Exercise 1.2 Uniformly accelerated motion: the equations of kinematics

The following questions will help you perfect your ability to use the equations of kinematics (sometimes called *suvat* equations) to solve problems involving uniformly accelerated motion.

1 Figure 1.1 shows a velocity–time graph for part of a journey made by an electric train.

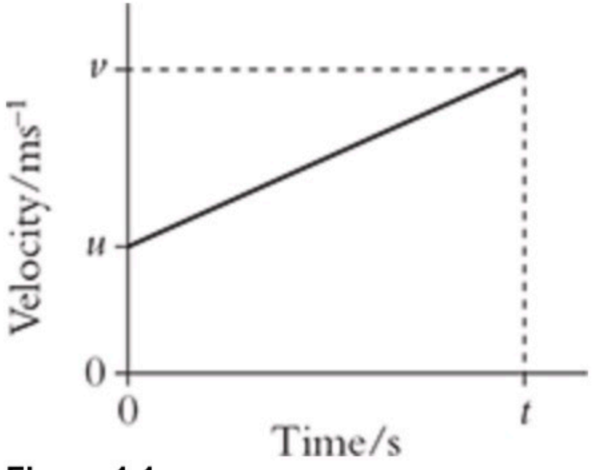

Figure 1.1

- **a** If the train had travelled at the same speed as its initial speed throughout the journey, state an algebraic expression for how far the train would have travelled.
- **b** Copy the graph and shade in the region of the graph that represents your answer to part **a**.

The remaining part of the graph shows the extra distance travelled by the train because it was accelerating.

- **c** Show that the acceleration, a, of the train can be given as $a = \frac{v-u}{t}$.
- **d** Show that the extra distance travelled by the train due to its acceleration can be expressed as $\frac{1}{2}at^2$.
- **e** Shade this region on your copy of the graph.
- **f** State the algebraic expression for the total distance travelled during the journey.

2 A passenger in a car starts a stopwatch when the car is travelling at 28.8 km hour^{-1}. The car accelerates with a constant acceleration of 2.0 ms^{-2} for the next 10 s.

Calculate the:

- **a** speed of the car after 10 s of acceleration (give your answer in ms^{-1})
- **b** distance that the car has travelled during the 10 s period (give your answer in m).

3 A girl drops her mobile phone from a window that is 15 m above the ground. Taking the acceleration of the Earth's gravitational field to be 10 ms^{-2} and ignoring any effects of air friction:

- **a** Sketch a velocity–time graph for the phone from when it leaves the girl's hand to when it hits the ground.
- **b** Calculate the time it takes for the phone to hit the ground.
- **c** Calculate the phone's velocity just before it hits the ground.

4 A baseball pitcher practises by throwing a ball vertically into the air with an initial velocity of 30 ms^{-1} and catching it when it falls back.

Ignoring any effects of air resistance, and using g = 10 ms^{-2}, calculate:

- **a** how much time it will take for the ball to reach its highest point
- **b** how far above the pitcher the ball reaches.

TIP

If you consider upwards as a positive direction, then acceleration due to gravity, which is downwards, must be negative.

5 When a parachutist jumps from an aeroplane, he hits the ground with a landing speed of 6.0 ms^{-1}.

What is the minimum jump height required to simulate this landing speed?

6 As of July 2020, the world 100 m and 200 m athletics records were both held by Usain Bolt. His times for these two events are 9.58 s for the 100 m and 19.19 s for the 200 m.

If we model Usain Bolt's running in both events by a uniform acceleration to his maximum speed followed by a constant speed to the finish, calculate Usain Bolt's maximum speed. (You may assume that he runs at the same maximum speed in both events and that there are no effects of air friction.)

TIP

Consider first sketching graphs of his two journeys and using what you know about speed-time graphs to produce a pair of simultaneous equations.