1 A cyclist starts from rest and takes 10 seconds to accelerate at a constant rate up to a speed of $15\,\text{m}\,\text{s}^{-1}$. After travelling at this speed for 20 seconds, the cyclist then decelerates to rest at a constant rate over the next 5 seconds.

(i) Sketch a velocity-time graph for the motion. [3]

(ii) Calculate the distance travelled by the cyclist. [3]

2 Fig. 1 is the velocity-time graph for the motion of a body. The velocity of the body is $v\,\text{m}\,\text{s}^{-1}$ at time t seconds.

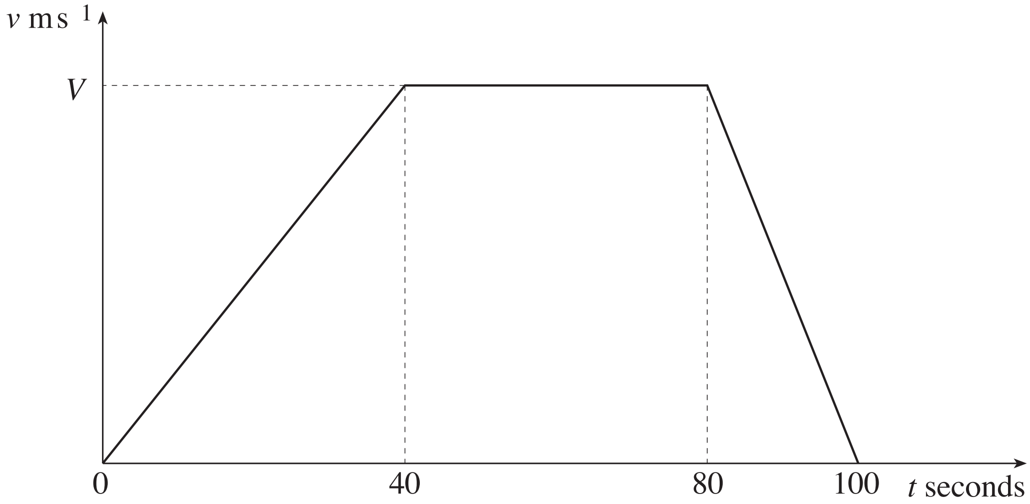

Fig. 1

The displacement of the body from $t = 0$ to $t = 100$ is 1400 m. Find the value of V. [4]

3 A particle travels in a straight line during the time interval $0 \leqslant t \leqslant 12$, where t is the time in seconds. Fig. 1 is the velocity-time graph for the motion.

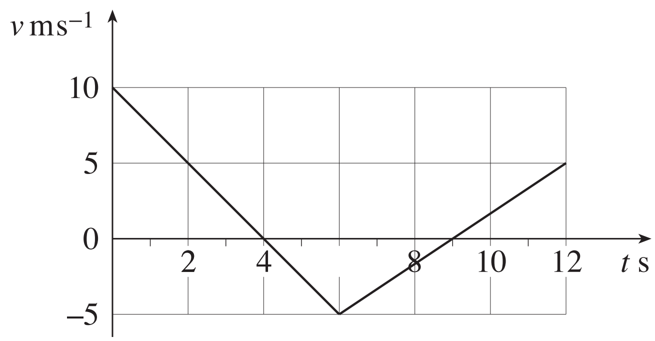

Fig. 1

(i) Calculate the acceleration of the particle in the interval $0 < t < 6$. [2]

(ii) Calculate the distance travelled by the particle from $t = 0$ to $t = 4$. [2]

(iii) When $t = 0$ the particle is at A. Calculate how close the particle gets to A during the interval $4 \leqslant t \leqslant 12$. [2]

4 **In this question take g as 10 m s^{-2}.**

A small ball is released from rest. It falls for 2 seconds and is then brought to rest over the next 5 seconds. This motion is modelled in the speed-time graph Fig. 6.

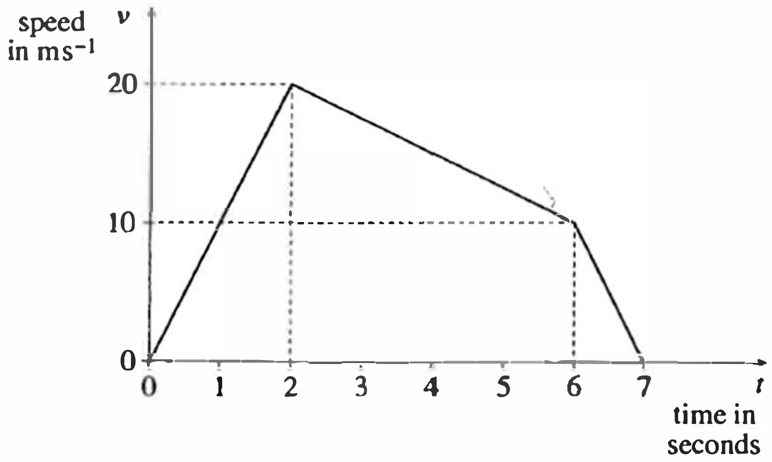

Fig. 6

For this model,

(i) calculate the distance fallen from $t = 0$ to $t = 7$, [3]

(ii) find the acceleration of the ball from $t = 2$ to $t = 6$, specifying the direction, [3]

(iii) obtain an expression in terms of t for the downward speed of the ball from $t = 2$ to $t = 6$, [3]

(iv) state the assumption that has been made about the resistance to motion from $t = 0$ to $t = 2$. [1]

The part of the motion from $t = 2$ to $t = 7$ is now modelled by $v = -\frac{3}{2}t^2 + \frac{19}{2}t + 7$.

(v) Verify that v agrees with the values given in Fig. 6 at $t = 2$, $t = 6$ and $t = 7$. [2]

(vi) Calculate the distance fallen from $t = 2$ to $t = 7$ according to this model. [7]

5 A box of emergency supplies is dropped to victims of a natural disaster from a stationary helicopter at a height of 1000 metres. The initial velocity of the box is zero.

At time t s after being dropped, the acceleration, $a\,\mathrm{m\,s^{-2}}$, of the box in the vertically downwards direction is modelled by

$$a = 10 - t \quad \text{for} \quad 0 \leqslant t \leqslant 10,$$

$$a = 0 \quad \text{for} \quad t > 10.$$

(i) Find an expression for the velocity, $v\,\mathrm{m\,s^{-1}}$, of the box in the vertically downwards direction in terms of t for $0 \leqslant t \leqslant 10$.

Show that for $t > 10$, $v = 50$. **[4]**

(ii) Draw a sketch graph of v against t for $0 \leqslant t \leqslant 20$. **[3]**

(iii) Show that the height, h m, of the box above the ground at time t s is given, for $0 \leqslant t \leqslant 10$, by

$$h = 1000 - 5t^2 + \frac{1}{6}t^3.$$

Find the height of the box when $t = 10$. **[4]**

(iv) Find the value of t when the box hits the ground. **[2]**

(v) Some of the supplies in the box are damaged when the box hits the ground. So measures are considered to reduce the speed with which the box hits the ground the next time one is dropped. Two different proposals are made. Carry out suitable calculations and then comment on each of them.

(A) The box should be dropped from a height of 500 m instead of 1000 m. **[2]**

(B) The box should be fitted with a parachute so that its acceleration is given by

$$a = 10 - 2t \quad \text{for} \quad 0 \leqslant t \leqslant 5,$$

$$a = 0 \quad \text{for} \quad t > 5.$$

[3]

6

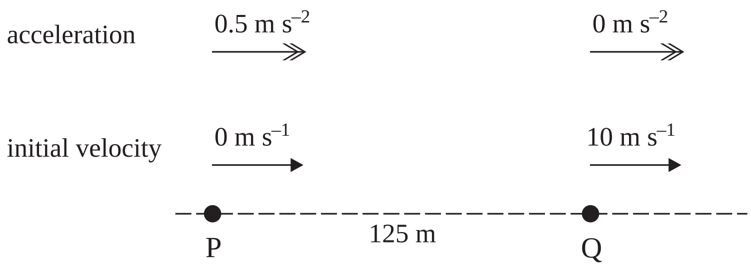

Fig. 4

Particles P and Q move in the same straight line. Particle P starts from rest and has a constant acceleration towards Q of $0.5\,\text{m}\,\text{s}^{-2}$. Particle Q starts 125 m from P at the same time and has a constant speed of $10\,\text{m}\,\text{s}^{-1}$ away from P. The initial values are shown in Fig. 4.

(i) Write down expressions for the distances travelled by P and by Q at time *t* seconds after the start of the motion. [2]

(ii) How much time does it take for P to catch up with Q and how far does P travel in this time? [5]