



- 1 A car starts from rest and moves along a straight horizontal road with constant acceleration 2.5 m s^{-2} .

Find

- the speed of the car after 6 s,
- the distance travelled by the car in the first 6 s.

(3 marks)

List suvat

$$u = 0, a = 2.5, t = 6$$

$$a) v = u + at$$

$$v = 0 + 2.5 \times 6$$

$$= 15 \text{ m s}^{-1}$$

$$\boxed{15 \text{ m s}^{-1}}$$

$$b) s = ut + \frac{1}{2}at^2$$

$$s = 0 + \frac{1}{2} \times 2.5 \times 6^2$$

$$= 45 \text{ m}$$

$$\boxed{45 \text{ m}}$$

2

A cyclist moving along a straight road slows down with constant deceleration from 12 m s^{-1} to 4 m s^{-1} over a distance of 40 m.

Find

- the deceleration of the cyclist,
- the time taken to slow down.

(4 marks)

List suvat

$$u = 12, v = 4, s = 40$$

a) No t , so use $v^2 = u^2 + 2as$

$$4^2 = 12^2 + 2 \times a \times 40$$

$$16 = 144 + 80a$$

$$80a = -128$$

$$a = -1.6$$

negative, so it is slowing down

deceleration 1.6 m s^{-2}

b) $v = u + at$

$$4 = 12 - 1.6t$$

$$1.6t = 8$$

$$t = 5 \text{ s}$$

5 s

3

A van is travelling at 54 km h^{-1} along a straight road. It then accelerates uniformly at 1.2 m s^{-2} for 8 s.

- Find the speed of the van at the end of the 8 s, in km h^{-1} .
- Find the distance travelled in the 8 s.

(4 marks)

Change to m s^{-1} first

$$54 \text{ km h}^{-1} = \frac{54\,000}{3600} \\ = 15 \text{ m s}^{-1}$$

$$u = 15, a = 1.2, t = 8$$

$$a) v = u + at$$

$$v = 15 + 1.2 \times 8 \\ = 24.6 \text{ m s}^{-1}$$

Back to km h^{-1} : $\times 3600 \div 1000$

$$24.6 \times 3.6 = 88.56$$

$$\boxed{88.6 \text{ km h}^{-1}}$$

$$b) s = ut + \frac{1}{2}at^2$$

$$s = 15 \times 8 + \frac{1}{2} \times 1.2 \times 8^2 \\ = 120 + 38.4 \\ = 158.4 \text{ m}$$

$$\boxed{158 \text{ m}}$$

4

A particle moves in a straight line with constant acceleration. It passes the point A with speed 4 m s^{-1} and the point B with speed 10 m s^{-1} , where $AB = 35 \text{ m}$.

- Find the acceleration of the particle.
- Find the time taken to travel from A to B .
- Find the speed of the particle as it passes the midpoint of AB .

(6 marks)

List suvat for A to B

$$u = 4, v = 10, s = 35$$

$$a) v^2 = u^2 + 2as$$

$$10^2 = 4^2 + 2 \times a \times 35$$

$$100 = 16 + 70a$$

$$a = \frac{84}{70}$$

$$= 1.2 \text{ m s}^{-2}$$

$$1.2 \text{ m s}^{-2}$$

$$b) s = \frac{1}{2}(u + v)t$$

$$35 = \frac{1}{2}(4 + 10)t$$

$$35 = 7t$$

$$t = 5 \text{ s}$$

$$5 \text{ s}$$

$$c) \text{Midpoint: } s = 17.5$$

$$v^2 = 4^2 + 2 \times 1.2 \times 17.5$$

$$= 16 + 42$$

$$= 58$$

$$v = \sqrt{58}$$

$$= 7.615...$$

$$7.62 \text{ m s}^{-1}$$

5

A particle starts from rest and moves in a straight line with constant acceleration $a \text{ m s}^{-2}$. In the fifth second of its motion it travels 9 m.

- Find the value of a .
- Find the total distance travelled in the first 5 seconds.

(4 marks)

The 5th second is from $t = 4$ to $t = 5$

From rest: $s = \frac{1}{2}at^2$

$$s(5) = \frac{1}{2}a \times 25$$

$$= 12.5a$$

$$s(4) = \frac{1}{2}a \times 16$$

$$= 8a$$

a) Distance in the 5th second

$$12.5a - 8a = 9$$

$$4.5a = 9$$

$$a = 2$$

$$a = 2$$

b) Distance in first 5 s

$$s(5) = 12.5 \times 2$$

$$= 25 \text{ m}$$

$$25 \text{ m}$$

6

A particle moves in a straight line with constant acceleration a . Its initial speed is u and after time t its speed is v and its displacement is s .

Starting from $v = u + at$ and $s = \frac{1}{2}(u + v)t$, show that $v^2 = u^2 + 2as$.

(3 marks)

Make t the subject of $v = u + at$

$$t = \frac{v - u}{a}$$

Substitute into $s = \frac{1}{2}(u + v)t$

$$s = \frac{1}{2}(u + v) \times \frac{v - u}{a}$$

$$s = \frac{(u + v)(v - u)}{2a}$$

Difference of two squares

$$s = \frac{v^2 - u^2}{2a}$$

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

$$v^2 = u^2 + 2as$$

as required

7

A car moves along a straight road with constant acceleration. It passes three signposts P , Q and R in that order, where $PQ = QR = 48$ m. The car takes 4 s to travel from P to Q and 2 s to travel from Q to R .

- Find the acceleration of the car.
- Find the speed of the car as it passes R .

(7 marks)

Let speed at P be u . Use $s = ut + \frac{1}{2}at^2$

P to Q : $s = 48$, $t = 4$

$$48 = 4u + 8a$$

$$u = 12 - 2a$$

P to R : $s = 96$, $t = 6$

$$96 = 6u + 18a$$

Substitute $u = 12 - 2a$

$$96 = 6(12 - 2a) + 18a$$

$$96 = 72 + 6a$$

$$a = 4$$

$$\boxed{4 \text{ m s}^{-2}}$$

b) $u = 12 - 2 \times 4 = 4$. Use $v = u + at$ from P to R

$$v = 4 + 4 \times 6$$

$$= 28 \text{ m s}^{-1}$$

$$\boxed{28 \text{ m s}^{-1}}$$

8

A car starts from rest at a junction and accelerates uniformly at 1.5 m s^{-2} for 12 s. It then travels at constant speed for T seconds before decelerating uniformly at 2.25 m s^{-2} until it stops at a set of traffic lights. The total distance from the junction to the lights is 900 m.

- Find the greatest speed of the car.
- Find the value of T .
- Find the total time for the journey.

(7 marks)

a) Stage 1: $v = u + at$

$$v = 0 + 1.5 \times 12$$

$$= 18 \text{ m s}^{-1}$$

$$\boxed{18 \text{ m s}^{-1}}$$

b) Stage 1 distance

$$s_1 = \frac{1}{2} \times 1.5 \times 12^2$$

$$= 108 \text{ m}$$

Stage 3: $u = 18, v = 0, a = -2.25$

$$0 = 18^2 - 2 \times 2.25 \times s_3$$

$$s_3 = \frac{324}{4.5}$$

$$= 72 \text{ m}$$

Stage 2 at constant speed

$$s_2 = 900 - 108 - 72$$

$$= 720 \text{ m}$$

$$T = \frac{720}{18}$$

$$= 40$$

$$\boxed{T = 40}$$

c) Stage 3 time: $v = u + at$

$$0 = 18 - 2.25t$$

$$t = 8 \text{ s}$$

$$\text{total} = 12 + 40 + 8$$

$$= 60 \text{ s}$$

$$\boxed{60 \text{ s}}$$

9

A lorry passes a point O on a straight road, moving with constant speed 20 m s^{-1} . At the instant the lorry passes O , a car starts from rest at O and accelerates in the same direction with constant acceleration 2.5 m s^{-2} .

- Find the time taken for the car to catch up with the lorry.
- Find the distance from O at which this happens.
- Find the speed of the car at this instant.

(6 marks)

Distance from O after t seconds

$$\text{Lorry: } s = 20t$$

$$\begin{aligned} \text{car: } s &= \frac{1}{2} \times 2.5t^2 \\ &= 1.25t^2 \end{aligned}$$

a) Same distance

$$1.25t^2 = 20t$$

$$1.25t(t - 16) = 0$$

$t = 0$ is the start, so

$$t = 16 \text{ s}$$

$$\boxed{16 \text{ s}}$$

b) Substitute

$$s = 20 \times 16$$

$$= 320 \text{ m}$$

$$\boxed{320 \text{ m}}$$

c) Car: $v = u + at$

$$v = 0 + 2.5 \times 16$$

$$= 40 \text{ m s}^{-1}$$

$$\boxed{40 \text{ m s}^{-1}}$$

10

A particle P moves along a straight line. At time $t = 0$ it passes through a fixed point O with velocity 6 m s^{-1} in the positive direction. It has a constant acceleration of 2 m s^{-2} in the negative direction.

- Find the two times at which P is 5 m from O on the positive side.
- Find the greatest distance of P from O on the positive side.
- Find the total distance travelled by P in the first 7 s .

(7 marks)

$$u = 6, a = -2: s = ut + \frac{1}{2}at^2$$

$$s = 6t - t^2$$

$$a) s = 5$$

$$6t - t^2 = 5$$

$$t^2 - 6t + 5 = 0$$

$$(t - 1)(t - 5) = 0$$

$$t = 1 \text{ or } t = 5$$

1 s and 5 s

$$b) \text{ Furthest when } v = 0$$

$$0 = 6 - 2t$$

$$t = 3$$

$$s = 18 - 9$$

$$= 9 \text{ m}$$

9 m

$$c) \text{ It turns at } t = 3, \text{ so find where it is at } t = 7$$

$$s = 42 - 49$$

$$= -7$$

7 m on the negative side of O

$$\text{Out } 9 \text{ m, then back } 9 + 7 = 16 \text{ m}$$

$$\text{distance} = 9 + 16$$

$$= 25 \text{ m}$$

25 m

11

Two points A and B are 200 m apart on a straight road. A cyclist starts from rest at A and moves towards B with constant acceleration 1.2 m s^{-2} . At the same instant a car passes B moving towards A at a constant speed of 15 m s^{-1} .

- Find the time at which the cyclist and the car pass each other.
- Find the distance from A at which they pass.
- Find the speed of the cyclist at that instant.

(7 marks)

Distances travelled after t seconds

$$\begin{aligned}\text{cyclist: } s &= \frac{1}{2} \times 1.2t^2 \\ &= 0.6t^2\end{aligned}$$

$$\text{car: } s = 15t$$

a) They meet when the distances add to 200

$$0.6t^2 + 15t = 200$$

$$3t^2 + 75t - 1000 = 0$$

Quadratic formula

$$\begin{aligned}t &= \frac{-75 \pm \sqrt{75^2 + 12000}}{6} \\ &= \frac{-75 \pm \sqrt{17625}}{6}\end{aligned}$$

$$t = 9.6265\dots$$

(reject the negative root)

$$\boxed{9.63 \text{ s}}$$

b) Distance from A

$$\begin{aligned}s &= 0.6 \times 9.6265^2 \\ &= 55.60\end{aligned}$$

$$\boxed{55.6 \text{ m}}$$

c) $v = u + at$

$$\begin{aligned}v &= 1.2 \times 9.6265 \\ &= 11.55\end{aligned}$$

$$\boxed{11.6 \text{ m s}^{-1}}$$

12

A car passes a stationary police motorcycle at a constant speed of 25 m s^{-1} along a straight road. Two seconds later the motorcycle sets off after the car. It accelerates uniformly from rest at 4 m s^{-2} until it reaches its top speed of 35 m s^{-1} , and then keeps this speed.

- Find the time taken for the motorcycle to reach its top speed, and the distance it covers in this time.
- Show that the motorcycle has not caught the car by the time it reaches its top speed.
- Find the time, measured from the moment the car passes the motorcycle, at which the motorcycle catches the car.
- Find the distance travelled by the car by then.

(9 marks)

a) Motorcycle: $u = 0$, $v = 35$, $a = 4$

$$35 = 0 + 4t$$

$$t = 8.75 \text{ s}$$

$$s = \frac{1}{2} \times 4 \times 8.75^2$$

$$= 153.125 \text{ m}$$

$$\boxed{8.75 \text{ s}, 153 \text{ m}}$$

b) Measure time t from when the car passes

Motorcycle reaches 35 at $t = 2 + 8.75 = 10.75$

$$\text{car distance} = 25 \times 10.75$$

$$= 268.75 \text{ m}$$

$268.75 > 153.125$, so the car is still ahead

c) After $t = 10.75$ the motorcycle moves at 35

$$\text{motorcycle} = 153.125 + 35(t - 10.75)$$

$$= 35t - 223.125$$

$$\text{car} = 25t$$

Equal distances

$$35t - 223.125 = 25t$$

$$10t = 223.125$$

$$t = 22.3125$$

$$\boxed{22.3 \text{ s}}$$

d) Car distance

$$s = 25 \times 22.3125$$

$$= 557.8 \text{ m}$$

558 m