

Course compass

Question directrice : How do we calculate change per unit, read delta, interpret signs and distinguish average from local slope?

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1 — Slope before mathematics: “how much does it rise while I move forward?”

Imagine a Mars rover at the foot of a ramp. It moves **10 metres horizontally** and gains **2 metres of height**. Before any formula, the question is simply: **for each metre forward, how many metres does the rover rise?**

A **rate of change** asks how much one quantity changes when another quantity changes by one unit. The same idea can describe water production per hour or temperature change per minute.

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Slope and rate of change: how much does it change per unit?

Why do we divide one change by another change?

Physical question

Start with a real ramp: how much height is gained for a given horizontal advance?

2 — Symbols: Δ , x, y and the slope formula

Δ is the Greek letter delta. It is pronounced “delta” and here means “change in”. Thus Δx is “delta x” and Δy is “delta y”.

$$\text{slope} = \Delta y \div \Delta x$$

Read it as: “slope equals change in y divided by change in x.”

Why divide?

Because we want the change in y *for one unit* of change in x. Division spreads the total change across the x-units.

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Slope and rate of change: how much does it change per unit?

m

slope or average rate

y_1, y_2

initial and final values

x_1, x_2

initial and final position

Symbols and units

Delta means change: compare one change with another.

3 — Complete example 1: rover climbing a slope

The rover advances 40 m horizontally and gains 12 m of height.

$$\Delta x = 40 \text{ m} \quad \Delta y = 12 \text{ m} \quad \text{slope} = 12 \div 40 = 0.30$$

0.30 means 0.30 m of height for every 1 m of horizontal advance. Because both quantities are in metres, the units cancel.

As a percentage: $0.30 \times 100 = 30\%$.

Warning: a 30% slope is not a 30° angle. Converting between slope percentage and angle requires trigonometry.

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Slope and rate of change: how much does it change per unit?

$$m = (y_2 - y_1) / (x_2 - x_1)$$

Where the relation comes from

The calculation answers a concrete question: height gained per horizontal metre.

4 — Two more examples: water production and cooling

Example 2 — Water production

A processing unit produces 18 kg of water in 6 h.

mass change = 18 kg time change = 6 h average rate = $18 \div 6 = 3$ kg/h

kg/h is read “kilograms per hour”.

Example 3 — Cooling

A box cools from 50 °C to 38 °C in 4 min.

$$\Delta T = 38 - 50 = -12 \text{ °C} \quad \Delta t = 4 \text{ min} \quad \text{average rate} = -12 \div 4 = -3 \text{ °C/min}$$

The negative sign means the temperature is decreasing.

5 — Sign and starting point tell the story

Positive slope means y increases as x increases; negative slope means y decreases; zero slope means no change over the interval.

Always compute a change as **final value** – **initial value**. If a rover goes from x=15 m to x=55 m, $\Delta x = 55 - 15 = 40$ m, not 55 m.

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Slope and rate of change: how much does it change per unit?

120 L used in 8 h.

$$m = 120 \div 8 = 15 \text{ L/h.}$$

Worked example

The sign tells the direction of change.

6 — Average and local slope

$\Delta y / \Delta x$ gives an **average slope** between two points. A real ramp can be gentle first and steeper later. The average does not describe every location.

Move the two measurement points closer together and you approach the **local slope**. That idea leads to the derivative in AM-01.11.

7 — What to type on a calculator

For the rover: $12 \div 40 =$ gives 0.3. Then $\times 100 =$ gives 30%.

For cooling: $38 - 50 =$ gives -12 , then $\div 4 =$ gives -3 .

The calculator cannot tell whether you chose the correct quantities or units.

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Slope and rate of change: how much does it change per unit?

Always check units, assumptions and the domain of validity.

A model is a tool: it does not replace testing and qualification.

Limits and verification

Translate the final number into a sentence with units and physical meaning.

8 — What to remember

- A slope or rate compares **two changes**.
- Δ is read “delta” and means “change in”.
- Change = final – initial.
- We divide to find change “per unit”.
- Units explain what the rate measures.
- An average slope can hide local changes.

Exercises and answers

Exercise 1

A rover advances 25 m and rises 5 m. Average slope?

$$5 \div 25 = 0.20 = 20\%.$$

Exercise 2

A tank gains 48 kg of water in 8 h. Average rate?

$$48 \div 8 = 6 \text{ kg/h.}$$

Exercise 3

Temperature rises from 20 °C to 32 °C in 6 min. Average rate?

$$\Delta T = 12 \text{ °C}; 12 \div 6 = +2 \text{ °C/min.}$$

Primary and technical sources

- [NIST — SI Units](#)
- [NASA/JPL Education](#)