Exercise walk-through

Displacement, Velocity, and Acceleration ▪ 1.2

eXercise

You must be able to

- define **position** 位置 and **displacement** 位移 $\Delta x = x_f - x_i$ (a vector)
- find **average velocity** 平均速度 $v_{avg} = \dfrac{\Delta x}{\Delta t}$ and describe **instantaneous velocity** 瞬时速度
- tell **speed** 速率 (scalar) from **velocity** 速度 (vector), and see when their sizes differ
- find **average acceleration** 加速度 $a_{avg} = \dfrac{\Delta v}{\Delta t}$
- decide if an object is **speeding up** or **slowing down** from the signs of v and a

Method — Displacement vs distance

Displacement is the change in position (a vector); **distance** 距离 is the path length (a scalar). A runner goes $+100$ m east then -40 m west:

- displacement $= (+100) + (-40) = +60$ m (60 m east)
- distance $= 100 + 40 = 140$ m

Method — Average velocity and acceleration

Use the change over the interval:

$$v_{avg} = \frac{\Delta x}{\Delta t}, \qquad a_{avg} = \frac{\Delta v}{\Delta t}.$$

A car speeds from 8 m s^{-1} to 20 m s^{-1} in 4 s: $a = \dfrac{20 - 8}{4} = +3$ m s^{-2}.

Method — Speeding up or slowing down

Compare the **signs** of v and a:

- same sign $\rightarrow$ speeding up
- opposite signs $\rightarrow$ slowing down

A ball moving in the $+$ direction with $a = -2$ m s^{-2} is slowing down.

Practice 2.1 ▪ 2 marks

A cyclist rides $+300$ m then returns -120 m. State (a) the displacement and (b) the distance travelled.

Solution 2.1

Method: Displacement vs distance

Worked steps

(a) $(+300) + (-120) = +180$ m B1. (b) $300 + 120 = 420$ m B1.

Practice 2.2 ▪ 2 marks

A car's velocity changes from $+30$ m s^{-1} to $+12$ m s^{-1} in 6.0 s. Find its average acceleration.

Solution 2.2

Method: Average velocity and acceleration

Worked steps

$$a = \frac{12 - 30}{6.0} = -3.0 \text{ m s}^{-2}$$ M1 A1.

Practice 2.3 ▪ 2 marks

An object moves in the $+$ direction while its acceleration is -4 m s^{-2}. State whether it is speeding up or slowing down, and why.

Solution 2.3

Method: Speeding up or slowing down

Worked steps

Slowing down B1 — v and a have opposite signs, so the acceleration opposes the motion B1.

Practice 2.4 ▪ 1 mark

In 5.0 s a train's displacement is $+250$ m. Find its average velocity.

Solution 2.4

Method: Average velocity and acceleration

Worked steps

$$v = \frac{250}{5.0} = +50 \text{ m s}^{-1}$$ B1.

Exam-style 3.1 ▪ 1 mark

Which pair are **both** vectors?

A speed and distance

B velocity and displacement

C speed and velocity

D distance and displacement

Solution 3.1

A speed and distance

B velocity and displacement ✓

C speed and velocity

D distance and displacement

Worked steps

B.

Exam-style 3.2 ▪ 1 mark

An object has velocity -6 m s^{-1} and acceleration -2 m s^{-2}. The object is

A speeding up

B slowing down

C at rest

D moving at constant velocity

Solution 3.2

Method: Average velocity and acceleration

A speeding up ✓

B slowing down

C at rest

D moving at constant velocity

Worked steps

A — v and a have the same sign, so the object speeds up.

Exam-style 3.3 ▪ 1 mark

A jogger runs one full lap of a 400 m track, returning to the start, in 100 s.
(a) State the total distance run.
(b) State the magnitude of the displacement.
(c) Hence find the average velocity for the lap.

Solution 3.3

Worked steps

(a) 400 m B1. (b) 0 m — start and end are the same point B1. (c) $v_{avg} = 0/100 = 0$ m s^{-1} B1.

Exam-style 3.4 ▪ 1 mark

A stone's velocity changes from $+5$ m s^{-1} to -5 m s^{-1} in 2.0 s.
(a) Find the average acceleration.
(b) Explain why the answer is negative even though the final speed equals the initial speed.

Solution 3.4

Method: Average velocity and acceleration

Worked steps

(a) $a = \dfrac{-5-(+5)}{2.0} = -5.0\ \text{m s}^{-2}$ A1. (b) Velocity is a vector; its direction reversed, so $\Delta v \neq 0$ even though the speed is unchanged B1.