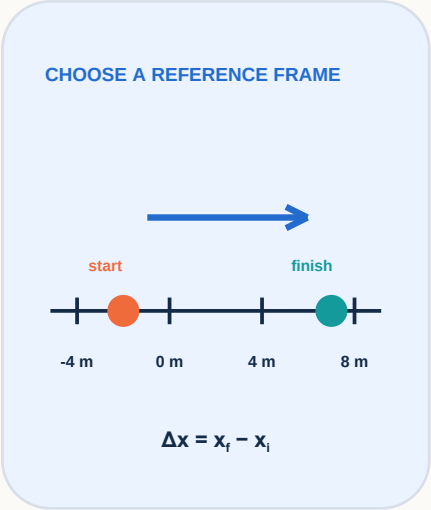
PEARSON EDEXCEL IAL PHYSICS | UNIT 1

LESSON 1.1.1

Motion, Displacement, Velocity and Acceleration

A precise description of motion starts with a reference frame, keeps direction visible, and builds one rate of change from another.



THE MOTION CHAIN

POSITION
x

>

DISPLACEMENT
change in position

>

VELOCITY
position change / time

>

ACCELERATION
velocity change / time

BY THE END, YOU SHOULD BE ABLE TO...

1. Separate distance from displacement and speed from velocity.
2. Calculate average velocity and average acceleration with correct signs and units.
3. Use velocity and acceleration directions to decide whether speed increases or decreases.

CORE HABIT

Define the positive direction before calculating. A negative sign gives direction; it does not automatically mean slowing down.

1 Position, distance, and displacement

Scalars describe magnitude only. Vectors describe magnitude and direction, so their signs depend on the chosen positive direction.

SCALAR OR VECTOR?

SCALARS

Distance and speed have magnitude only. Distance records the total path travelled.

VECTORS

Displacement and velocity include direction. In one dimension, the sign represents direction.

REFERENCE-FRAME METHOD

1. Mark the origin. 2. Choose positive direction. 3. Record initial and final positions. 4. Calculate final - initial.

WORKED POSITION CHANGE

A cart moves from x = -2 m to x = +7 m.

$$\Delta x = x_f - x_i = +7 - (-2) = +9 \text{ m}$$

Only the endpoints determine displacement; the path determines distance.

AVERAGE RATES

AVERAGE VELOCITY

$$v_{avg} = \frac{\Delta x}{\Delta t}$$

SI unit: $\mathbf{m\ s^{-1}}$

AVERAGE SPEED

$$\text{speed}_{avg} = \frac{\text{distance}}{\Delta t}$$

SI unit: $\mathbf{m\ s^{-1}}$

RETURN-TRIP CHECK

Walk 10 m right, then 10 m back in 20 s: distance = 20 m and average speed = 1.0 m/s, but displacement = 0 m and average velocity = 0 m/s.

2 Acceleration and direction

Acceleration is the rate of change of velocity. An object accelerates when velocity magnitude changes, direction changes, or both.

AVERAGE ACCELERATION

$$a_{avg} = \frac{\Delta v}{\Delta t} = \frac{(v_f - v_i)}{(t_f - t_i)}$$

SI unit: $m\ s^{-2}$ | subtraction order: final − initial

DOES THE OBJECT SPEED UP OR SLOW DOWN?

v + a +

Same direction -> speed increases.

v + a -

Opposite directions -> speed decreases.

v - a -

Same direction -> speed increases.

v - a +

Opposite directions -> speed decreases.

Negative acceleration means acceleration points in the negative direction - not necessarily deceleration.

AVERAGE VS INSTANTANEOUS

AVERAGE

One value describes a finite time interval.

INSTANTANEOUS

A value at one moment; approximated using a very small time interval.

EXAM-STYLE CHECK

Velocity changes from $+6\ m\ s^{-1}$ at 1 s to $-2\ m\ s^{-1}$ at 5 s.

$$\Delta v = v_f - v_i = -2 - (+6) = -8\ m\ s^{-1} \quad | \quad \Delta t = 5 - 1 = 4\ s$$

$$a_{avg} = \frac{\Delta v}{\Delta t} = -8 / 4 = -2\ m\ s^{-2}$$

Final check: equation -> substitution -> signed answer -> SI unit -> direction statement.