Course compass

Question directrice : What is a vector, what do its components mean, and how can directed displacements or forces be combined?

Markers: 📏 MEASURED · 📐 CONVENTION · 🧱 CALCULATED · 🎓 TEACHING ASSUMPTION · ⚠️ APPROXIMATION

- understand the concept
- do a simple calculation
- explain every symbol
- check a result

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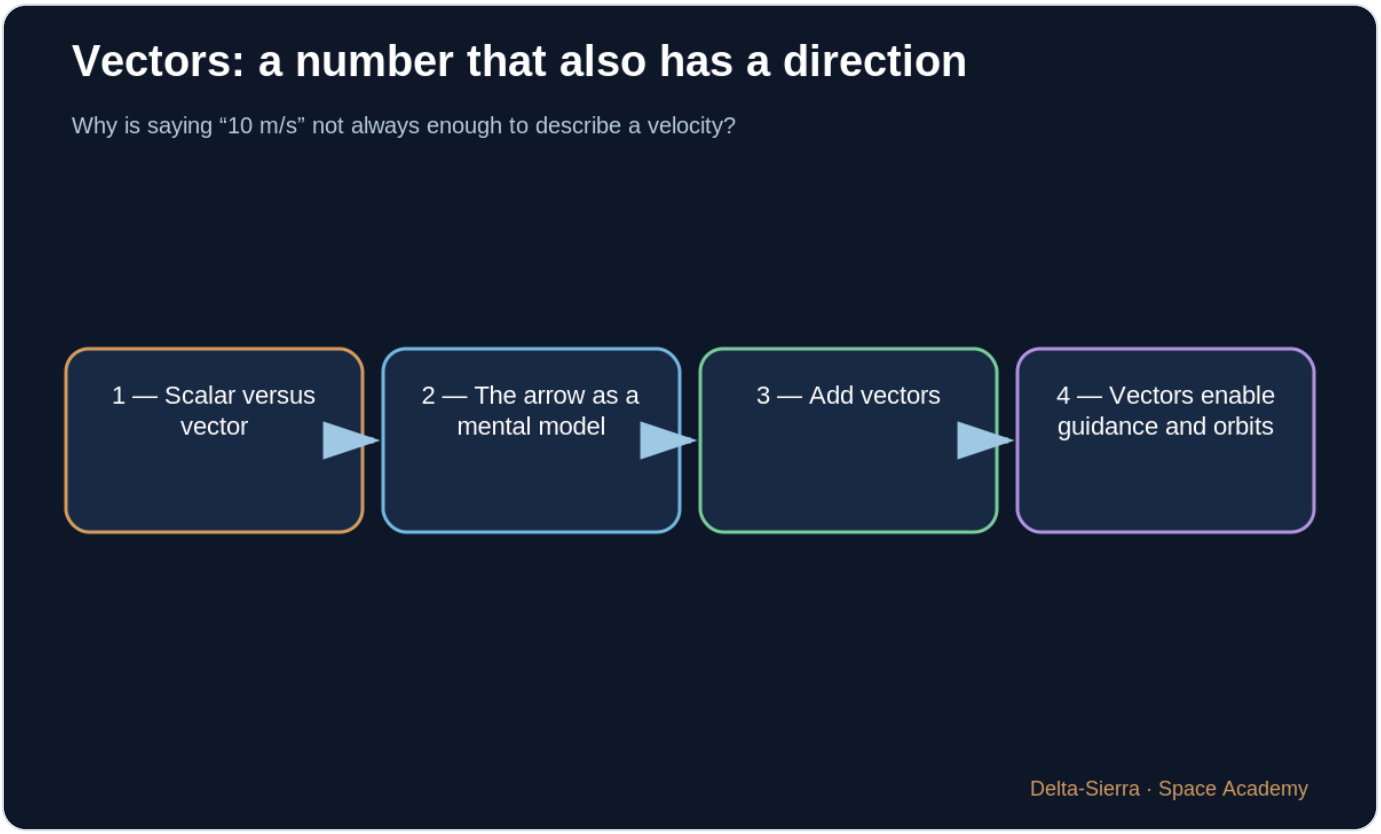
1 — A vector is an arrow carrying two pieces of information

The word **vector** sounds technical, but the mental picture is simple: **a vector is an arrow**.

It carries two things: **size** and **direction**. Size answers “how much?” Direction answers “which way?”

Number or vector?

“10 metres” gives only a distance. “10 metres east” gives distance plus direction. “50 newtons upward” similarly gives both force magnitude and direction.



A vector answers two questions: how much, and which way?

2 — Scalar versus vector, without jargon

A **scalar** is described by a value without a particular direction, such as a mass of 10 kg or a temperature of 20 °C.

A **vector** needs direction as well as size. Displacement, directed velocity and force are common examples.

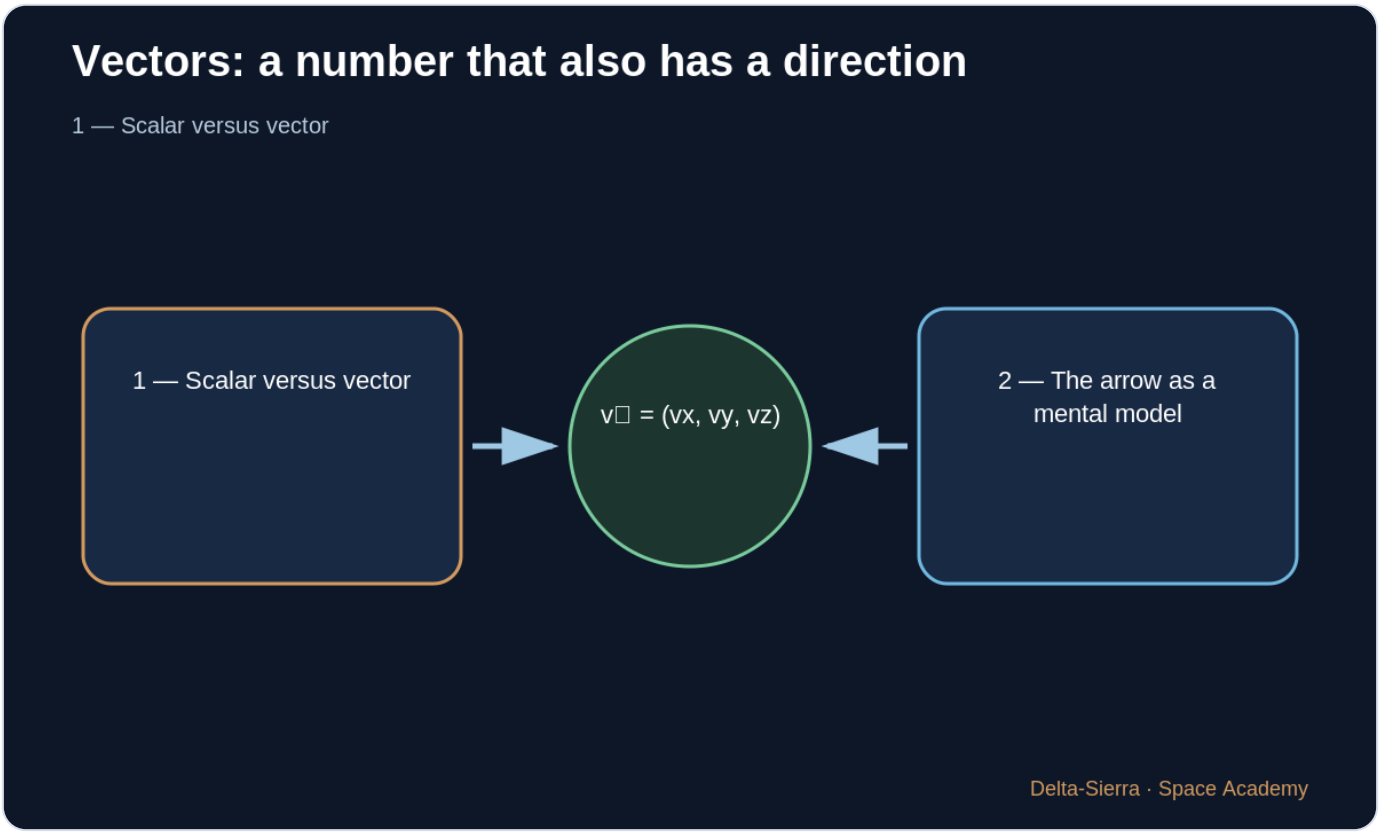
The term **magnitude** means the size of the vector — the length of the arrow in the model.

3 — x and y: describing the same arrow with two numbers

In a two-dimensional diagram we often choose **x** for horizontal and **y** for vertical.

The **x-component** tells how much the arrow goes right or left. The **y-component** tells how much it goes up or down.

A component is not a new object. It is one part of the description of the same vector.



One slanted arrow can be described by an x-part and a y-part.

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4 — Master example: a rover moves 6 m right and 8 m up

On a local map a rover moves **6 m to the right** and **8 m upward**. Its components are x = 6 m and y = 8 m.

The direct displacement forms the hypotenuse of a right triangle.

Pythagoras explained

For a right triangle, the square of the longest side equals the sum of the squares of the other two sides:

$$\text{distance}^2 = 6^2 + 8^2 = 36 + 64 = 100$$.

The symbol ² means “squared”: 6² means 6 × 6. To return from 100 to the distance, take the **square root**, written √. √100 = 10.

The displacement vector therefore has a magnitude of **10 m**.

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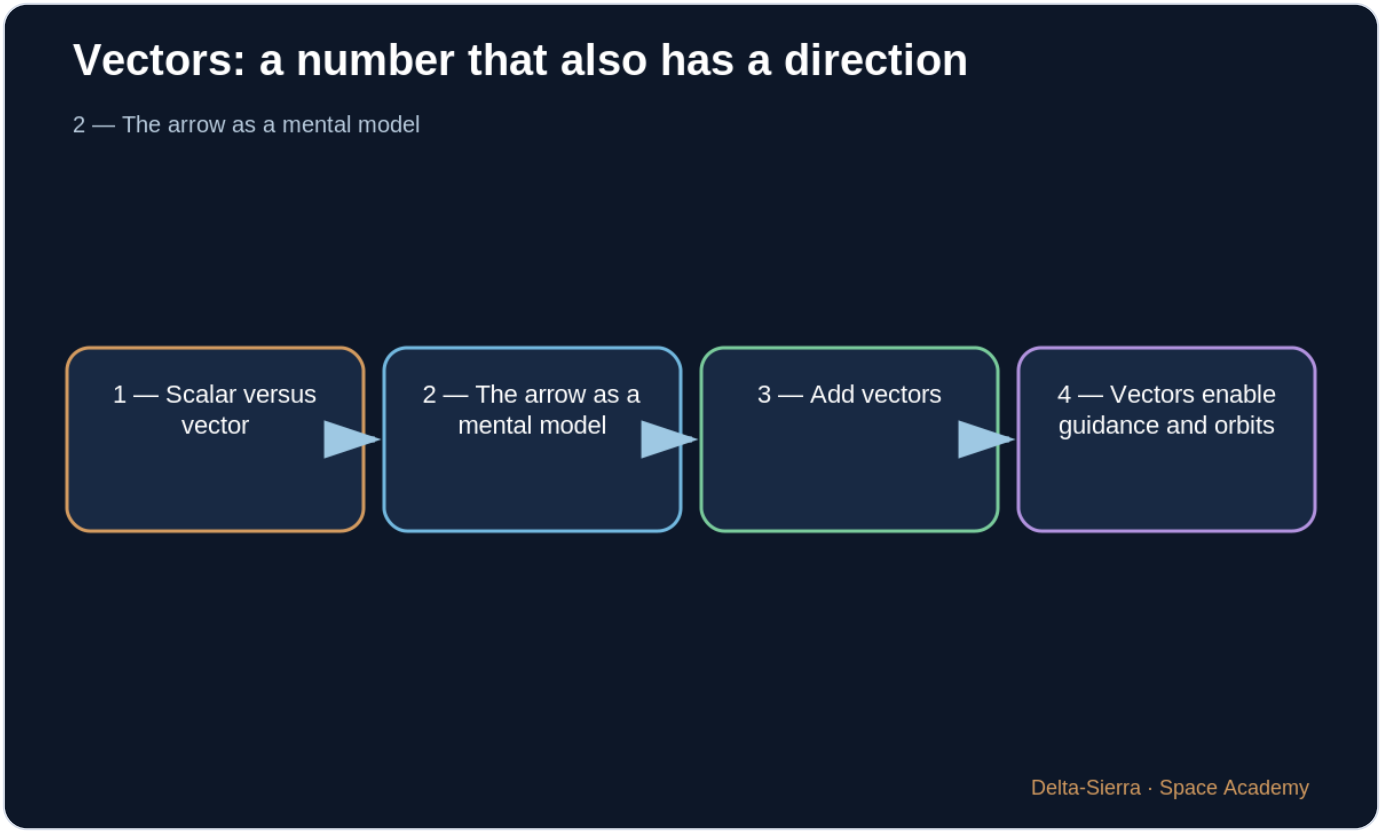
5 — Adding vectors: chaining directed actions

Adding vectors means combining actions that have directions.

Two successive moves

5 m east plus 3 m east gives 8 m east. If the second move is 3 m west, choose east as positive: the second move is −3 m, so $5 + (-3) = 2$ m east.

The minus sign does not mean an impossible negative distance. It encodes the opposite direction on the chosen axis.



Plus and minus signs can encode opposite directions on one axis.

6 — Three complete examples

Example A — Rover displacement

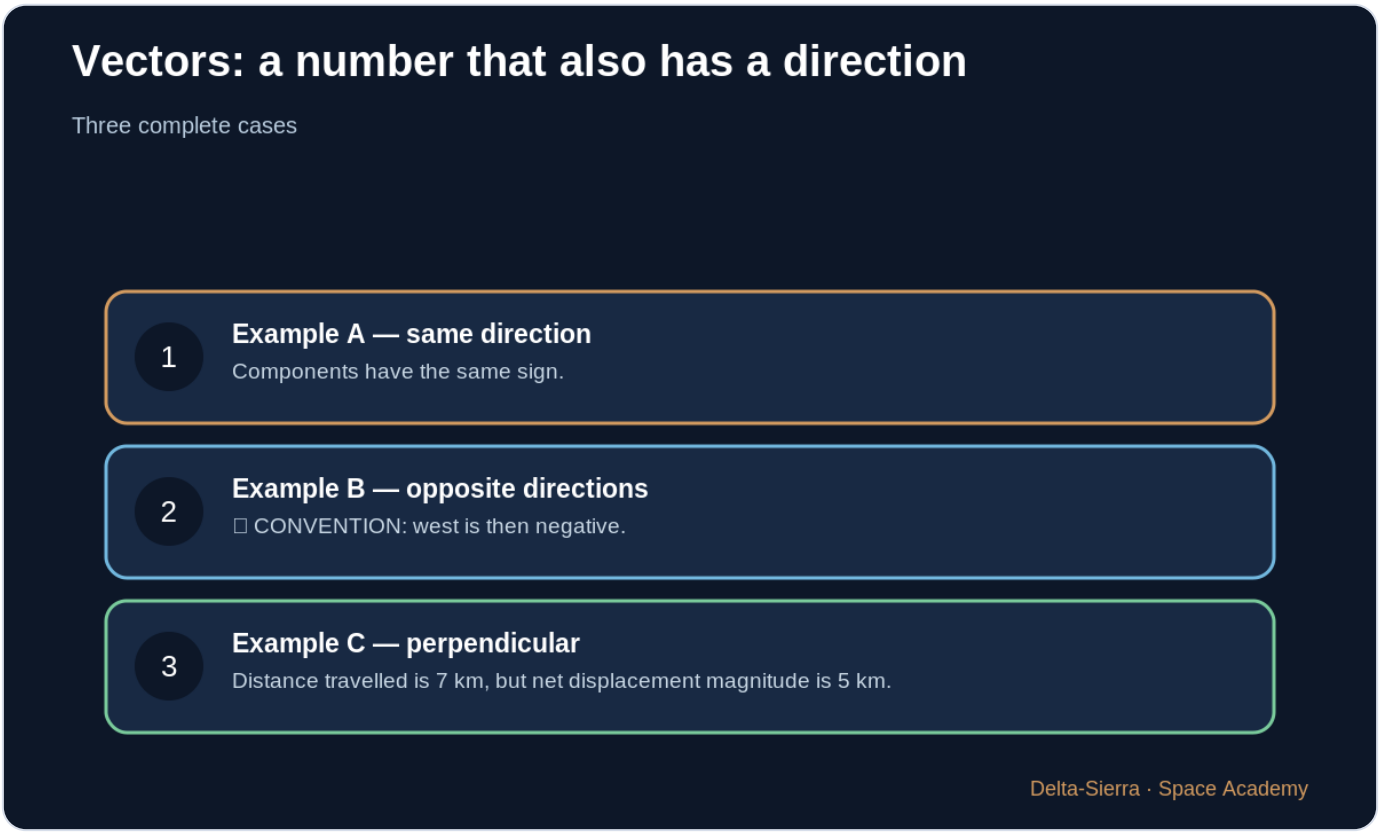
4 m east and 3 m north give a direct displacement of $\sqrt{(4^2+3^2)}=5$ m.

Example B — Two lateral thrusters

20 N right and 5 N left give $20 + (-5)=15$ N to the right.

Example C — Vehicle velocity

A rover moving at 2 m/s north has both a speed magnitude and a direction. If it turns around while remaining at 2 m/s, its vector velocity has changed even though the displayed speed is unchanged.



Displacement, force and velocity are situations where direction matters.

7 — Resultant and zero vector

The **resultant** is the vector obtained after combining several vectors. Two equal forces acting exactly opposite each other can have a zero resultant on that axis.

Balanced forces

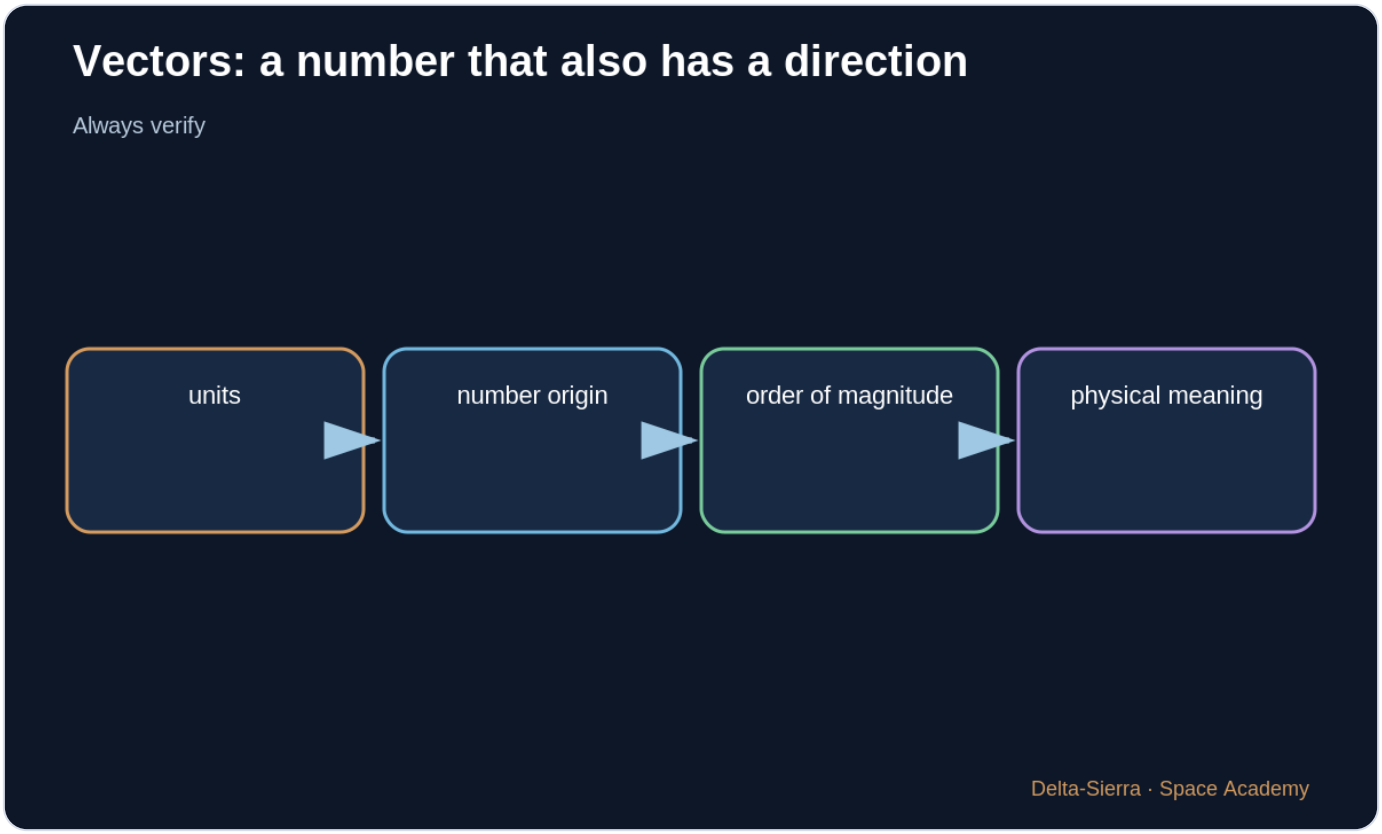
10 N right and 10 N left give 0 N resultant on the axis. This does not mean no forces exist; it means their directed effects cancel on that axis.

8 — Calculator: finding vector magnitude

For 6 m and 8 m components: calculate 6 × 6 = 36; 8 × 8 = 64; add to get 100; press √ to obtain 10.

9 — Why vectors matter in missions

Navigation cannot rely on “how fast” alone. It needs the direction of motion, the direction of thrust, and how corrections combine. The mathematics becomes more advanced in three dimensions, but the core idea remains **size + direction**.



A good result needs both a plausible size and a direction consistent with the situation.

10 — Common traps

- Giving directions without defining the convention.
- Adding magnitudes while ignoring opposite directions.
- Confusing distance travelled with direct displacement.
- Dropping the unit.
- Using terms such as magnitude, component or resultant without translating them into plain language.

Exercises and answers

Exercise 1

A rover moves 3 m east and 4 m north. Direct displacement?

Answer: $\sqrt{(3^2+4^2)}=5$ m.

Exercise 2

12 N right and 7 N left act on one axis. Resultant?

Answer: 5 N to the right.

Exercise 3

Why can 10 m/s be incomplete information?

Answer: because vector velocity also needs a direction.

Primary and educational sources

- NIST SP 811 — SI units
- NASA Glenn — Rocket Control