Average Speed

Physics | JEE Main & Advanced

Don't Memorize. Visualize.

> Average speed is the total distance divided by the total time. It is not the mean of the speeds: the speed you hold for longer counts for more.

AVERAGE SPEED

Total distance covered, divided by the total time taken.

Never negative. Units: km/h or m/s.

AVERAGE VELOCITY

Total displacement (from start to finish, with direction), divided by the total time.

Zero for a trip that ends where it began.

The trip in the Short

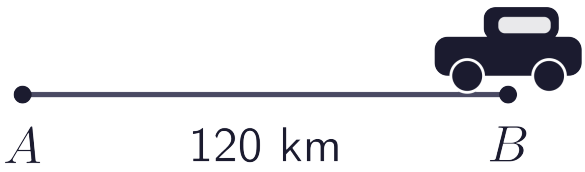
A car drives from A to B, 120 km, at 40 km/h, and comes back at 60 km/h.

There: 3 hours

$$t_1 = \frac{120\ \text{km}}{40\ \text{km/h}} = 3\ \text{h}$$

Back: 2 hours

$$t_2 = \frac{120\ \text{km}}{60\ \text{km/h}} = 2\ \text{h}$$





Average speed of the whole trip

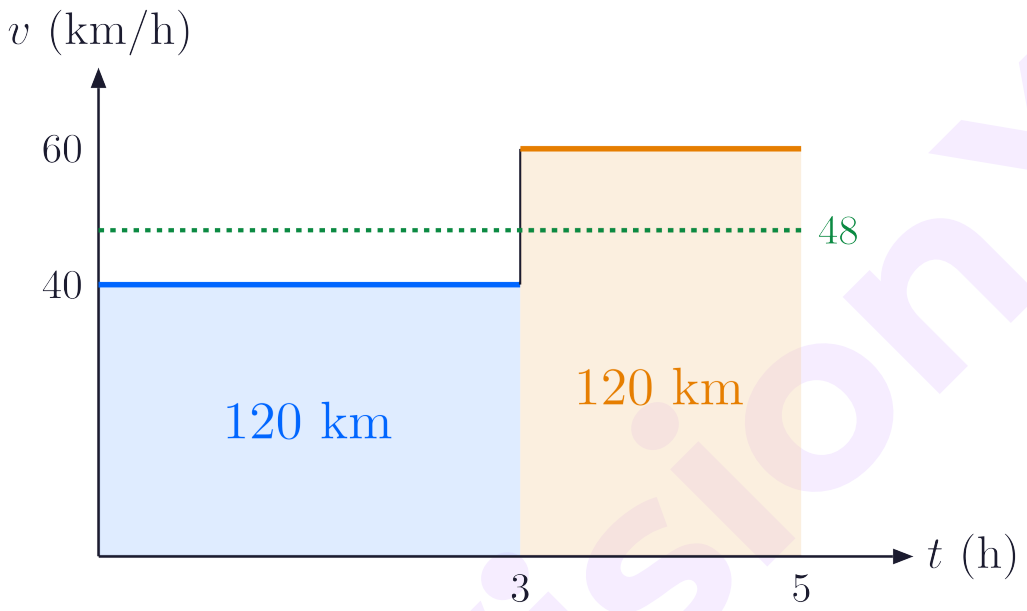
$$v_{\text{avg}} = \frac{\text{total distance}}{\text{total time}} = \frac{120 + 120}{3 + 2}\ \text{km/h} = \frac{240}{5}\ \text{km/h} = \mathbf{48\ km/h}$$

CAREFUL

For the same round trip the **average velocity** is 0: the car ends where it started, so the displacement is zero. Average speed 48 km/h, average velocity 0. JEE questions ask for one or the other; read which.

Why 48 and not 50

Draw speed against time. The area under each step is the distance on that leg: $40 \times 3 = 120$ and $60 \times 2 = 120$. The dashed line at 48 for 5 hours covers the same 240 km.



The car spends 3 of the 5 hours at 40 and only 2 at 60, so the average leans towards 40. Each speed counts as many times as the hours it was held:

$$v_{\text{avg}} = \frac{40 \times 3 + 60 \times 2}{5} = \frac{240}{5} = 48.$$

Equal distances

Two legs of the same length at v_1 and v_2:

$$v_{\text{avg}} = \frac{2v_1v_2}{v_1 + v_2}$$

Here $\frac{2\times40\times60}{100} = 48$.

Equal times

Two legs of the same duration at v_1 and v_2:

$$v_{\text{avg}} = \frac{v_1 + v_2}{2}$$

Only then is the plain mean right.

Solved example

A bus covers the first half of a journey at 30 km/h and the second half at 60 km/h. Find its average speed.

Equal distances, so use the formula for equal distances, or take a length: say each half is 60 km. Then the times are $\frac{60}{30} = 2$ h and $\frac{60}{60} = 1$ h, and $v_{\text{avg}} = \frac{120}{3} = 40$ km/h.

40 km/h (not 45)

Key formulas

$$v_{\text{avg}} = \frac{\text{total distance}}{\text{total time}} \qquad \text{average velocity} = \frac{\text{total displacement}}{\text{total time}}$$

$$\text{equal distances: } v_{\text{avg}} = \frac{2v_1v_2}{v_1 + v_2} \qquad \text{equal times: } v_{\text{avg}} = \frac{v_1 + v_2}{2}$$

Practice set

Easy to hard. The answers start on the next page.

Q1. **Quiz from the Short.** A car goes up a hill at 20 km/h and comes back down the same road at 30 km/h. Its average speed is: (A) 25 km/h (B) 26 km/h (C) 24 km/h.

Q2. A car goes 60 km at 30 km/h and then 60 km more at 60 km/h. Find its average speed.

Q3. A car drives for 1 hour at 40 km/h and then for 1 hour at 60 km/h. Find its average speed.

Q4. For the round trip of the Short (A to B at 40 km/h, back at 60 km/h), find the average velocity.

Q5. A cyclist covers one third of a distance at 20 km/h and the rest at 60 km/h. Find the average speed.

Q6. A particle covers half of a distance at speed v_0. For the other half, it moves at v_1 for half the time and at v_2 for the other half of the time. Find its average speed.

Watch the animated lesson on YouTube

Average Speed (Short)

Scan the code to open the JEEVisionX channel on YouTube. This lesson is in the JEE Concepts Visualization Shorts playlist.

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Answers

Q1

(C) 24 km/h

Call the road d. Time $= \frac{d}{20} + \frac{d}{30} = \frac{d}{12}$, so the average speed is $2d \div \frac{d}{12} = 24$ km/h. 25 km/h is the mean of the two speeds: the slow climb lasts longer, so it counts for more.

Q2

40 km/h

Times 2 h and 1 h: $\frac{120}{3} = 40$. Equal distances, so also $\frac{2\times30\times60}{90} = 40$.

Q3

50 km/h

Equal times, so here the plain mean is right: $\frac{40+60}{2} = 50$, or $\frac{100\text{ km}}{2\text{ h}}$.

Q4

0

The car returns to A, so the displacement is zero. (Its average speed is still 48 km/h.)

Q5

36 km/h

Take the distance as 3 km. 1 km at 20 km/h takes $\frac{1}{20}$ h; 2 km at 60 km/h take $\frac{1}{30}$ h. Total $\frac{1}{20} + \frac{1}{30} = \frac{1}{12}$ h, so $v_{\text{avg}} = 3 \times 12 = 36$.

Q6

$$\frac{2v_0(v_1+v_2)}{2v_0+v_1+v_2}$$

The second half is equal times, so it is covered at $u = \frac{v_1+v_2}{2}$. The two halves are equal distances: $v_{\text{avg}} = \frac{2v_0u}{v_0+u}$. Put in u and multiply top and bottom by 2.

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