AM-02.02 · SPACE ACADEMY

AM-02.02 — Speed, velocity, and acceleration: how fast, which direction, and how quickly does it change?

Why does acceleration not simply mean “go faster”?

Course compass

Goal: understand every word, symbol, unit and operation before using the formula.

Method: concrete situation → vocabulary → step-by-step calculation → three examples → check.

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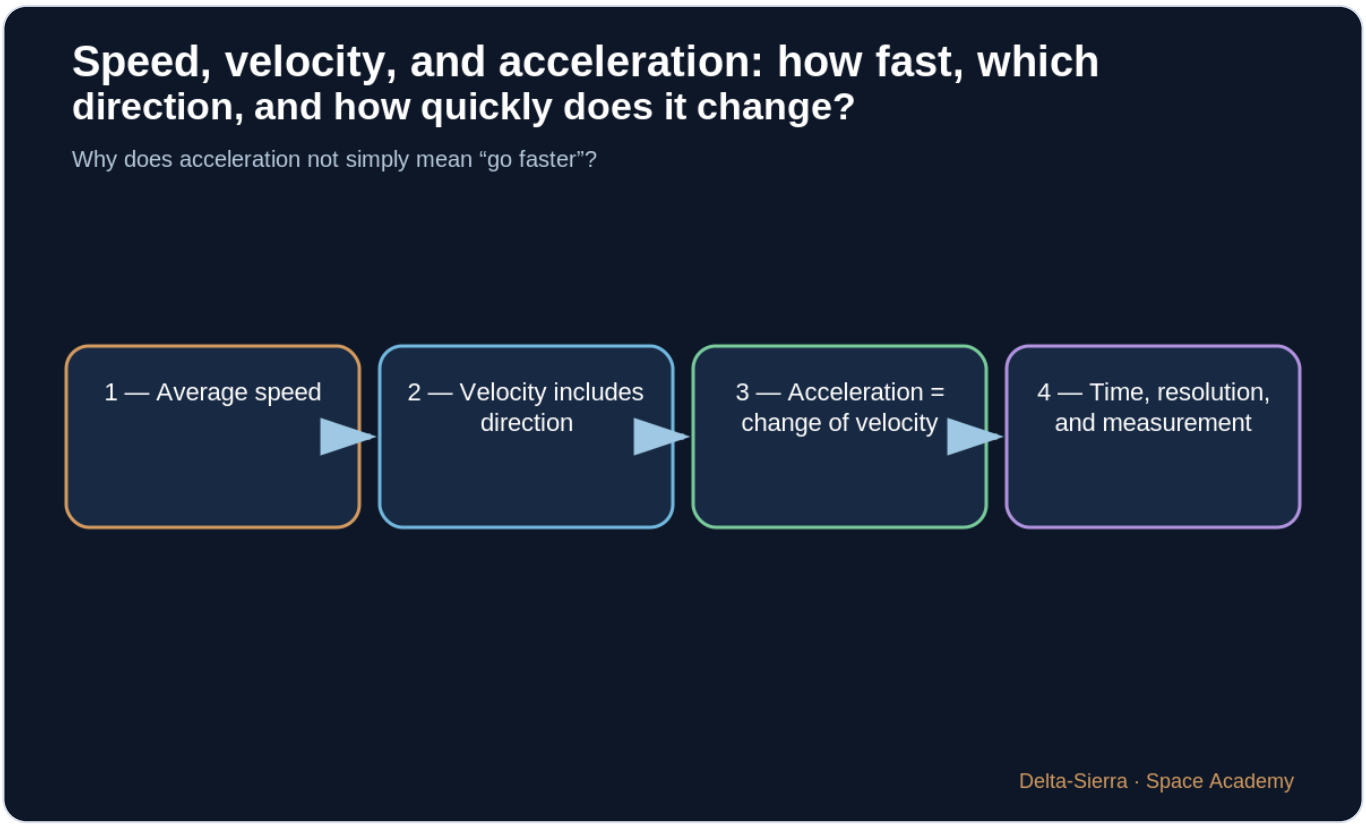
1 — A rover moves, then brakes

A rover covers 120 m in 20 s, then slows to a stop. **Speed/velocity** tells how fast position changes. **Acceleration** tells how fast velocity changes.



Velocity and acceleration describe two different levels of change.

2 — Average speed: distance divided by time

$$\text{average speed} = \text{distance} \div \text{time}$$

m/s is read “metres per second”.

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120 m ÷ 20 s = 6 m/s
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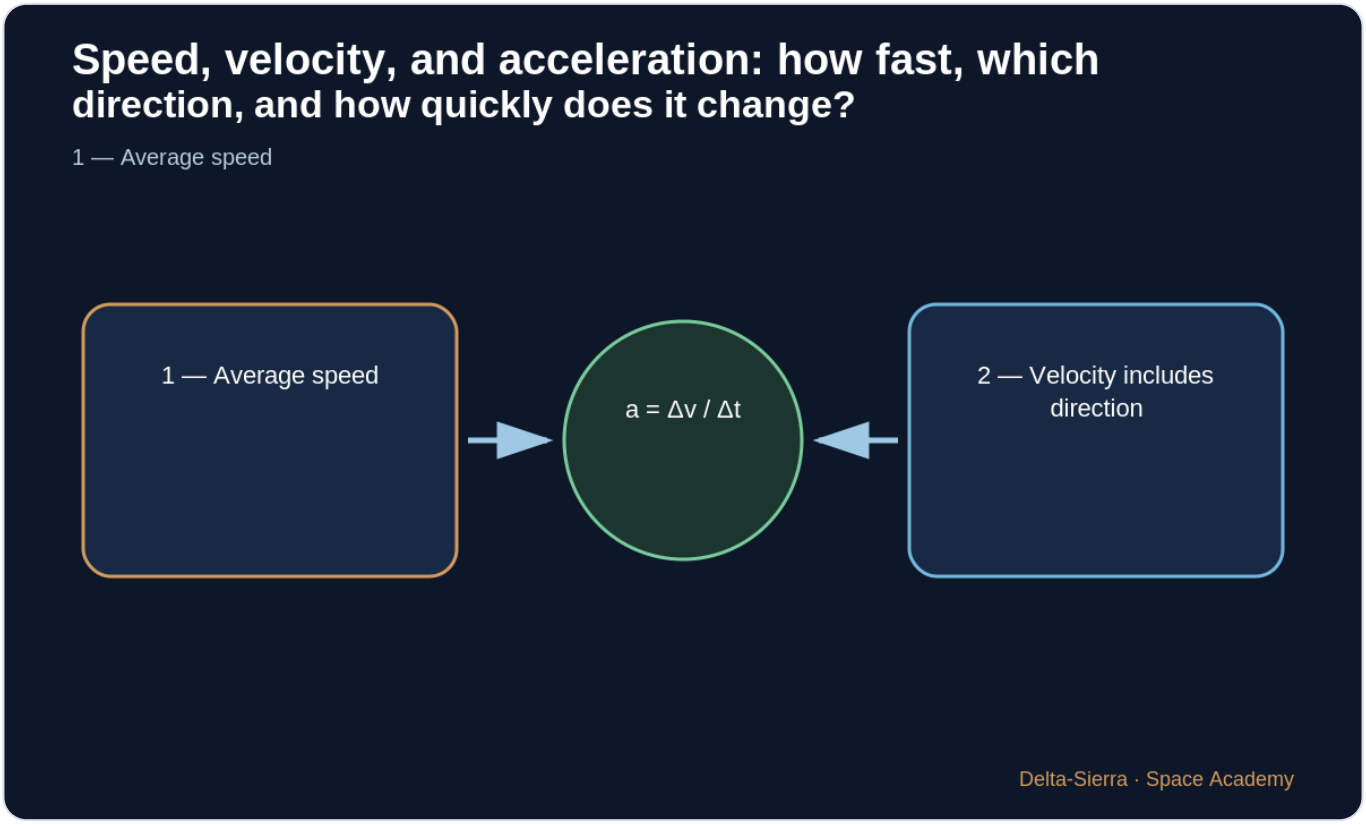
Why divide? We want the average number of metres corresponding to one second.



m/s means metres travelled during one second.

3 — From m/s to km/h

Multiply m/s by 3.6 to obtain km/h; divide by 3.6 for the reverse conversion.

```
6 × 3.6 = 21.6 km/h
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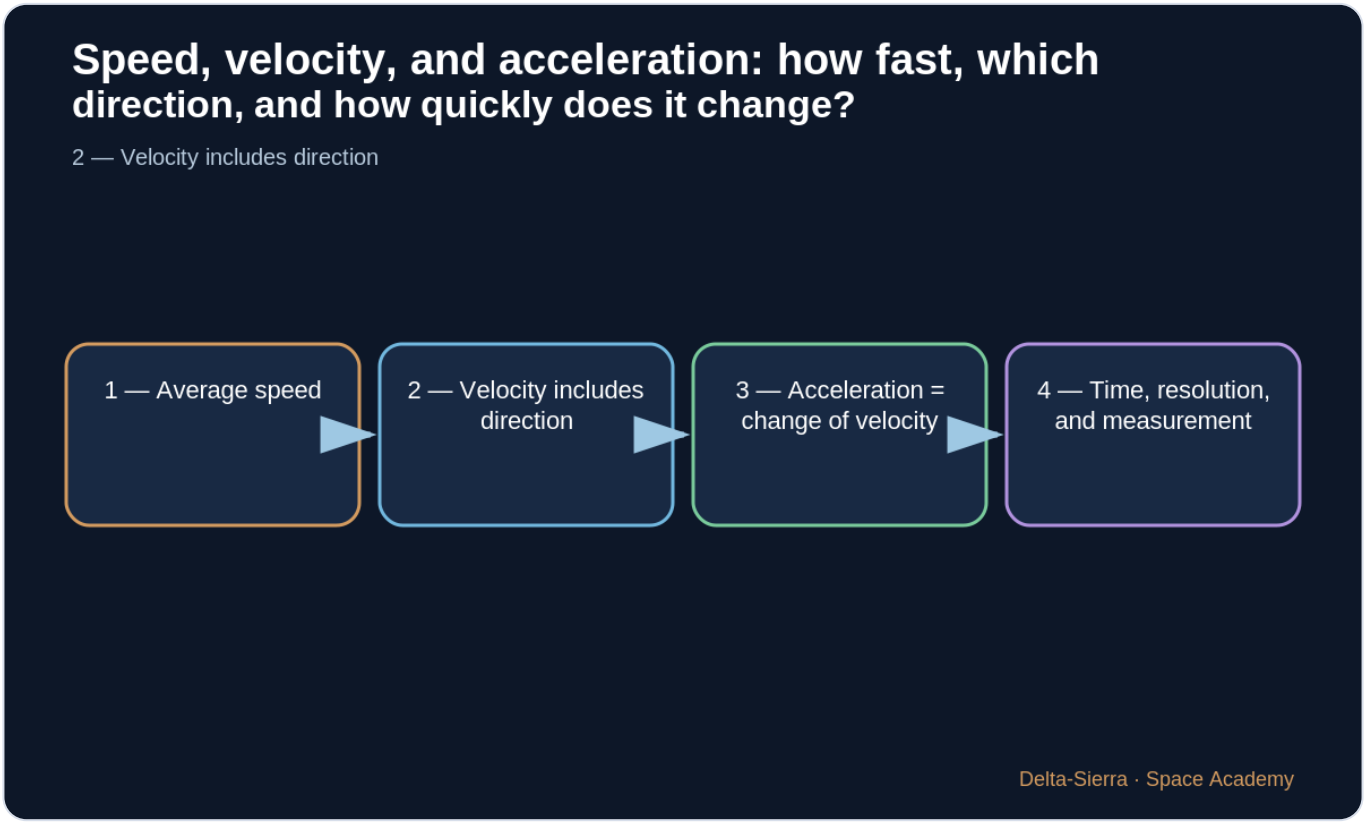
4 — Direction matters

Choose east positive. +4 m/s means 4 m/s east; −4 m/s means 4 m/s west. Speed magnitude answers “how fast”; velocity includes direction.



A sign or arrow carries the direction information.

5 — Acceleration: velocity change per second

$$a = \Delta v \div \Delta t$$

Δv is “delta v”, change in velocity. **Δt** is “delta t”, elapsed time. **m/s²** is read “metres per second squared”.

```
initial v = 2 m/s
final v = 8 m/s
Δv = 6 m/s
time = 3 s
a = 6 ÷ 3 = 2 m/s²
```

6 — Braking can give a negative acceleration

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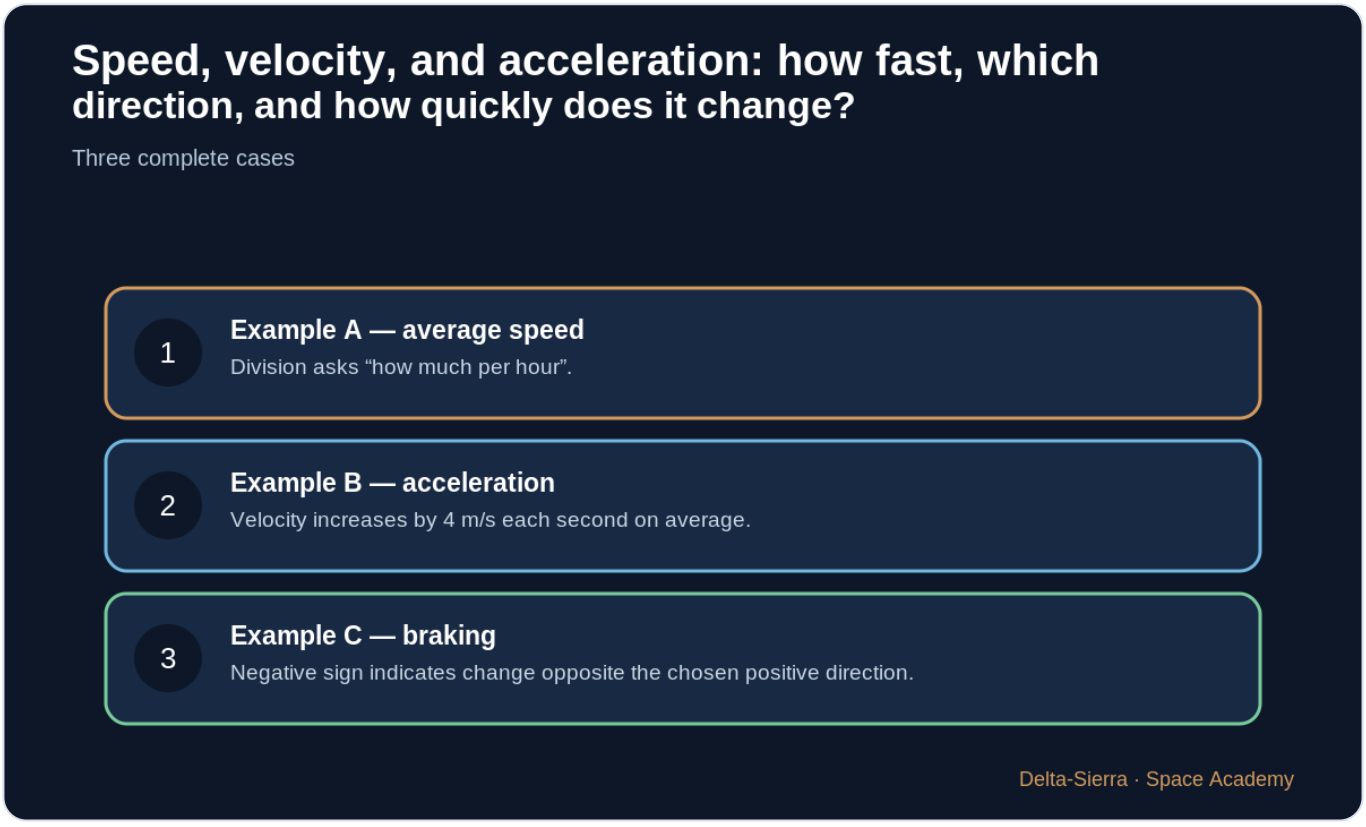
v changes from +10 to 0 m/s in 5 s
Δv = −10 m/s
a = −10 ÷ 5 = −2 m/s²
```

The sign comes from the chosen axis.

7 — Three Mars examples



Rover, winch and lander examples.

Example A — Exploration rover

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300 m ÷ 50 s = 6 m/s = 21.6 km/h
```

Example B — Winch starts

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0 to 1.5 m/s in 3 s → a = 0.5 m/s²
```

Example C — Lander descent

Up is positive. Vertical velocity changes from −20 to −5 m/s in 5 s.

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Δv = +15 m/s
a = +3 m/s²
```

Acceleration is upward, reducing the descent speed.

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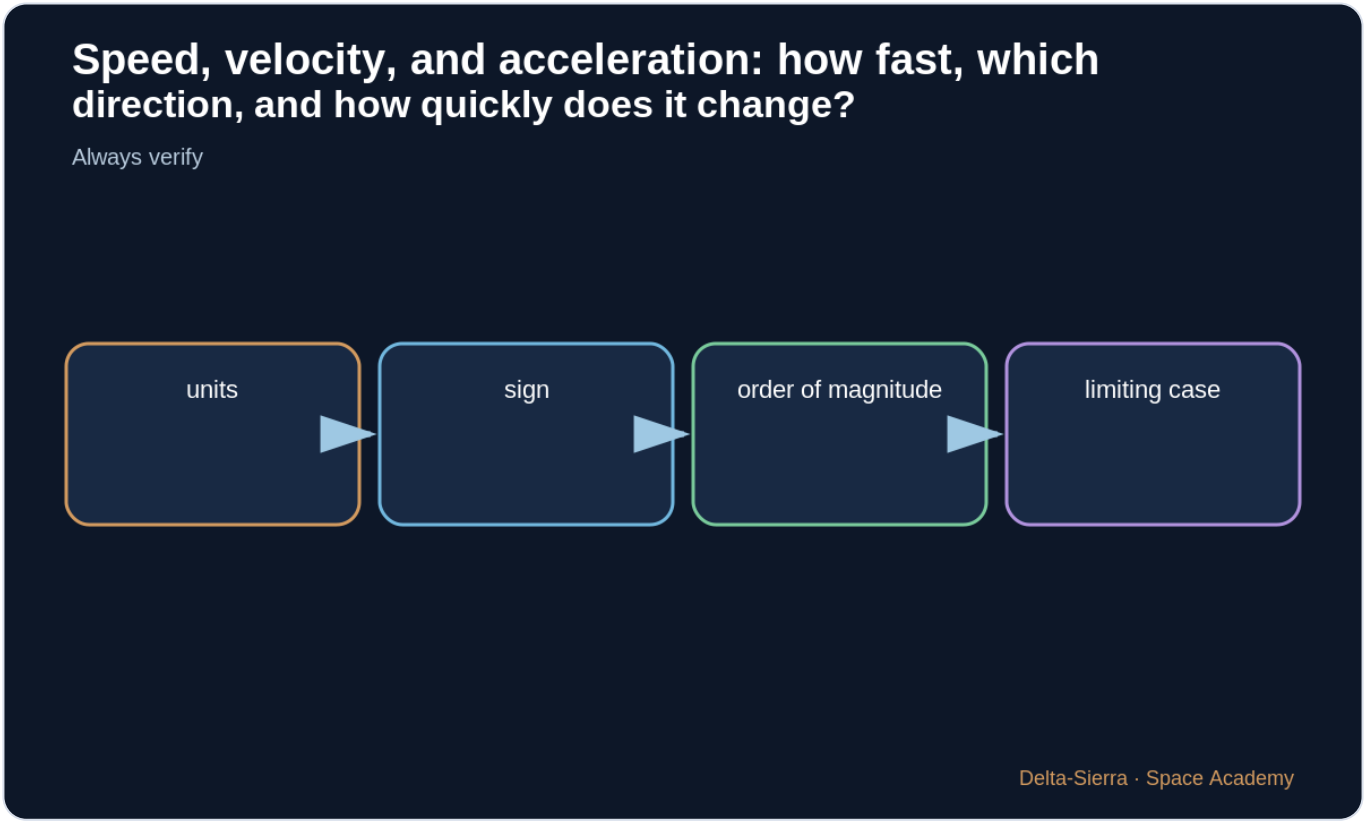
8 — Reading graphs

On a position-time graph, steeper slope means greater velocity. On a velocity-time graph, slope represents acceleration.



Final check: units, sign, physical direction and magnitude.

Beginner checkpoint — what is changing?

Before using a formula, identify the level of change. Distance tells how much path was covered. Velocity tells how quickly position changes. Acceleration tells how quickly velocity changes. If the question says “metres every second”, it is talking about velocity. If it says “the velocity increases by two metres per second every second”, it is talking about acceleration.

The sign also belongs to the chosen direction. A descending lander can have a negative vertical velocity while having a positive acceleration upward during braking. That is not contradictory: the craft is still moving downward, but its downward velocity is becoming smaller in magnitude. Reading signs as directions, rather than as “good” or “bad” numbers, prevents many beginner mistakes.

9 — Corrected exercises

Exercise 1

200 m in 40 s?

5 m/s = 18 km/h.

Exercise 2

Velocity changes from 4 to 10 m/s in 3 s.

2 m/s².

Primary and educational sources

- NASA Science - Basics of Space Flight: Gravity & Mechanics
- NASA Science - Basics of Space Flight Glossary
- NIST - International System of Units (SI)