Exercise walk-through

5.6
Describing motion along a line (4.5.6.1.1–4.5.6.1.5, RP7)

AQA · GCSE · Physics

Describing motion along a line

- **Distance** is how far an object moves; it is a **scalar**.
- **Displacement** is the distance in a straight line from the start to the end, with a direction; it is a **vector**.
- **Speed** is a scalar. Typical speeds: walking 1.5 m/s, running 3 m/s, cycling 6 m/s, sound in air 330 m/s.

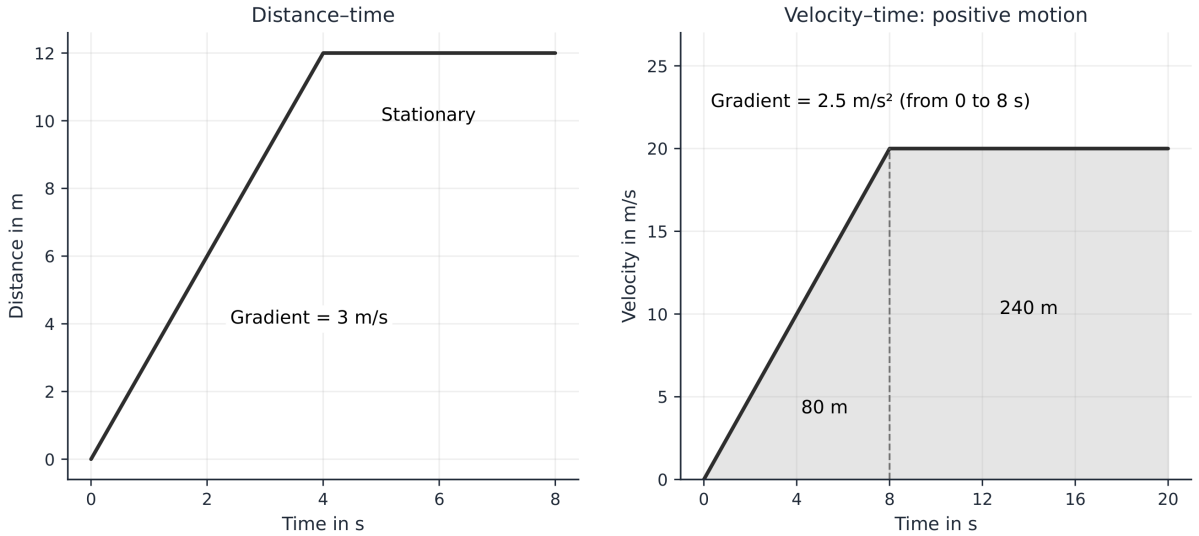
$$a = \frac{\Delta v}{t}$$

Describing motion along a line (2)

- **Velocity** is **speed** in a given direction; it is a **vector**. An object moving in a circle at constant speed has a changing velocity, because its direction changes.
- On a distance–time graph, the gradient is the speed. (HT) For an accelerating object, draw a tangent and find its gradient to get the speed at that **moment**.
- On a velocity–time graph, the gradient is the acceleration, and (HT) the area under the graph is the distance travelled.

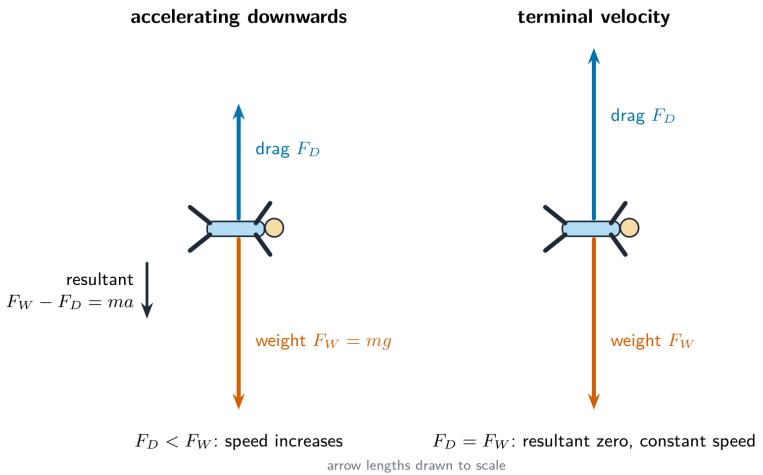
$$v^2 - u^2 = 2as$$

Figure: Describing motion along a line



- The gradient of a distance–time graph is **speed**; the gradient of a velocity–time graph is **acceleration** and the area under it is distance.
- Read the axes and units first.

Figure: Describing motion along a line (2)



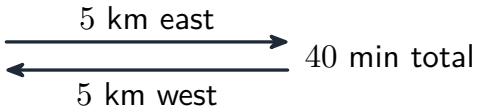
- Forces on a skydiver: **drag** is smaller than weight while accelerating, and equal to it at **terminal velocity**.
- Match each part of the diagram to the text.

Exercises 2.1·2.2

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

300 m in 240 s

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



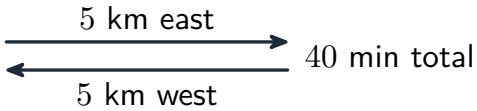
Exercises 2.1·2.2

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

300 m in 240 s

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.

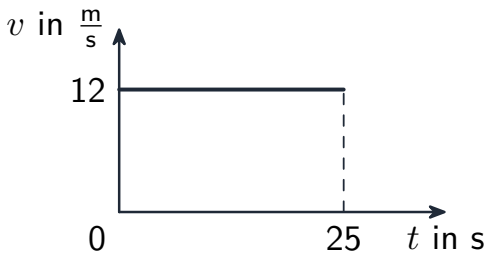
2.2 A car travels 5 km east, then 5 km west in 40 minutes total. State the distance travelled and the displacement. [3]



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).

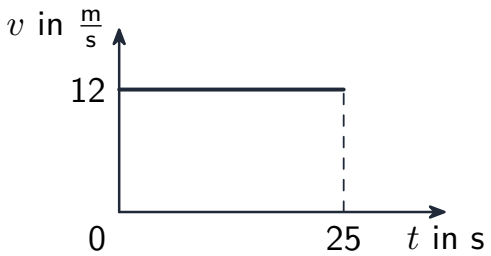
Exercise 2.3

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



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

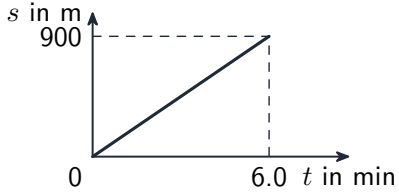
Exercise 3.1

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]



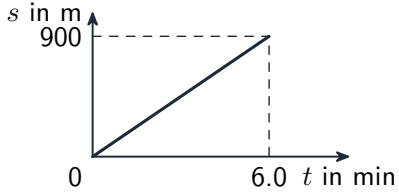
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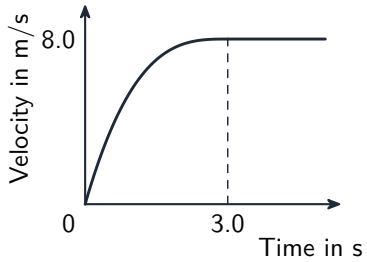
3.1 (a) Gradient = rise/run with time converted: 6.0 min = 360 s (C1).

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

(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.

Exercise 3.2

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.



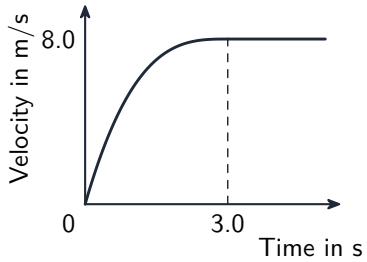
(a) Describe the forces on the ball in the first 3 seconds and after. [3]

(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]

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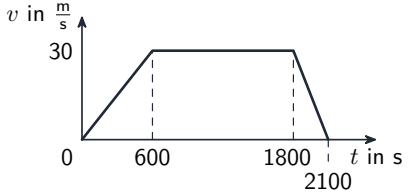
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3.2 (a) First 3 s: weight downwards exceeds drag, resultant force down, so it accelerates; as speed grows drag grows; after 3 s drag = weight – resultant zero, constant velocity. (b) Terminal velocity; reached when the drag (air resistance) equals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

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Exercise 3.3

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



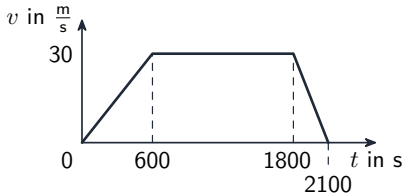
(a) Calculate the three accelerations ($\mathrm{m/s^2}$). [3]

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

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

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)