Average Speed vs Average Velocity

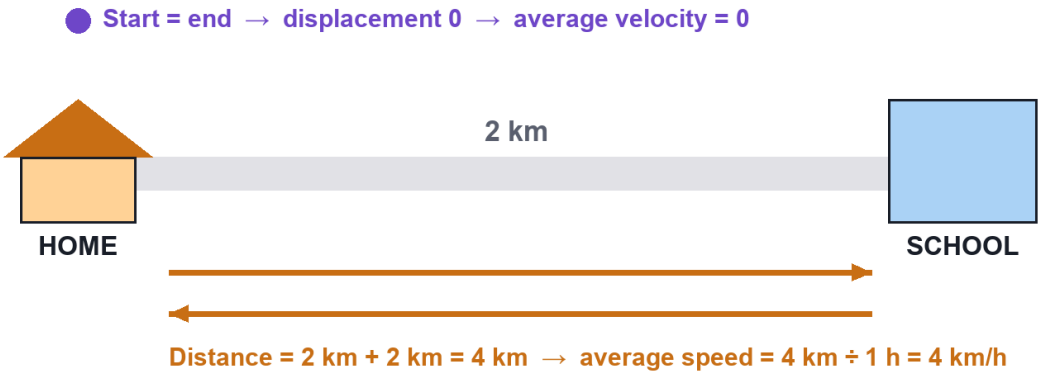
Class 9 Physics · Chapter: Motion
🎬 **Video explanation (PrayogX reel):** https://www.instagram.com/reel/DfFtaBIDf56/

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1. The surprising walk

A boy walks 2 km from home to school and 2 km back, all in **1 hour**. He walked **4 km**, so his **average speed is 4 km/h**. But he ended where he started, so his **average velocity is 0**.

Home → school → home: 4 km walked, displacement 0



2. Key definitions

Term	Meaning
Distance	Total length of the path actually travelled (scalar, never negative).
Displacement	Shortest straight-line change in position from start to end, with direction (vector). Zero if you return to the start.
Average speed	Total distance ÷ total time taken (scalar).
Average velocity	Total displacement ÷ total time taken (vector: has a direction).

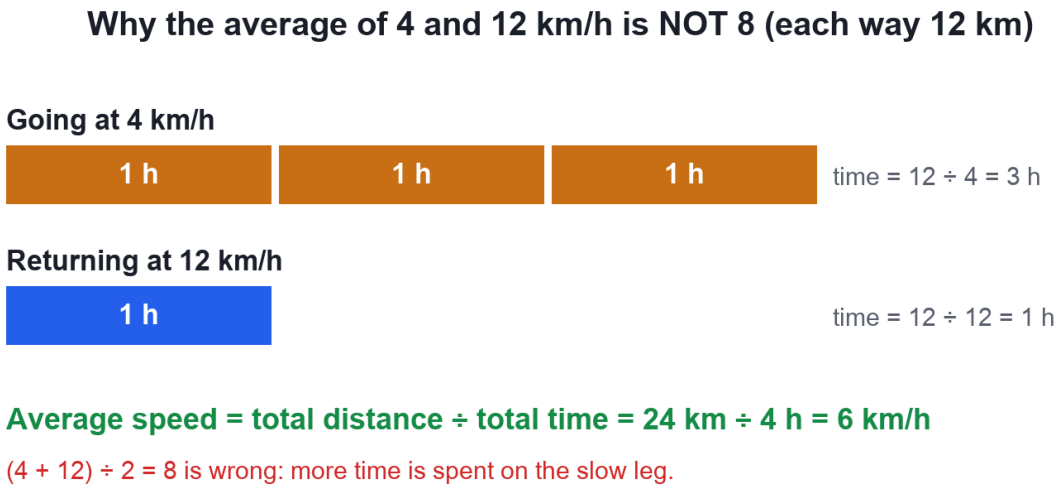
3. The formulas

Average speed = total distance ÷ total time
Average velocity = total displacement ÷ total time

SI unit of both: **m/s** (km/h is also common; 1 km/h = 5/18 m/s).

4. The trap: averaging two speeds

Going 12 km at 4 km/h and returning 12 km at 12 km/h, the average speed is **not** (4 + 12) ÷ 2 = 8 km/h. The slow leg takes 3 h and the fast leg 1 h, so the average speed = 24 km ÷ 4 h = **6 km/h**.



For equal distances at speeds v_1 and v_2, average speed = $2v_1v_2 \div (v_1 + v_2) = 2 \times 4 \times 12 \div 16 = 6$ km/h.

5. Comparison table

Feature	Average speed	Average velocity
Uses	Total distance	Displacement
Type	Scalar	Vector
Can it be zero while you moved?	No	Yes (round trip)
Can it be negative?	No	Its sign shows direction along a line
Relation	|average velocity| ≤ average speed (equal only for straight-line motion in one direction)	

6. Solved examples

Example 1. A car goes 60 km east in 1 h and then 40 km west in 1 h. Find its average speed and average velocity.
Distance = 60 + 40 = 100 km, time = 2 h → average speed = **50 km/h**. Displacement = 60 − 40 = 20 km east → average velocity = **10 km/h east**.

Example 2. An athlete runs one full lap of a 400 m circular track in 50 s. Average speed = 400 ÷ 50 = **8 m/s**; displacement = 0, so average velocity = **0**.
Example 3. A cyclist rides 10 km at 20 km/h and the next 10 km at 10 km/h. Time = 0.5 h + 1 h = 1.5 h, so average speed = 20 ÷ 1.5 ≈ **13.3 km/h** (not 15).

7. Key takeaways

- Average speed uses **total distance**; average velocity uses **displacement**.
- A round trip has average velocity **0** but a non-zero average speed.
- Never average two speeds directly; divide total distance by total time.
- |Average velocity| is never more than average speed.

Practice questions (CBSE style)

1. Define average speed and average velocity. Which one is a vector? (1 mark)
2. A boy walks 3 km north and then 4 km south in 2 h. Find his average speed and average velocity. (2 marks)
3. Can the average velocity of a body be zero when its average speed is not zero? Give an example. (2 marks)
4. A bus covers the first 30 km at 30 km/h and the next 30 km at 60 km/h. Find its average speed. (3 marks)
5. A runner completes 2 laps of a circular track of radius 50 m in 100 s. Find the average speed and average velocity. (Take π = 3.14) (3 marks)
6. Explain why the average of 4 km/h and 12 km/h over equal distances is not 8 km/h. (2 marks)
7. State the relation between the magnitude of average velocity and average speed. When are they equal? (2 marks)

Answer key with worked solutions

1. Average speed = total distance ÷ total time; average velocity = displacement ÷ total time. Average velocity is a vector.
2. Distance = 7 km → average speed = 7 ÷ 2 = 3.5 km/h. Displacement = 4 − 3 = 1 km south → average velocity = 0.5 km/h south.
3. Yes. A round trip (home → school → home) has displacement 0, so average velocity 0, but the distance and average speed are not zero.
4. Time = 30/30 + 30/60 = 1 + 0.5 = 1.5 h; distance = 60 km → average speed = 40 km/h.
5. Distance = 2 × 2πr = 2 × 2 × 3.14 × 50 = 628 m → average speed = 6.28 m/s. The runner ends at the start, so displacement = 0 and average velocity = 0.
6. More time is spent at the lower speed (3 h at 4 km/h vs 1 h at 12 km/h for 12 km each way), so average speed = 24 ÷ 4 = 6 km/h.
7. |Average velocity| ≤ average speed. They are equal when the body moves in a straight line without changing direction.