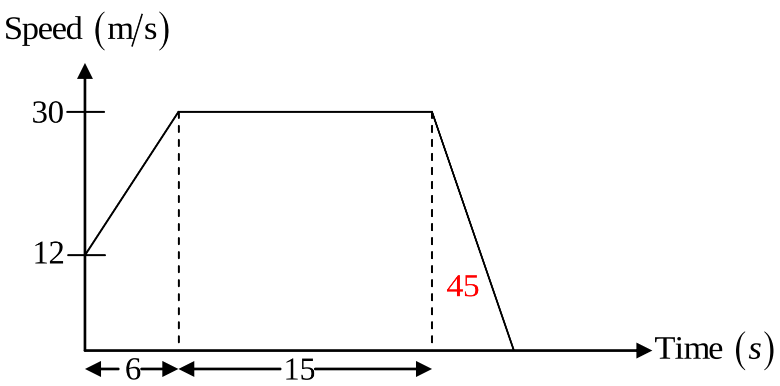
Applied Maths Induction Workshop 1 – Accelerated Linear Motion – Solutions

2010 – Ordinary Level – Question 1

A car travels along a straight level road.
It passes a point P at a speed of $12\,\text{m/s}$ and accelerates uniformly for 6 seconds to a speed of $30\,\text{m/s}$.
It then travels at a constant speed of $30\,\text{m/s}$ for 15 seconds.
Finally the car decelerates uniformly from $30\,\text{m/s}$ to rest at a point Q.
The car travels 45 metres while decelerating.

Find (i) the acceleration
(ii) the deceleration
(iii) $|PQ|$, the distance from P to Q
(iv) the average speed of the car as it travels from P to Q.

Solution



Acceleration

$$\left.\begin{aligned} u &= 12 \\ v &= 30 \\ t &= 6 \end{aligned}\right\} \; v = u + at \;\Rightarrow\; a = \frac{v-u}{t} \;\Rightarrow\; a = \frac{30-12}{6} \;\Rightarrow\; \boxed{a = 3\,\text{m/s}^2} \quad \text{...(i)}$$

Deceleration

$$\left.\begin{aligned} u &= 30 \\ v &= 0 \\ s &= 45 \end{aligned}\right\} \; v^2 = u^2 + 2as \;\Rightarrow\; a = \frac{v^2-u^2}{2s} \;\Rightarrow\; a = \frac{0-900}{90} \;\Rightarrow\; \boxed{a = -10\,\text{m/s}^2} \quad \text{...(ii)}$$

(iii) Distance from P to Q equals area under graph

$$= (6\times12) + \left(\frac{1}{2}\times6\times18\right) + (15\times30) + 45$$

$$= \boxed{621 \text{ metres}}$$

(iv) $$\text{Average Speed} = \frac{\text{Total Distance}}{\text{Total Time}}$$

Firstly, must find time elapsed during deceleration phase:

$$\left.\begin{array}{l} u = 30 \\ v = 0 \\ a = -10 \end{array}\right\} v = u + at \quad \Rightarrow \quad t = \frac{v-u}{a} \quad \Rightarrow \quad t = \frac{0-30}{-10} \quad \Rightarrow \quad t = 3$$

$\Rightarrow$ $\text{Total Time} = 6 + 15 + 3 = 24 \text{ seconds}$

$\Rightarrow$ $\text{Average Speed} = \dfrac{621}{24} \simeq \boxed{26 \text{ seconds}}$

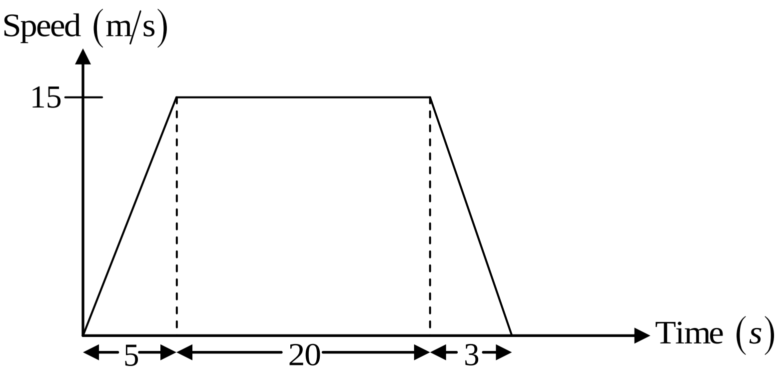
2007 – Ordinary Level – Question 1

A car travels from p to q along a straight level road.
It starts from rest at p and accelerates uniformly for 5 seconds to a speed of $15\,\text{m/s}$.
It then moves at a constant speed of $15\,\text{m/s}$ for 20 seconds.
Finally the car decelerates uniformly from $15\,\text{m/s}$ to rest at q in 3 seconds.

(i) Draw a speed-time graph of the motion of the car from p to q.
(ii) Find the uniform acceleration of the car.
(iii) Find the uniform deceleration of the car.
(iv) Find $|pq|$, the distance from p to q.
(v) Find the speed of the car when it is $13\cdot5$ metres from p.

Solution

(i)



(ii) Acceleration

$$\left.\begin{array}{l} u=0 \\ v=15 \\ t=5 \end{array}\right\} v=u+at \Rightarrow a=\frac{v-u}{t} \Rightarrow a=\frac{15-0}{5} \Rightarrow \boxed{a=3\,\text{m/s}^2}$$

(iii) Deceleration

$$\left.\begin{array}{l} u=15 \\ v=0 \\ t=3 \end{array}\right\} v=u+at \Rightarrow a=\frac{v-u}{t} \Rightarrow a=\frac{0-15}{3} \Rightarrow \boxed{a=-5\,\text{m/s}^2}$$

(iv) $|pq|=$ Area under graph

$$=\left[\frac{1}{2}\times5\times15\right]+\left[20\times15\right]+\left[\frac{1}{2}\times3\times15\right]$$
$$=37\cdot5+300+22\cdot5$$
$$=\boxed{360\text{ m}}$$

(v) Reaches $13\cdot5$ m from p during acceleration phase.

$$\left.\begin{array}{l} u=0 \\ a=3 \\ s=13\cdot5 \end{array}\right\} v^2=u^2+2as \Rightarrow v=\sqrt{u^2+2as} \Rightarrow v=\sqrt{0+(2)(3)(13\cdot5)} \Rightarrow \boxed{v=9\,\text{m/s}}$$

2007 – Higher Level – Question 1(b)

A train accelerates uniformly from rest to a speed $v\,\text{m/s}$.

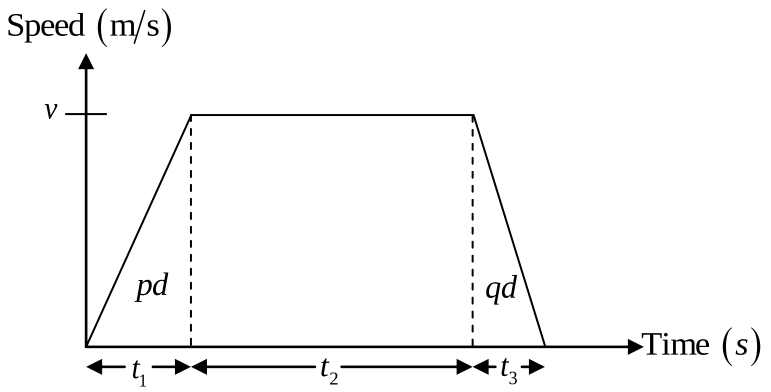
It then continues at this speed for a period of time and then decelerates uniformly to rest.

In travelling a total distance d metres the train accelerates through a distance pd metres and decelerates through a distance qd metres, where $p<1$ and $q<1$.

(i) Draw a speed-time graph for the motion of the train.

(ii) If the average speed of the train for the whole journey is $\dfrac{v}{p+q+b}$, find the value of b.

Solution



$$\text{Average Speed} = \frac{\text{Total Distance}}{\text{Total Time}}$$

We know that the total distance is d. We therefore need to find the time for each section of the journey.

Acceleration

$$\text{Area under graph} = pd \quad \Rightarrow \quad \frac{1}{2}(t_1)(v) = pd \quad \Rightarrow \quad \boxed{t_1 = \frac{2pd}{v}}$$

Constant Speed

$$\text{Area under graph} = d - pd - qd \quad \Rightarrow \quad t_2 v = d - pd - qd \quad \Rightarrow \quad \boxed{t_2 = \frac{d - pd - qd}{v}}$$

Deceleration

$$\text{Area under graph} = qd \quad \Rightarrow \quad \frac{1}{2}(t_3)(v) = qd \quad \Rightarrow \quad \boxed{t_3 = \frac{2qd}{v}}$$

$$\Rightarrow \quad \text{Total Time} = \frac{2pd}{v} + \frac{d - pd - qd}{v} + \frac{2qd}{v} = \frac{2pd + d - pd - qd + 2qd}{v} = \frac{d + pd + qd}{v}$$

$$\Rightarrow \qquad \text{Average Speed} = \frac{d}{\frac{d + pd + qd}{v}} = \frac{\not{d}\,v}{\not{d}\,(1 + p + q)} = \frac{v}{p + q + 1}$$

But $\qquad \text{Average Speed} = \dfrac{v}{p + q + b} \qquad \Rightarrow \qquad \boxed{b = 1}$

1999 – Higher Level – Question 1(b)

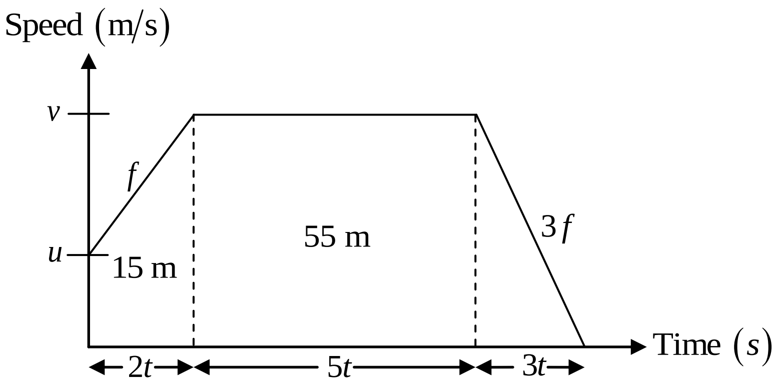
A particle travels in a straight line with constant acceleration f for $2t$ seconds and covers 15 metres. The particle then travels a further 55 metres at constant speed in $5t$ seconds. Finally the particle is brought to rest by a constant retardation $3f$.

(i) Draw a speed-time graph for the motion of the particle.

(ii) Find the initial velocity of the particle in terms of t .

(iii) Find the total distance travelled in metres, correct to two decimal places.

Solution



<u>Constant Speed</u>

$5tv = 55 \quad \Rightarrow \quad v = \dfrac{11}{t}$

<u>Acceleration</u>

$$\left.\begin{array}{l} u = u \\ a = f \\ t = 2t \\ s = 15 \\ v = \frac{11}{t} \end{array}\right\} \text{ There is enough information here for two equations in } u \text{ and } f$$

$$s = ut + \frac{1}{2}at^2 \quad \Rightarrow \quad 15 = 2ut + 2ft^2 \quad \Rightarrow \quad f = \frac{15 - 2ut}{2t^2}$$

$$v = u + at \quad \Rightarrow \quad \frac{11}{t} = u + 2ft$$

$$\Rightarrow \quad 11 = ut + 2ft^2 \quad \Rightarrow \quad f = \frac{11 - ut}{2t^2}$$

$$\Rightarrow \quad 11 - ut = 15 - 2ut$$

$$\Rightarrow \quad ut = 4 \quad \Rightarrow \quad \boxed{u = \frac{4}{t} \text{ m/s}} \quad \text{...(ii)}$$

(iii) Need to find distance travelled during deceleration:

$$\left.\begin{array}{l} u=\frac{11}{t} \\ v=0 \\ a=-3f \end{array}\right\} v^2=u^2+2as \quad \Rightarrow \quad s=\frac{v^2-u^2}{2a} \quad \Rightarrow \quad s=\frac{0-\frac{121}{t^2}}{-6f}$$

$$\Rightarrow \quad s=\frac{121}{6ft^2}$$

But $f=\dfrac{11-ut}{2t^2} \quad \Rightarrow \quad f=\dfrac{11-\left(\frac{4}{t}\right)t}{2t^2} \quad \Rightarrow \quad f=\dfrac{7}{2t^2}$

$$\Rightarrow \quad s=\frac{121}{6\left(\frac{7}{2\cancel{t^2}}\right)\cancel{t^2}}$$

$$\Rightarrow \quad s=\frac{121}{21}\simeq 5\cdot 76 \text{ m}$$

$\Rightarrow$ Total distance travelled $\simeq 15+55+5\cdot 76=\boxed{75\cdot 76 \text{ m}}$

2009 – Higher Level – Question 1(b)

A train accelerates uniformly from rest to a speed v m/s with uniform acceleration f m/s^2.

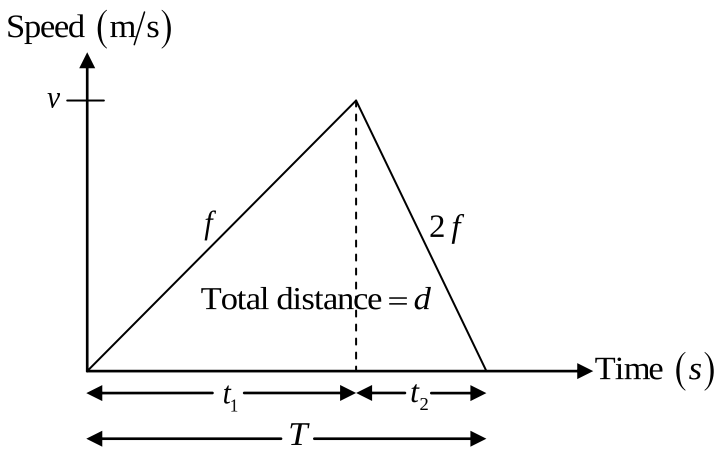
It then decelerates uniformly to rest with uniform retardation $2f$ m/s^2.

The total distance travelled is d metres.

(i) Draw a speed-time graph for the motion of the train.

(ii) If the average speed of the train for the whole journey is $\sqrt{\frac{d}{3}}$, find the value of f.

Solution



$$t_1 : t_2 = 2f : f = 2:1 \quad \Rightarrow \quad t_1 = \frac{2}{3}T \quad \text{and} \quad t_2 = \frac{1}{3}T$$

<u>Acceleration</u>

$$\left.\begin{array}{l} u = 0 \\ a = f \\ t = \frac{2}{3}T \end{array}\right\} \; v = u + at \quad \Rightarrow \quad v = \frac{2}{3}fT$$

$$d = \text{Area under graph} \Rightarrow \quad d = \frac{1}{2}T\left(\frac{2}{3}fT\right) \quad \Rightarrow \quad d = \frac{fT^2}{3}$$

$$\text{Average Speed} = \frac{\text{Total Distance}}{\text{Total Time}} = \frac{d}{T} = \frac{fT}{3}$$

But, $\quad \text{Average Speed} = \sqrt{\frac{d}{3}} \Rightarrow \quad \frac{fT}{3} = \sqrt{\frac{d}{3}} \quad \Rightarrow \quad \frac{f^2T^2}{9} = \frac{d}{3} \quad \Rightarrow \quad d = \frac{f^2T^2}{3}$

$$\Rightarrow \quad \frac{fT^2}{3} = \frac{f^2T^2}{3} \quad \Rightarrow \quad f = f^2 \quad \Rightarrow \quad f(f-1) = 0 \quad \Rightarrow \boxed{\cancel{f=0}} \quad \boxed{f=1}$$

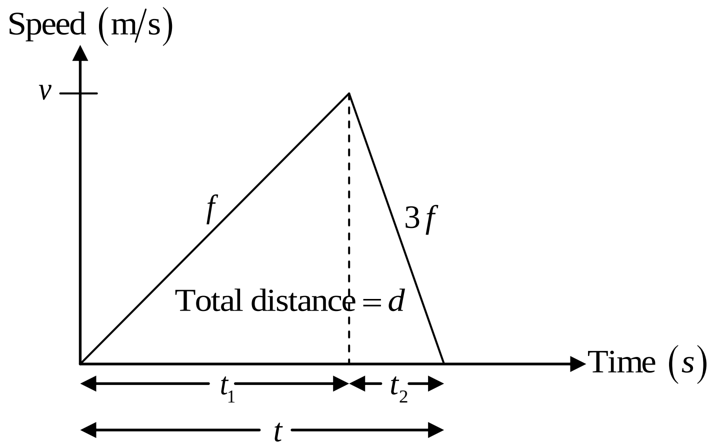
2006 – Higher Level – Question 1(a)

A lift starts from rest. For the first part of its descent it travels with uniform acceleration f. It then travels with uniform retardation $3f$ and comes to rest. The total distance travelled is d and the total time taken is t.

(i) Draw a speed-time graph for the motion.

(ii) Find d in terms of f and t.

Solution



$t_1 : t_2 = 3:1 \quad \Rightarrow \quad t_1 = \frac{3}{4}t \quad$ and $\quad t_2 = \frac{1}{4}t$

Acceleration

$$\left.\begin{array}{l} u = 0 \\ a = f \\ t = \frac{3}{4}t \end{array}\right\} v = u + at \quad \Rightarrow \quad v = \frac{3}{4}ft$$

$$d = \text{Area under graph} \Rightarrow \quad d = \frac{1}{2}t\left(\frac{3}{4}ft\right) \quad \Rightarrow \quad d = \frac{3ft^2}{8}$$

2008 – Higher Level – Question 1(a)

A ball is thrown vertically upwards with an initial velocity of $39\cdot2\,\text{m/s}$.

Find (i) the time taken to reach the maximum height

(ii) the distance travelled in 5 seconds.

Solution

$$\left.\begin{aligned} u &= 39\cdot2 \\ a &= -9\cdot8 \\ v &= 0 \end{aligned}\right\} \; v = u + at \;\Rightarrow\; t = \frac{v-u}{a} \;\Rightarrow\; t = \frac{0-39\cdot2}{-9\cdot8} \;\Rightarrow\; \boxed{t = 4\text{ s}} \quad ...(i)$$

(ii) First five seconds: 4 seconds upwards, 1 second downwards.

<u>Upwards</u>

$$\left.\begin{aligned} u &= 39\cdot2 \\ a &= -9\cdot8 \\ t &= 4 \end{aligned}\right\} \; s = ut + \frac{1}{2}at^2 \;\Rightarrow\; s = (39\cdot2)(4) + \frac{1}{2}(-9\cdot8)(16) \;\Rightarrow\; s = 78\cdot4\text{ m}$$

<u>Downwards</u>

$$\left.\begin{aligned} u &= 0 \\ a &= 9\cdot8 \\ t &= 1 \end{aligned}\right\} \; s = ut + \frac{1}{2}at^2 \;\Rightarrow\; s = (0)(1) + \frac{1}{2}(9\cdot8)(1) \;\Rightarrow\; s = 4\cdot9$$

$\Rightarrow$ Distance travelled in 5 seconds $= 78\cdot4 + 4\cdot9 = \boxed{83\cdot3\text{ m}}$

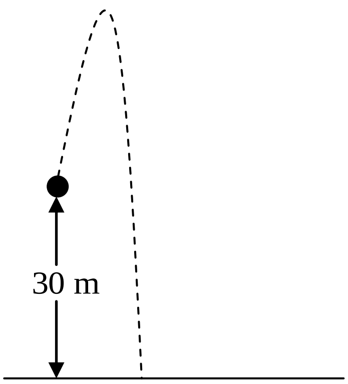
2002 – Higher Level – Question 1(a)

A stone is thrown vertically upwards under gravity with a speed of u m/s from a point 30 metres above the horizontal ground.
The stone hits the ground 5 seconds later.

(i) Find the value of u.

(ii) Find the speed with which the stone hits the ground.

Solution



(i)

$$\left.\begin{array}{l} a=-9\cdot 8 \\ s=-30 \\ t=5 \end{array}\right\} \quad s=ut+\frac{1}{2}at^2 \quad \Rightarrow \quad 2s=2ut+at^2 \quad \Rightarrow \quad u=\frac{2s-at^2}{2t}$$

$$\Rightarrow \quad u=\frac{-60+245}{10} \quad \Rightarrow \quad \boxed{u=18\cdot 5\text{ m/s}}$$

(ii)

$$\left.\begin{array}{l} u=18\cdot 5 \\ a=-9\cdot 8 \\ t=5 \end{array}\right\} \quad v=u+at \quad \Rightarrow \quad v=18\cdot 5+(-9\cdot 8)(5) \quad \Rightarrow \quad \boxed{v=-30\cdot 5\text{ m/s}}$$

$\Rightarrow$ $30\cdot 5$ m/s in a downward direction.

2008 – Higher Level – Question 1(b)

Two particles P and Q, each having constant acceleration, are moving in the same direction along parallel lines. When P passes Q the speeds are $23\,\text{m/s}$ and $5\cdot5\,\text{m/s}$, respectively. Two minutes later Q passes P, and Q is then moving at $65\cdot5\,\text{m/s}$.

Find (i) the acceleration of P and the acceleration of Q

(ii) the speed of P when Q overtakes it

(iii) the distance P is ahead of Q when they are moving with equal speeds.

Solution

(i) Motion of P:

$$\left.\begin{aligned} u &= 23 \\ a &= a_1 \\ t &= 120 \end{aligned}\right\}$$

Motion of Q:

$$\left.\begin{aligned} u &= 5\cdot5 \\ v &= 65\cdot5 \\ a &= a_2 \\ t &= 120 \end{aligned}\right\} v = u + at \quad \Rightarrow \quad a = \frac{v-u}{t}$$

$$\Rightarrow \quad a_2 = \frac{65\cdot5 - 5\cdot5}{120} \Rightarrow \boxed{a_2 = \frac{1}{2}\,\text{m/s}^2}$$

Overtaking occurs when $s_1 = s_2$

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

$$\Rightarrow \quad s = (23)(120) + \frac{1}{2}a_1(120^2) \qquad \Rightarrow \quad s = (5\cdot5)(120) + \frac{1}{2}\left(\frac{1}{2}\right)(120^2)$$

$$\Rightarrow \quad s = 2760 + 7200a_1 \qquad \Rightarrow \quad s = 4260$$

$$\Rightarrow \quad 2760 + 7200a_1 = 4260 \qquad \text{...when overtaking occurs}$$

$$\Rightarrow \quad \boxed{a_1 = \frac{5}{24}\,\text{m/s}^2}$$

(ii) Motion of P:

$$\left.\begin{aligned} u &= 23 \\ a &= \tfrac{5}{24} \\ t &= 120 \end{aligned}\right\} v = u + at \quad \Rightarrow \quad v = 23 + \frac{5}{24}(120) \quad \Rightarrow \quad \boxed{v = 48\,\text{m/s}}$$

(iii) Need to find the time at which $v_1 = v_2$ and then find the difference between s_1 and s_2 at this time.

Motion of P

$$\left.\begin{aligned} u &= 23 \\ a &= \tfrac{5}{24} \\ t &= t \end{aligned}\right\} \quad v = u + at$$

$$v_1 = 23 + \frac{5}{24}t$$

Motion of Q

$$\left.\begin{aligned} u &= 5\cdot 5 \\ a &= \tfrac{1}{2} \\ t &= t \end{aligned}\right\} \quad v = u + at$$

$$v_2 = 5\cdot 5 + \frac{1}{2}t$$

$$v_1 = v_2$$

$$\Rightarrow \quad 23 + \frac{5}{24}t = 5\cdot 5 + \frac{1}{2}t \qquad \text{...multiply by 24}$$

$$\Rightarrow \quad 552 + 5t = 132 + 12t$$

$$\Rightarrow \quad 7t = 420$$

$$\Rightarrow \quad t = 60$$

$$s_1 = (23)(60) + \frac{1}{2}\left(\frac{5}{24}\right)\left(60^2\right)$$

$$s_1 = 1755$$

$$s_2 = (5\cdot 5)(60) + \frac{1}{2}\left(\frac{1}{2}\right)\left(60^2\right)$$

$$s_2 = 1230$$

$$1755 - 1230 = 525$$

$\Rightarrow$ P is 525 metres ahead of Q when they are travelling with equal speeds.

2005 – Higher Level – Question 1(a)

Car A and car B travel in the same direction along a horizontal straight road.

Each car is travelling at a uniform speed of $20\,\text{m/s}$.

Car A is at a distance of d metres in front of car B.

At a certain instant car A starts to brake with a constant retardation of $6\,\text{m/s}^2$.

$0\cdot5\,\text{s}$ later car B starts to brake with a constant retardation of $3\,\text{m/s}^2$.

Find (i) the distance travelled by car A before it comes to rest.

(ii) the minimum value of d for car B not to collide with car A.

Solution

(i) Car A

$$\left.\begin{array}{l} u=20 \\ a=-6 \\ v=0 \end{array}\right\} v^2=u^2+2as \quad \Rightarrow \quad s=\frac{v^2-u^2}{2a} \quad \Rightarrow \quad s=\frac{0-400}{-12} \quad \Rightarrow \quad \boxed{s=\frac{100}{3}\text{ m}}$$

(i) Car B

First $0\cdot5$ seconds

$$\left.\begin{array}{l} u=20 \\ t=0\cdot5 \\ a=0 \end{array}\right\} s=ut+\frac{1}{2}at^2$$

$$\Rightarrow \quad s=(20)(0\cdot5)$$

$$\Rightarrow \quad s=10$$

Afterwards

$$\left.\begin{array}{l} u=20 \\ a=-3 \\ v=0 \end{array}\right\} s=\frac{v^2-u^2}{2a}$$

$$\Rightarrow \quad s=\frac{0-400}{-6}$$

$$\Rightarrow \quad s=\frac{200}{3}$$

$\Rightarrow$ Overall, it takes car B $\left(10+\frac{200}{3}\right)=\frac{230}{3}$ metres to stop.

$\Rightarrow$ d must be at least $\frac{230}{3}-\frac{100}{2}=\boxed{\frac{130}{3}\text{ metres}}$

2008 – Ordinary Level – Question 1

Four points a, b, c and d lie on a straight level road.
A car, travelling with uniform retardation, passes point a with a speed of $30\,\text{m/s}$ and passes point b with a speed of $20\,\text{m/s}$.
The distance from a to b is 100 m. The car comes to rest at d.

Find (i) the uniform retardation of the car

(ii) the time taken to travel from a to b

(iii) the distance from b to d

(iv) the speed of the car at c, where c is the midpoint of $[bd]$.

Solution

a to b:

$$\left.\begin{array}{l} u=30 \\ v=20 \\ s=100 \end{array}\right\} v^2=u^2+2as \Rightarrow a=\frac{v^2-u^2}{2s} \Rightarrow a=\frac{400-900}{200}$$

$$\Rightarrow \boxed{a=-2\cdot5\,\text{m/s}^2} \text{ ...(i)}$$

a to b:

$$\left.\begin{array}{l} u=30 \\ v=20 \\ a=-2\cdot5 \end{array}\right\} v=u+at \Rightarrow t=\frac{v-u}{a} \Rightarrow t=\frac{20-30}{-2\cdot5}$$

$$\Rightarrow \boxed{t=4\text{ seconds}} \text{ ...(ii)}$$

a to d:

$$\left.\begin{array}{l} u=30 \\ v=0 \\ a=-2\cdot5 \end{array}\right\} v^2=u^2+2as \Rightarrow s=\frac{v^2-u^2}{2a} \Rightarrow s=\frac{0-900}{-5}$$

$$\Rightarrow \boxed{s=180\text{ m}} \text{ ...(iii)}$$

a to c:

$$\left.\begin{array}{l} u=30 \\ a=-2\cdot5 \\ s=140 \end{array}\right\} v^2=u^2+2as \Rightarrow v=\sqrt{u^2+2as} \Rightarrow v=\sqrt{900-700}$$

$$\Rightarrow \boxed{v=\sqrt{200}=10\sqrt{2}\,\text{m/s}}$$

...(iv)

2004 – Ordinary Level – Question 1

Three points a, b and c, lie on a straight level road such that $|ab| = |bc| = 100$ m.
A car, travelling with uniform retardation, passes point a with a speed of $20\,\text{m/s}$ and passes point b with a speed of $15\,\text{m/s}$.

(i) Find the uniform retardation of the car.

(ii) Find the time it takes the car to travel from a to b, giving your answer as a fraction.

(iii) Find the speed of the car as it passes c, giving your answer in the form $p\sqrt{q}$, where $p, q \in \mathbb{N}$.

(iv) How much further, after passing c, will the car travel before coming to rest? Give your answer to the nearest metre.

Solution

a to b: $\left.\begin{array}{l} u = 20 \\ v = 15 \\ s = 100 \end{array}\right\} v^2 = u^2 + 2as \Rightarrow a = \dfrac{v^2 - u^2}{2s} \Rightarrow a = \dfrac{225 - 400}{200}$

$\Rightarrow \boxed{a = -\frac{7}{8}\,\text{m/s}^2}$ ...(i)

a to b: $\left.\begin{array}{l} u = 20 \\ v = 15 \\ a = -\frac{7}{8} \end{array}\right\} v = u + at \Rightarrow t = \dfrac{v - u}{a} \Rightarrow t = \dfrac{15 - 20}{-\frac{7}{8}} = -5\left(-\dfrac{8}{7}\right)$

$\Rightarrow \boxed{t = \frac{40}{7}\text{ seconds}}$ ...(ii)

a to c: $\left.\begin{array}{l} u = 20 \\ a = -\frac{7}{8} \\ s = 200 \end{array}\right\} v^2 = u^2 + 2as \Rightarrow v = \sqrt{u^2 + 2as} \Rightarrow v = \sqrt{400 + 2\left(-\frac{7}{8}\right)(200)}$

$\Rightarrow v = \sqrt{50} \Rightarrow \boxed{v = 5\sqrt{2}\,\text{m/s}}$ ...(iii)

c to rest: : $\left.\begin{array}{l} u = 5\sqrt{2} \\ a = -\frac{7}{8} \\ v = 0 \end{array}\right\} v^2 = u^2 + 2as \Rightarrow s = \dfrac{v^2 - u^2}{2a} \Rightarrow s = \dfrac{0 - 50}{-\frac{7}{4}}$

$\Rightarrow \boxed{s \simeq 29\text{ m}}$ ...(iv)

2003 – Higher Level – Question 1(a)

The points p, q and r all lie in a straight line.
A train passes point p with speed u m/s. The train is travelling with uniform retardation f m/s^2. The train takes 10 seconds to travel from p to q and 15 seconds to travel from q to r, where $|pq| = |qr| = 125$ metres.

(i) Show that $f = \frac{1}{3}$.

(ii) The train comes to rest s metres after passing r.
Find s, giving your answer correct to the nearest metre.

Solution

p to q: $\left.\begin{array}{l} u = u \\ a = -f \\ t = 10 \\ s = 125 \end{array}\right\}$ $s = ut + \frac{1}{2}at^2 \Rightarrow 125 = 10u - 50f$

$\Rightarrow \boxed{2u - 10f = 25}$ ...Equation 1

p to r: $\left.\begin{array}{l} u = u \\ a = -f \\ t = 25 \\ s = 250 \end{array}\right\}$ $s = ut + \frac{1}{2}at^2 \Rightarrow 250 = 25u - \frac{625}{2}f$

$\Rightarrow 500 = 50u - 625f$

$\Rightarrow \boxed{-2u + 25f = -20}$ ...Equation 2

Equation 1 + Equation 2: $15f = 5 \Rightarrow \boxed{f = \frac{1}{3}\text{ m/s}^2}$

$\Rightarrow \boxed{u = \frac{85}{6}\text{ m/s}}$

Assume train continues on and comes to rest at some point m:

p to m: $\left.\begin{array}{l} u = \frac{85}{6} \\ a = -\frac{1}{3} \\ v = 0 \end{array}\right\}$ $v^2 = u^2 + 2as \Rightarrow s = \frac{v^2 - u^2}{2a} \Rightarrow s = \frac{0 - \frac{7225}{36}}{-\frac{2}{3}} \simeq 301$

r to rest $= 301 - 250 = \boxed{51\text{ metres}}$