1. A car is initially at rest on a straight horizontal road.

The car then accelerates along the road with a constant acceleration of $3.2\,\text{m}\,\text{s}^{-2}$

Find

(a) the speed of the car after 5 s,

(1)

(b) the distance travelled by the car in the first 5 s.

(2)

2.

At time $t = 0$, a small stone is thrown vertically upwards with speed $14.7\,\text{m s}^{-1}$ from a point A.

At time $t = T$ seconds, the stone passes through A, moving downwards.

The stone is modelled as a particle moving freely under gravity throughout its motion.

Using the model,

(a) find the value of T,

(2)

(b) find the total distance travelled by the stone in the first 4 seconds of its motion.

(4)

(c) State one refinement that could be made to the model, apart from air resistance, that would make the model more realistic.

(1)

3.

The point A is 1.8 m vertically above horizontal ground.

At time $t = 0$, a small stone is projected vertically upwards with speed $U\,\text{m s}^{-1}$ from the point A.

At time $t = T$ seconds, the stone hits the ground.

The speed of the stone as it hits the ground is $10\,\text{m s}^{-1}$

In an initial model of the motion of the stone as it moves from A to where it hits the ground

- the stone is modelled as a particle moving freely under gravity
- **the acceleration due to gravity is modelled as having magnitude $10\,\text{m s}^{-2}$**

Using the model,

(a) find the value of U,

(3)

(b) find the value of T.

(2)

(c) Suggest one refinement, apart from including air resistance, that would make the model more realistic.

(1)

In reality the stone will not move freely under gravity and will be subject to air resistance.

(d) Explain how this would affect your answer to part (a).

(1)

4.

A small stone is projected vertically upwards with speed $39.2\,\text{m s}^{-1}$ from a point O.

The stone is modelled as a particle moving freely under gravity from when it is projected until it hits the ground 10 s later.

Using the model, find

(a) the height of O above the ground,

(3)

(b) the total length of time for which the speed of the stone is less than or equal to $24.5\,\text{m s}^{-1}$

(3)

(c) State one refinement that could be made to the model that would make your answer to part (a) more accurate.

(1)

5. A man throws a tennis ball into the air so that, at the instant when the ball leaves his hand, the ball is 2 m above the ground and is moving vertically upwards with speed $9\,\text{m s}^{-1}$

The motion of the ball is modelled as that of a particle moving freely under gravity and the acceleration due to gravity is modelled as being of constant magnitude $10\,\text{m s}^{-2}$

The ball hits the ground T seconds after leaving the man's hand.

Using the model, find the value of T.

(4)

6.

A ball is thrown vertically upwards with speed u m s^{-1} from a point P at height h metres above the ground. The ball hits the ground 0.75 s later. The speed of the ball immediately before it hits the ground is 6.45 m s^{-1}. The ball is modelled as a particle.

(a) Show that $u = 0.9$

(3)

(b) Find the height above P to which the ball rises before it starts to fall towards the ground again.

(2)

(c) Find the value of h.

(3)

7.

A small stone is projected vertically upwards from a point O with a speed of $19.6\,\text{m}\,\text{s}^{-1}$.

Modelling the stone as a particle moving freely under gravity,

(a) find the greatest height above O reached by the stone,

(2)

(b) find the length of time for which the stone is more than 14.7 m above O.

(5)

8.

At time $t = 0$ a ball is projected vertically upwards from a point O and rises to a maximum height of 40 m above O. The ball is modelled as a particle moving freely under gravity.

(a) Show that the speed of projection is 28 m s^{-1}.

(3)

(b) Find the times, in seconds, when the ball is 33.6 m above O.

(5)

9.

At time $t = 0$, two balls A and B are projected vertically upwards. The ball A is projected vertically upwards with speed 2 m s^{-1} from a point 50 m above the horizontal ground. The ball B is projected vertically upwards from the ground with speed 20 m s^{-1}. At time $t = T$ seconds, the two balls are at the same vertical height, h metres, above the ground. The balls are modelled as particles moving freely under gravity. Find

(a) the value of T,

(5)

(b) the value of h.

(2)

10.

A stone is projected vertically upwards from a point A with speed $u\,\mathrm{m\,s^{-1}}$. After projection the stone moves freely under gravity until it returns to A. The time between the instant that the stone is projected and the instant that it returns to A is $3\frac{4}{7}$ seconds.

Modelling the stone as a particle,

(a) show that $u = 17\frac{1}{2}$,

(3)

(b) find the greatest height above A reached by the stone,

(2)

(c) find the length of time for which the stone is at least $6\frac{3}{5}$ m above A.

(6)

11.

A cyclist is moving along a straight horizontal road and passes a point A. Five seconds later, at the instant when she is moving with speed 10 m s^{-1}, she passes the point B. She moves with constant acceleration from A to B.

Given that $AB = 40\,\text{m}$, find

(a) the acceleration of the cyclist as she moves from A to B,

(4)

(b) the time it takes her to travel from A to the midpoint of AB.

(5)

12.

A ball is projected vertically upwards with a speed of $14.7\ \text{m s}^{-1}$ from a point which is $49\ \text{m}$ above horizontal ground. Modelling the ball as a particle moving freely under gravity, find

(a) the greatest height, above the ground, reached by the ball,

(4)

(b) the speed with which the ball first strikes the ground,

(3)

(c) the total time from when the ball is projected to when it first strikes the ground.

(3)

13.

A lorry is moving along a straight horizontal road with constant acceleration. The lorry passes a point A with speed u m s^{-1}, ($u < 34$), and 10 seconds later passes a point B with speed 34 m s^{-1}. Given that $AB = 240$ m, find

(a) the value of u,

(3)

(b) the time taken for the lorry to move from A to the mid-point of AB.

(6)

14.

A particle P is projected vertically upwards from a point A with speed u m s^{-1}. The point A is 17.5 m above horizontal ground. The particle P moves freely under gravity until it reaches the ground with speed 28 m s^{-1}.

(a) Show that $u = 21$

(3)

At time t seconds after projection, P is 19 m above A.

(b) Find the possible values of t.

(5)

The ground is soft and, after P reaches the ground, P sinks vertically downwards into the ground before coming to rest. The mass of P is 4 kg and the ground is assumed to exert a constant resistive force of magnitude 5000 N on P.

(c) Find the vertical distance that P sinks into the ground before coming to rest.

(4)