

AM-02.01 — Position, distance, and displacement: “where am I?” is not “how far did I travel?”

Why must a mission distinguish position, path length, and displacement?

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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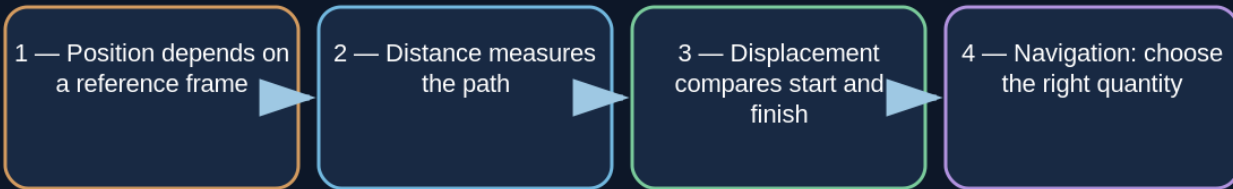
1 — A simple scene: where is the rover, and how far did it drive?

A rover leaves the habitat, drives 100 m east, then comes back 40 m west. Three different questions appear: where is it now, how much path did it cover, and how much did its position change from start to finish?

Those are **position**, **distance** and **displacement**.

Position, distance, and displacement: “where am I?” is not “how far did I travel?”

Why must a mission distinguish position, path length, and displacement?



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Position, path length and displacement answer different questions.

2 — Position needs an origin and an axis

Choose the habitat as the origin, 0. Choose east as positive and west as negative. That sign choice is a convention.

If the rover is 60 m east, write $x = +60 \text{ m}$. The letter x is simply the name of the chosen axis.

Axis: reference line with a direction. **Origin:** the point assigned 0. **Coordinate:** a number locating a point on the axis.

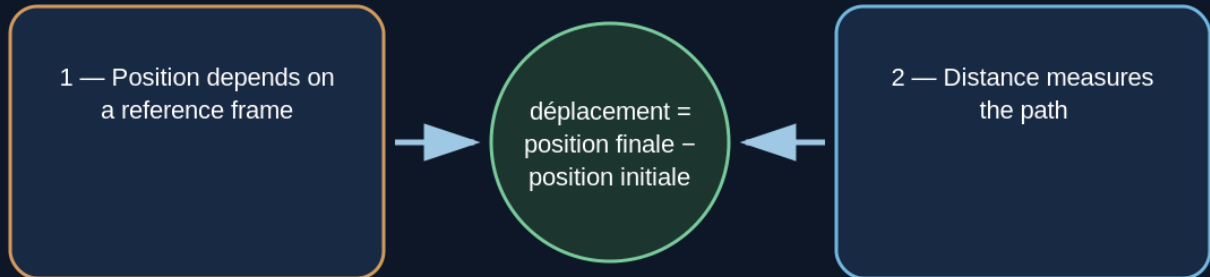
3 — Distance: how much path was actually travelled?

outbound = 100 m
return = 40 m
total distance = $100 + 40 = 140 \text{ m}$

Why add? The wheels really travelled both parts of the route, so both matter for wear, time and energy.

Position, distance, and displacement: “where am I?” is not “how far did I travel?”

1 — Position depends on a reference frame



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Distance follows the path, even when direction changes.

4 — Displacement: compare only start and finish

$$\Delta x = x_{\text{final}} - x_{\text{initial}}$$

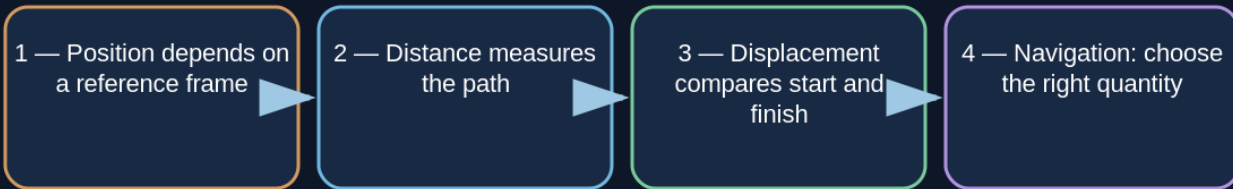
Δ is read “delta” and means change here. Δx is “delta x”.

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x initial = 0 m  
x final = +60 m  
 $\Delta x = 60 - 0 = +60 \text{ m}$ 
```

The positive sign tells us the net change is in the chosen positive direction.

Position, distance, and displacement: “where am I?” is not “how far did I travel?”

2 — Distance measures the path



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Displacement directly joins the starting and final positions.

5 — Why can displacement be negative?

From +20 m to −30 m:

$$\Delta x = -30 - (+20) = -50 \text{ m}$$

The minus sign does not mean “negative distance”. It gives direction.

6 — On a map: two axes locate a point

Use x for east-west and y for north-south. The point (3 m, 4 m) is 3 m along x and 4 m along y from the origin.

$$\text{straight-line length} = \sqrt{3^2 + 4^2} = \sqrt{25} = 5 \text{ m}$$

Why Pythagoras? The x and y components are perpendicular.

7 — Three concrete examples

Position, distance, and displacement: “where am I?” is not “how far did I travel?”

Three complete cases

1

Example A — straight line

Δ is read “delta” and means change here.

2

Example B — return

Two different quantities, two correct answers.

3

Example C — two axes

Pythagoras applies to perpendicular components.

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Round trip, beacon navigation and crater detour.

Example A — Sensor round trip

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80 m east + 80 m west = 160 m distance
displacement = 0 m
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Example B — Habitat to antenna

From (0,0) to (300,400) m.

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straight displacement =  $\sqrt{(300^2 + 400^2)}$  = 500 m
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Example C — Crater detour

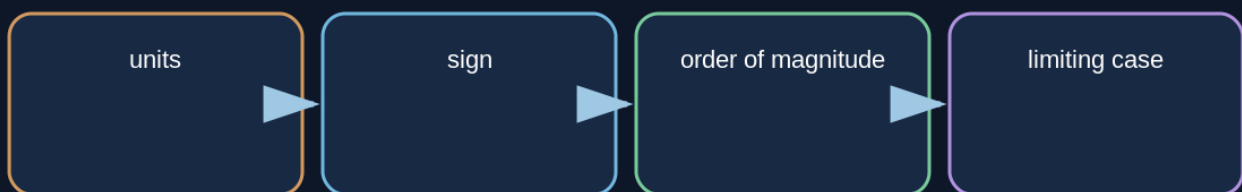
Actual route 900 m; finish only 600 m straight-line from start. Distance = 900 m, displacement magnitude = 600 m.

8 — What each quantity is used for

- position: where the rover is;
- distance: energy, wear and travel time;
- displacement: direction and correction needed to reach a target.

Position, distance, and displacement: “where am I?” is not “how far did I travel?”

Always verify



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Final check: does the question ask about the path, or only start and finish?

Beginner checkpoint — ask “path or start-to-finish?”

When a problem mentions a rover journey, do not immediately calculate. First ask what the question wants. If it asks how much the wheels travelled, use distance and add the lengths of the route. If it asks how far and in what direction the rover ended from its starting point, use displacement. If it asks where the rover is on the map, use position coordinates relative to the chosen origin.

The same trip can therefore have three valid numbers. A rover may travel 900 m around a crater, finish 600 m from its starting point, and have final coordinates such as (480 m, 360 m). None of those numbers replaces the others. Each describes a different aspect of the mission.

9 — Corrected exercises

Exercise 1

50 m forward then 20 m back.

Distance = 70 m; displacement = +30 m if forward is positive.

Exercise 2

From $x = -10$ m to +25 m.

$\Delta x = +35$ m.

Primary and educational sources

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