AQA · GCSE · PHYSICS • EXERCISE SHEET

5.6 Describing motion along a line

Name: _____ Class: _____ Date: _____ **Total: 29 marks**

KEY WORDS Distance • Displacement • Speed • Velocity • Acceleration • terminal velocity

Objective

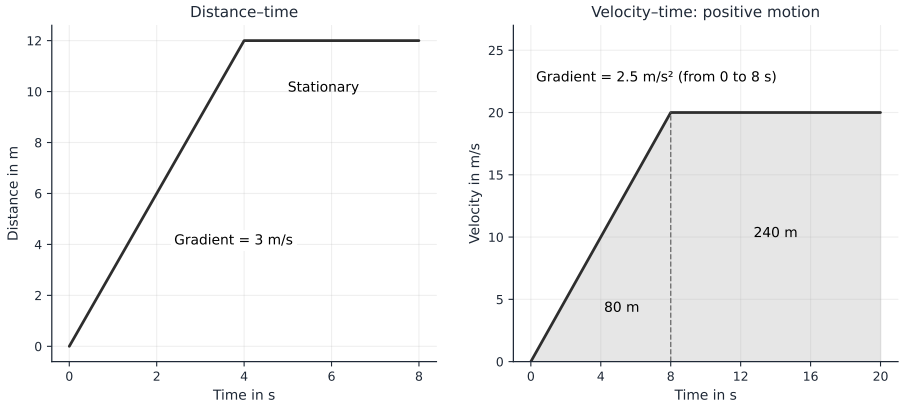
Distinguish distance/displacement and speed/velocity, recall typical speeds, and read distance–time and velocity–time graphs (gradient, tangent, area). Original questions for spec statements 4.5.6.1.1–4.5.6.1.5.

1 Key knowledge and worked examples

Scalar		Vector	
distance	– how far	displacement	– straight-line distance AND direction
speed		velocity	– speed in a given direction

Typical values to recall: walking ≈ 1.5 m/s, running ≈ 3 m/s, cycling ≈ 6 m/s, **sound in air ≈ 330 m/s**. Speed varies with age, terrain, fitness, distance; sound and wind speeds vary too.

$$s = vt \quad \text{(constant speed)} \qquad a = \frac{\Delta v}{t} \qquad v^2 - u^2 = 2as$$



Steepness means speed on one, acceleration on the other.

Graph rules:

Graph	Gradient	Flat section	(HT) Area under
distance–time	speed	stationary	–
velocity–time	acceleration	constant velocity	signed area gives displacement

(HT) On a curved d–t graph, draw a **tangent** at the time and take its gradient for instantaneous speed. On a v–t graph, **count squares** for the area. Add signed areas for displacement; add their magnitudes for total distance. Area is distance directly only while velocity remains positive.

Free fall near Earth: $a \approx 9.8$ m/s^2. Deceleration means slowing down; with the initial motion taken positive, acceleration is negative.

Worked example (v–t graph). The graph rises from 0 to 20 m/s in 8 s, then flat for 12 s.

- Acceleration: $a = \Delta v/t = 20/8 = 2.5$ m/s^2.
- (HT) Positive-velocity areas: $s = \frac{1}{2}\Delta t_1 v + v\Delta t_2 = \frac{1}{2} \times 8 \times 20 + 20 \times 12 = 320$ m.

2 Practice

2.1 A person walks 300 m in 240 s. Calculate the average speed and state whether it matches a typical walking value. [3]

2.2 A car travels 5 km east, then 5 km west in 40 minutes total. State the distance travelled and the displacement. [3]

2.3 A v–t graph is flat at 12 m/s for 25 s. State the acceleration and (HT) the distance travelled. [2]

3 Exam-style questions

3.1 A cyclist's distance–time graph rises in a straight line from 0 to 900 m in 6.0 minutes.

(a) Show the graph's gradient and calculate her speed. [3]

(b) She then stops for 4.0 minutes. Describe the graph for that section and state her speed. [2]

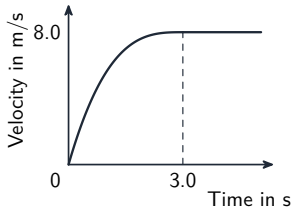
(c) Compare her motion with a typical cyclist's speed of 6 m/s. [1]

3.2 A ball is dropped and its v–t graph curves: steep at first, flattening to a constant 8.0 m/s after 3.0 s.

(a) Describe the forces on the ball in the first 3 seconds and after. [3]

(b) State what the constant final speed is called and the condition for it. [2]

(c) Estimate the distance fallen in the first 3 s if the supplied average velocity was 6.0 m/s. [2]



3.3 A train's velocity–time graph: $0 \rightarrow 30$ m/s over 600 s at uniform acceleration, then 30 m/s constant for 1200 s, then decelerating uniformly to rest in 300 s.

(a) Calculate the three accelerations (m/s^2). [3]

(b) (HT) Calculate the total distance travelled. [3]

(c) Calculate the average speed for the whole journey. [2]

Solutions

2.1 $v = s/t = 300/240 = \mathbf{1.25}$ m/s (C1, A1); close to the typical 1.5 m/s walking value – a normal walking pace.

2.2 Distance $= 5 + 5 = \mathbf{10}$ km; displacement $= \mathbf{0}$ – she is back at the start; time 40 min is extra context (no mark but must not enter the displacement).

2.3 Acceleration $= 0$ (constant velocity, B1); distance $= 12 \times 25 = \mathbf{300}$ m.

3.1 (a) Gradient = rise/run with time converted: 6.0 min = 360 s (C1).

$$v = \frac{\Delta s}{\Delta t} = \frac{900 \text{ m}}{360 \text{ s}} = \mathbf{2.5} \text{ m/s}$$

(gradient described C1, answer A1) (b) A horizontal (flat) line; speed zero – stationary. (c) $2.5 < 6$ m/s – she cycles slower than the typical cyclist.

3.2 (a) First 3 s: weight downwards exceeds drag, resultant force down, so it accelerates; as speed grows drag grows; after 3 s drag = weight – resultant zero, constant velocity. (b) Terminal velocity; reached when the drag (air resistance) equals the weight. (c) $s = \bar{v}t = 6.0 \times 3.0 = \mathbf{18}$ m (C1, A1).

3.3 (a) Stage 1: $a = 30/600 = \mathbf{0.050}$ m/s^2; stage 2: $\mathbf{0}$; stage 3: $a = -30/300 = \mathbf{-0.10}$ m/s^2 (deceleration 0.10 m/s^2). (b) (HT) Areas: $\frac{1}{2} \times 600 \times 30 = 9000$ m; $1200 \times 30 = 36\,000$ m; $\frac{1}{2} \times 300 \times 30 = 4500$ m; total $= \mathbf{49\,500}$ m (each stage C1 accumulated, total A1). (c) Total time $= 600 + 1200 + 300 = 2100$ s.

$$\bar{v} = \frac{s_{\text{total}}}{t_{\text{total}}} = \frac{49\,500}{2100} = \mathbf{24} \text{ m/s (2 s.f.)}$$

(C1, A1)