

KINEMATICS DAY 1: POSITION, DISPLACEMENT & VELOCITY

WARMUP How Fast Is Fast?

Usain Bolt ran 100 m in 9.58 s. **(a)** Find his average speed in m/s. **(b)** A typical walking pace is about 1.4 m/s — roughly how many times faster than walking is that? **(c)** Estimate: is Bolt faster or slower than a car driving through a school zone (~25 km/h)?

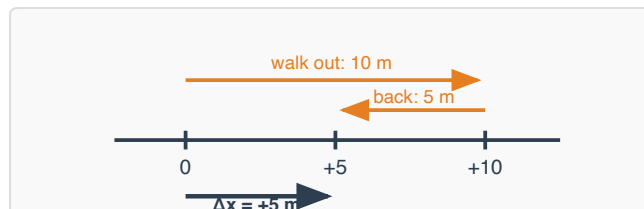
Physics in the Wild — Your Odometer Lies (Sort Of): Drive around the block and back to your driveway. Your car's odometer says you traveled 1.2 km — but your GPS says your trip covered 0 km "as the crow flies." Both are right: the odometer measures *distance* (the path you actually traced), while the straight line from start to finish is *displacement*. Physics needs both ideas, and today we learn to never confuse them again.

POSITION & DISPLACEMENT

Position (x): where you are, measured from a chosen origin. It has a *sign* — the sign tells you which side of the origin.

Displacement: $\Delta x = x_f - x_i$ — change in position. Sign matters!

Distance: total path length traveled. Always positive, no direction.



WE DO Exercise 1: Number-Line Walk

You start at position $x = +2$ m, walk to $x = +10$ m, then turn around and walk back to $x = +5$ m. Find **(a)** the total distance traveled and **(b)** your displacement.

AVERAGE SPEED VS AVERAGE VELOCITY

TWO DIFFERENT "HOW FAST"

Average speed = distance / time

Always positive. Uses the whole path.

Average velocity = $\Delta x / \Delta t$

Has a sign (direction). Only cares where you started and ended.

They agree only when you never change direction. The moment you turn around, average speed > average velocity.

WE DO Exercise 2: The Round Trip

A student walks 60 m east to a friend's locker in 40 s, then walks 60 m back west in 60 s. Find **(a)** average speed for the whole trip and **(b)** average velocity for the whole trip.

YOU DO Exercise 3: Jogger With a Turn

A jogger runs 240 m east in 120 s, then 90 m west in 60 s. Take east as positive. Find **(a)** total distance, **(b)** displacement, **(c)** average speed, and **(d)** average velocity.

YOU DO Exercise 4: Solving for Time

A cyclist holds a steady 6.0 m/s. How long does it take to cover 1.5 km? Give your answer in seconds, then convert to minutes.

Sign convention — set it and keep it. Before any problem, choose which direction is positive (we usually pick east/right/up) and stick with it for the *entire* problem. A negative answer isn't wrong — it's information: it tells you the direction.

UNIT CONVERSIONS YOU'LL USE ALL YEAR

KM/H $\leftrightarrow$ M/S

km/h $\rightarrow$ m/s: divide by 3.6

m/s $\rightarrow$ km/h: multiply by 3.6

Why 3.6? $1 \text{ km} = 1000 \text{ m}$ and $1 \text{ h} = 3600 \text{ s}$, so $1 \text{ km/h} = 1000/3600 \text{ m/s}$.

Speed	m/s	km/h
Walking	1.4	5
School zone car	7	25
Highway car	28	100

WE DO Exercise 5: Convert It

A car travels at 90 km/h. What is its speed in m/s?

YOU DO Exercise 6: Convert It Back

A sprinter runs at 9.0 m/s. What is that in km/h? Could they get a speeding ticket in a school zone (limit 25 km/h)?

YOU DO Exercise 7: Position as a Function

An object's position is given by $x(t) = 5 + 3t$ (x in meters, t in seconds). **(a)** Where is the object at $t = 0$? **(b)** Where is it at $t = 4 \text{ s}$? **(c)** What is its displacement from $t = 0$ to $t = 4 \text{ s}$? **(d)** What does the "3" in the equation represent physically?

CHALLENGE Exercise 8: Meeting Point

Student A starts at $x = 0$ walking at $+2.0 \text{ m/s}$. Student B starts at $x = +30 \text{ m}$ walking at -1.0 m/s (toward A). **(a)** How long until they meet? **(b)** At what position do they meet? *Hint: write a position equation for each student and set them equal.*

PAPER PRACTICE

PRACTICE PROBLEMS

P1 Multi-Segment Walk

You walk 12 m east, 5 m west, then 8 m east. Find your total distance and your displacement (take east as positive).

P2 Drive With a Turn

A driver goes 40 km north in 0.50 h, then 20 km south in 0.25 h. Find **(a)** average speed and **(b)** average velocity (magnitude and direction) for the whole trip, both in km/h.

P3 Light From the Sun

Sunlight travels at 3.0×10^8 m/s and the Sun is 1.5×10^{11} m away. How many seconds does light take to reach Earth? Convert to minutes.

P4 The Average-Speed Trap

A bus drives 60 km to another town at 30 km/h, then returns the same 60 km at 60 km/h. Show that the average speed for the round trip is **not** 45 km/h, and find the real value. *Hint: total distance over total time — find each leg's time first.*