1. (a) A particle is projected vertically upwards from the point p. At the same instant a second particle is let fall vertically from q. The particles meet at r after 2 seconds. The particles have equal speeds when they meet at r.

2009

Prove that $|pr| = 3|rq|$.

qr $\quad v = u + ft$

qr $\quad v = 0 + 2g$

pr $\quad v = u - 2g$

$\Rightarrow \quad 2v = u$

qr $\quad v^2 = u^2 + 2fs$

qr $\quad v^2 = 0 + 2g|qr|$ $\quad qr = \frac{v^2}{2g}$

pr $\quad v^2 = u^2 - 2g|pr|$

$v^2 = 4v^2 - 2g|pr|$ $\quad pr = \frac{3v^2}{2g}$

$3v^2 = 2g|pr|$

$3(2g|qr|) = 2g|pr|$ $\quad pr = 3(qr)$

$3|qr| = |pr|$

5 5 5 5 20

or

qr $\quad v = u + ft$

qr $\quad v = 0 + 2g$

pr $\quad v = u - 2g$

$\Rightarrow \quad u = 4g$

qr $\quad v^2 = u^2 + 2fs$

qr $\quad 4g^2 = 0 + 2g|qr|$

$\Rightarrow |qr| = 2g$

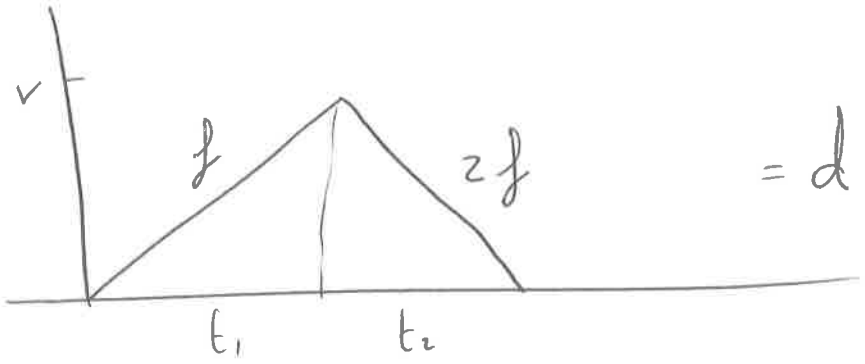
pr $\quad 4g^2 = 16g^2 - 2g|pr|$

$\Rightarrow |pr| = 6g$

$3|qr| = |pr|$

5 5 5 5 20

2009 b



Av. speed $= \dfrac{d}{t_1+t_2} = \sqrt{\dfrac{d}{3}}$ (→find f)

$t_1 : t_2 = 2f : f$

$t_1 = \frac{2}{3}T$ $\quad$ $t_2 = \frac{1}{3}T$

$\dfrac{d}{T} = \sqrt{\dfrac{d}{3}}$

$\dfrac{d}{\sqrt{d/3}} = T$

1st bit: $v = u + at$

$v = 0 + f \cdot \frac{2}{3}T$

$v = f\frac{2}{3}T$

Area: $\frac{1}{2}(T) f \frac{2}{3}T = d$

$f\frac{T^2}{3} = d$

$\frac{f}{3}\left(\frac{d^2}{d/3}\right) = d$

$\frac{f}{3}(3d) = d$ $\qquad$ $f = 1$

1. **(a)** A car is travelling at a uniform speed of 14 m s^{-1} when the driver notices a traffic light turning red 98 m ahead.

2010

Find the minimum constant deceleration required to stop the car at the traffic light,

(i) if the driver immediately applies the brake

(ii) if the driver hesitates for 1 second before applying the brake.

(i)
$$v^2 = u^2 + 2fs$$
$$0 = 14^2 + 2f(98)$$
$$196f = -196$$
$$\Rightarrow \quad f = -1 \text{ m s}^{-2}$$

5

(ii)
$$s = ut + \tfrac{1}{2}ft^2$$
$$s = 14(1) + 0$$
$$s = 14$$

5

$$v^2 = u^2 + 2fs$$
$$0 = 14^2 + 2f(98 - 14)$$
$$0 = 14^2 + 168f$$

5

$$f = \frac{-196}{168}$$
$$= -\frac{7}{6} \text{ or } -1.17 \text{ m s}^{-2}$$

5

20

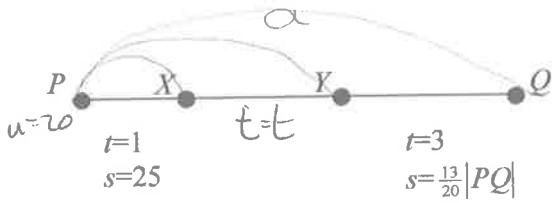
1. (b) A particle passes P with speed 20 m s^{-1} and moves in a straight line to Q with uniform acceleration.

In the first second of its motion after passing P it travels 25 m.

2010

In the last 3 seconds of its motion before reaching Q it travels $\frac{13}{20}$ of $|PQ|$.

Find the distance from P to Q.



PX $\quad s = ut + \frac{1}{2}ft^2$

$25 = 20(1) + \frac{1}{2}f(1)^2$

$5 = \frac{1}{2}f$

$\Rightarrow f = 10$ — 5

PY $\quad s = ut + \frac{1}{2}ft^2$

$\frac{7}{20}|PQ| = 20(t+1) + 5(t+1)^2$ — 5

$= 5t^2 + 30t + 25$

PQ $\quad s = ut + \frac{1}{2}ft^2$

$|PQ| = 20(t+4) + 5(t+4)^2$ — 5

$= 5t^2 + 60t + 160$

$\frac{7}{20}|PQ| = 5t^2 + 30t + 25$

$\frac{7}{20}(5t^2 + 60t + 160) = 5t^2 + 30t + 25$ — 5

$65t^2 + 180t - 620 = 0$ — 5

$\Rightarrow t = 2$

$|PQ| = 20(6) + 5(6)^2$

$= 300$ m — 5

30