Speed versus Velocity

Class 9 Physics · Chapter: Motion
🎬 **Video explanation (PrayogX reel):** https://www.instagram.com/reel/DfCuvZuExzh/

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1. The big question

Two cars on a highway both show **60 km/h** on their speedometers. One is going **east**, the other **west**. Physics says they have the **same speed** but **different velocities**. Why? Because velocity cares about **direction**, and speed does not.

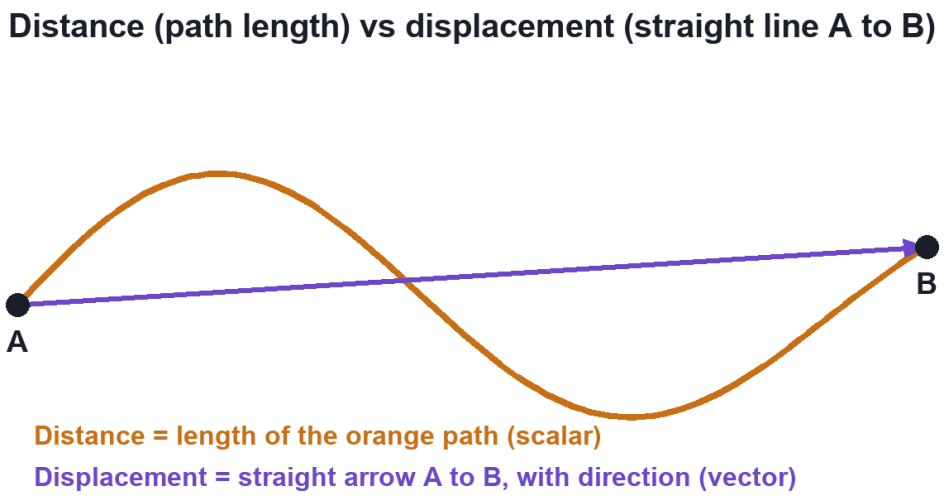
2. Key definitions

Term	Meaning
Distance	The total length of the path actually travelled. Only magnitude (scalar).
Displacement	The shortest straight-line distance from the initial to the final position, **with direction** (vector).
Speed	The distance travelled per unit time: how fast an object moves. A **scalar**.
Velocity	The displacement per unit time: speed in a given direction. A **vector**.
Scalar quantity	Has magnitude only (e.g. distance, speed, mass, time).
Vector quantity	Has magnitude **and** direction (e.g. displacement, velocity, force).

3. The formulas

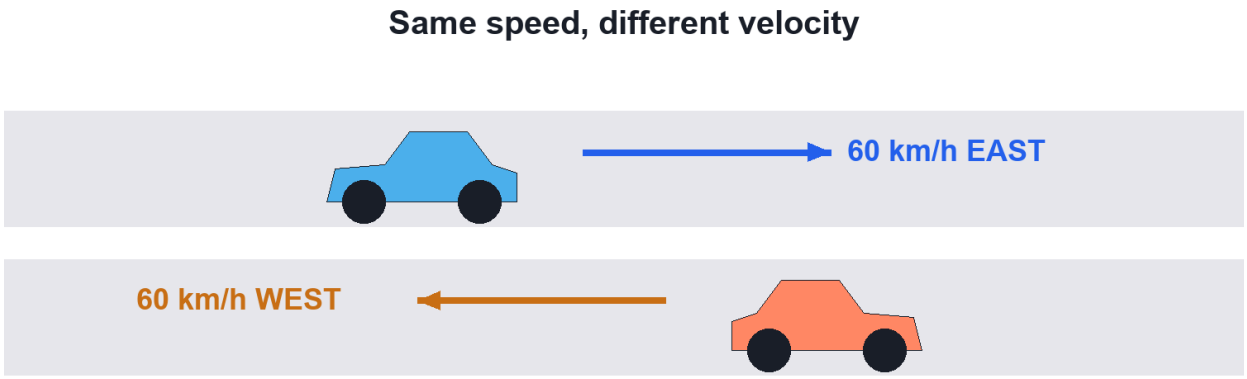
Speed = Distance travelled ÷ Time taken → $v = s / t$
Velocity = Displacement ÷ Time taken (with direction)
SI unit of both: metre per second (**m/s** or m s^{-1}). Everyday unit: km/h.
Conversion: 1 km/h = 5/18 m/s (so 60 km/h = 60 × 5/18 ≈ 16.7 m/s; 36 km/h = 10 m/s).

4. Distance vs displacement (the root of the difference)



Moving from A to B along a wiggly road: the **distance** is the length of the whole orange path; the **displacement** is the straight purple arrow from A to B. Speed uses the path; velocity uses the arrow. So, for the same trip, **average speed ≥ magnitude of average velocity**; they are equal only for straight-line motion in one direction.

5. Same speed, different velocity



Both cars: speed = 60 km/h. Car 1: velocity = 60 km/h **east**. Car 2: velocity = 60 km/h **west**. Since direction is part of velocity, the two velocities are **different** (in fact, opposite).

6. The twist: constant speed, changing velocity

Uniform circular motion: constant speed, changing velocity



Purple arrows: velocity, always along the tangent; its DIRECTION keeps changing.

A car going round a circular track at a steady 60 km/h has **constant speed**, but its direction changes at every point, so its **velocity keeps changing**. This is called **uniform circular motion**, and because the velocity changes, it is an **accelerated motion**.
Velocity changes when **(i)** the speed changes, **(ii)** the direction changes, or **(iii)** both change.

7. Speed vs velocity: comparison table

Point	Speed	Velocity
Definition	Distance ÷ time	Displacement ÷ time
Type of quantity	Scalar	Vector
Direction	Not needed	Must be stated
Can it be negative?	No (always ≥ 0)	Yes (sign shows direction)
Can it be zero while moving?	No (if the object is moving)	Average velocity can be zero (round trip)
SI unit	m/s	m/s

8. Examples and analogies

- **Speedometer** shows speed only. To give velocity you must add the direction: "60 km/h towards north".
- **Analogy:** speed is like saying "I walked fast"; velocity is like saying "I walked fast towards the school gate".
- **Ceiling fan blade tip, Earth around the Sun, a stone whirled on a string:** nearly constant speed, changing velocity.

9. Solved examples

Solved example 1. A car covers 150 km in 2.5 h. Find its average speed in km/h and in m/s.
Solution: Speed = 150 km ÷ 2.5 h = **60 km/h**. In m/s: 60 × 5/18 = **16.67 m/s**.
Solved example 2. A girl walks 30 m east in 10 s and then 30 m west in 10 s. Find her average speed and average velocity.
Solution: Distance = 30 + 30 = 60 m; time = 20 s; average speed = 60 ÷ 20 = **3 m/s**.
Displacement = 0 (she is back at the start), so average velocity = 0 ÷ 20 = **0 m/s**.
Solved example 3. A cyclist goes 400 m north in 50 s. Find speed and velocity.
Solution: Straight line, one direction, so distance = displacement = 400 m. Speed = 400 ÷ 50 = **8 m/s**; velocity = **8 m/s due north**.

10. Key takeaways

- Speed = distance ÷ time (**scalar**); velocity = displacement ÷ time (**vector**).
- Same speed can mean different velocities if directions differ.
- Constant speed in a circle = **changing velocity** (direction changes).
- SI unit of both: **m/s**; 1 km/h = 5/18 m/s.
- Speed is never negative; velocity can be negative or zero.

Practice questions (CBSE style)

Q1 (MCQ). Which of these is a vector quantity?
(a) speed (b) distance (c) velocity (d) time
Q2 (MCQ). An object moves along a circular path at a constant speed. Its velocity:
(a) is constant (b) changes because its direction changes (c) is zero (d) is equal to its speed
Q3 (Short answer, 2 marks). Distinguish between speed and velocity (any two points).
Q4 (Short answer, 2 marks). Can an object have a non-zero average speed but zero average velocity? Give an example.
Q5 (Numerical, 2 marks). Convert 72 km/h into m/s. A train moves at this speed for 5 minutes in a straight line. How far does it go?
Q6 (Numerical, 3 marks). An athlete runs one full round of a circular track of radius 70 m in 44 s. Find (a) the distance, (b) the displacement, (c) the average speed and (d) the average velocity after one round. (Take π = 22/7.)
Q7 (Application, 3 marks). Two buses leave a stop at the same time, both at 40 km/h, one towards Delhi (north) and one towards Agra (south). Do they have the same speed? The same velocity? Explain.
Q8 (Diagram based, 3 marks). Draw a circular path and show the direction of velocity of an object at four points. What does your diagram tell you about the velocity in uniform circular motion?
Q9 (Case based, 4 marks). Ravi drives 12 km north from home to school in 20 minutes, then 12 km back home in 20 minutes.
(a) Total distance? (1) (b) Total displacement? (1) (c) Average speed in km/h? (1) (d) Average velocity for the whole trip? (1)

Answer key with worked solutions

A1. (c) velocity.
A2. (b) it changes because its direction changes (uniform circular motion).
A3. (i) Speed = distance ÷ time; velocity = displacement ÷ time. (ii) Speed is a scalar (no direction); velocity is a vector (has direction). (iii) Speed is never negative; velocity can be negative or zero.
A4. Yes. If an object returns to its starting point, the displacement is zero, so average velocity is zero, but it covered a distance, so average speed is non-zero. Example: a runner completing one round of a track.
A5. 72 × 5/18 = **20 m/s**. Time = 5 min = 300 s. Distance = 20 × 300 = **6000 m = 6 km**.
A6. (a) Distance = 2πr = 2 × 22/7 × 70 = **440 m**. (b) Displacement = **0** (back at the start). (c) Average speed = 440 ÷ 44 = **10 m/s**. (d) Average velocity = 0 ÷ 44 = **0 m/s**.
A7. Same speed: yes, both 40 km/h. Same velocity: no; one is 40 km/h north, the other 40 km/h south. Velocity includes direction, so they are different (opposite).
A8. Draw a circle; at each point draw an arrow along the tangent in the direction of motion (as in Section 6). The arrows all have the same length (same speed) but point in different directions, so the velocity changes continuously; uniform circular motion is accelerated motion.
A9. (a) 12 + 12 = **24 km**. (b) **0** (he is back home). (c) Total time = 40 min = 2/3 h; average speed = 24 ÷ (2/3) = **36 km/h**. (d) Average velocity = 0 ÷ (2/3 h) = **0 km/h**.