2003 – Linear Motion 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.

(b) A man runs at constant speed to catch a bus.
At the instant the man is 40 metres from the bus, it begins to accelerate uniformly from rest away from him.
The man just catches the bus 20 seconds later.

(i) Find the constant speed of the man.

(ii) If the constant speed of the man had instead been 3 m/s, show that the closest he gets to the bus is 17.5 metres.

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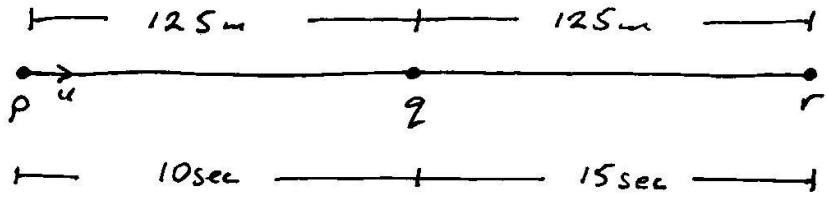
Q1/ (a) (i)



p → q

$u = u$
$v = -$
$a = -f$
$s = 125\,m$
$t = 10\,sec$

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

$125 = u(10) + \frac{1}{2}(-f)(10)^2$

$125 = 10u - 50f \quad (\div 5)$

$$\boxed{25 = 2u - 10f}$$

p → r

$u = u$
$v = -$
$a = -f$
$s = 250\,m$
$t = 25\,sec$

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

$250 = u(25) + \frac{1}{2}(-f)(25)^2$

$250 = 25u - \frac{625}{2}f$

$500 = 50u - 625f \quad (\div 25)$

$$\boxed{20 = 2u - 25f}$$

Do simultaneous eqns:

$2u - 10f = 25$
$2u - 25f = 20 \quad (\times -1)$

$2u - 10f = 25$
$-2u + 25f = -20$

$15f = 5$
$f = \frac{1}{3}$

Find u:

$2u - 10f = 25$
$2u - 10\left(\frac{1}{3}\right) = 25$
$6u - 10 = 75$
$6u = 85$
$u = \frac{85}{6}$

0

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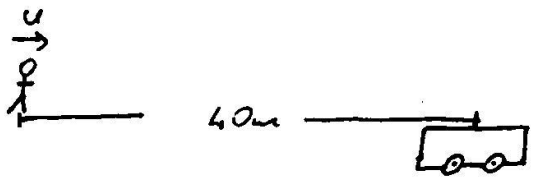
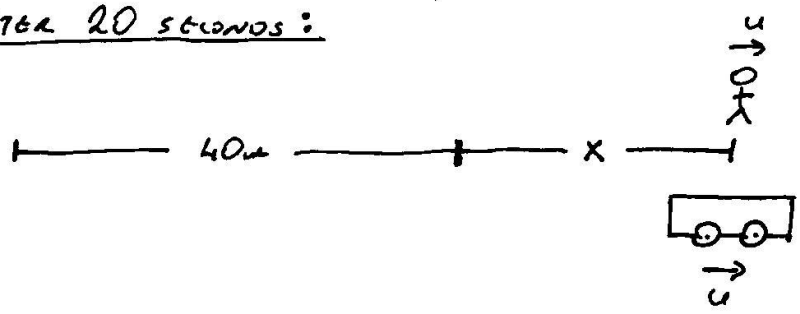
Q4

(b) START:



AFTER 20 SECONDS:



* MAN HAS TRAVELLED DIST $(40+X)$ IN 20 SEC.
* BUS HAS TRAVELLED DIST X IN 20 SEC.
* IF THE MAN JUST CATCHES THE BUS, THEIR SPEEDS ARE EQUAL.

(i) **MAN**

$u = u$
$v = u$
$a = 0$
$s = 40 + X$
$t = 20$

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

$40 + X = u(20)$

$\boxed{40 = 20u - X}$

BUS

$u = 0$
$v = u$
$a = a$
$s = X$
$t = 20$

$v = u + at$

$u = 0 + a(20)$

$\boxed{u = 20a.}$

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

$X = (0)(20) + \frac{1}{2}(a)(20)^2$

$\boxed{X = 200a}$

SUB IN GIVES →

SO, $X = 10u$

So,

$$40 = 20u - x$$

BUT $x = 10u$

$$40 = 20u - 10u$$

$$40 = 10u \Rightarrow \underline{\underline{4\,m/s = u}}$$

FIND a:

$$u = 20a \Rightarrow 4 = 20a \Rightarrow \underline{\underline{0.2\,m/s^2 = a}}$$

(ii) MAN WILL BE CLOSEST TO THE BUS WHEN THEIR SPEEDS ARE EQUAL, AFTER THAT THE BUS WILL BE PULLING AWAY.

SPEED OF MAN IS 3 m/s, SO SPEED OF BUS IS 3 m/s

FIND TIME FOR BUS TO REACH THIS SPEED:

BUS

$u = 0$, $v = 3$, $a = 0.2$, $s = ?$, $t = ?$

$v = u + at$

$3 = 0 + (0.2)(t)$

$3 = 0.2t$

$\underline{\underline{15\,sec = t}}$

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

$s = (0)(15) + \frac{1}{2}(0.2)(15)^2$

$s = 0.1(225)$

$\underline{\underline{s = 22.5\,m}}$

MAN FIND DIST TRAVELLED BY MAN IN 15 SEC.

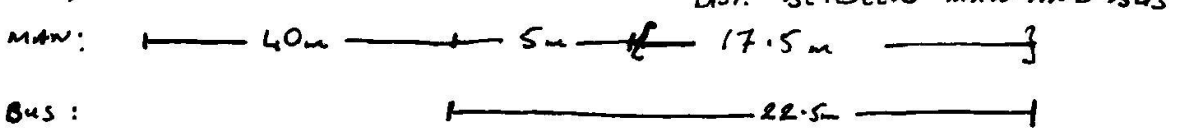
$u = 3$, $v = 3$, $a = 0$, $s = ?$, $t = 15$

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

$s = 3(15) + \frac{1}{2}(0)t^2$

$\underline{\underline{s = 45\,m}}$

SO,



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Q1/(b)

(ii) FIND DISTANCE FROM P TO REST

$u = \frac{85}{6}$

$v = 0$

$a = -\frac{1}{3}$

$s = ?$

$t = -$

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

$(0)^2 = \left(\frac{85}{6}\right)^2 + 2\left(-\frac{1}{3}\right)s$

$0 = \frac{7225}{36} - \frac{2}{3}s \qquad (\times 36)$

$0 = 7225 - 24s$

$24s = 7225$

$s = 301\text{m}$

P → Rest = 301

P → r = 250

51 m = Distance S.