same way. What test does she use?

- **A** One is a scalar multiple of the other
- **B** Their dot product is 0
- **C** They have the same length
- **D** Their dot product is 1

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**6** A builder wants to check a corner is square using vectors. What test does he use?

- **A** One is a scalar multiple of the other
- **B** Their dot product is 0
- **C** They have the same length
- **D** Their dot product is 1

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**7** The vectors (2, 6) and (1, 3) are parallel. What do you multiply (1, 3) by to get (2, 6)?

- A 2
- B 3
- C 6
- D 1/2

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**8** What is the dot product of (2, 5) and (5, -2)?

- A 0
- B 10
- C -10
- D 20

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**9** **Which pair of vectors are perpendicular?**

- **A** (3, 1) and (1, 3)
- **B** (2, 3) and (3, -2)
- **C** (1, 1) and (2, 2)
- **D** (4, 1) and (1, 4)

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**10** **Two vectors are parallel. What can you say about the directions they point in?**

- **A** They point the same way or exactly opposite
- **B** They point at right angles
- **C** They have the same length
- **D** They meet at one point

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## ANSWER KEY

**1.** Yes

**2.** Yes

**3.** No

**4.** Yes

**5.** One is a scalar multiple of the other

**6.** Their dot product is 0

**7.** 2

**8.** 0

**9.** (2, 3) and (3, -2)

**10.** They point the same way or exactly opposite

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