M1 Jan 2009.

1.

$u = 6\,m/s \rightarrow$ ; $u = 0$.

(P) $0.5\,kg$ ; (Q) $m\,kg$

$v_1 = \rightarrow 0.8\,m/s$ ; $v_2 = \rightarrow 4\,m/s$

(i) $m_1u_1 + m_2u_2 = m_1v_1 + m_2v_2$

$0.5 \times 6 + 0 = 0.5 \times 0.8 + m \times 4$

$3 = 0.4 + 4m$

$4m = 2.6$

$m = \frac{2.6}{4} = 0.65\ kg$

(ii) $v_1 \xleftarrow{0.8}$ ; $v_2 \rightarrow 4$

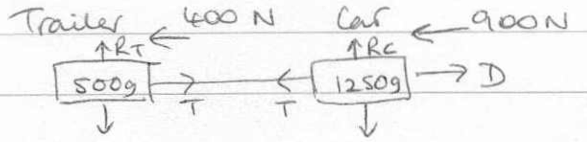
$0.5 \times 6 + 0 = 0.5 \times (-0.8) + 4m$

$\therefore\ 3 = -0.4 + 4m$

$4m = 3.4$

$m = \frac{3.4}{4} = 0.85\ kg$

2 (i)




(i) constant speed so acceleration $= 0$. Using $F = ma$

on trailer $T - 400 = 0$ so $T = 400$ N

on car $D - 900 - T = 0$ so $D = 1300$ N

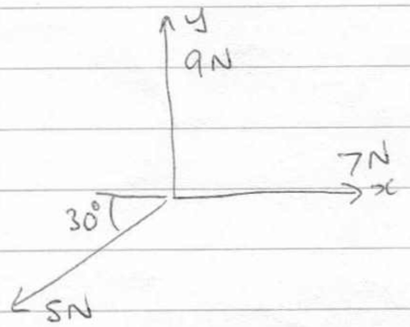
(ii) If $a = 0.6\,m/s^2$ then using $F = ma$

on trailer $T - 400 = 500a$ $\therefore T = 700\,N$

on car $D - 900 - T = 1250a$ $D = 2350\,N$.

and over whole system $D - 900 - 400 = (1250 + 500)a$ ✓

3.



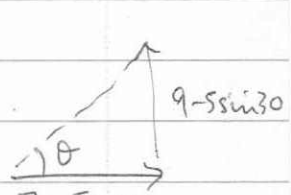

(i) along x axis component in x direction is $-5\cos 30° = -4.33\,N$. (3sf)

along y axis component is $-5\sin 30° = -2.5\,N$

(ii) Resultant of all forces $R^2 = X^2 + Y^2$

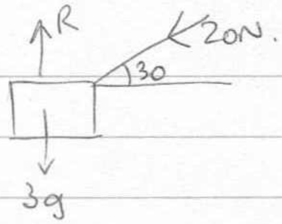
$R^2 = (7 - 5\cos 30)^2 + (9 - 5\sin 30)^2 = 49.378\ldots$

$R = 7.03\ N$ (3sf)




$\tan\theta = \frac{9 - 5\sin 30}{7 - 5\cos 30} \Rightarrow \theta = 67.67°$

4.




(i) Resolve 20N force

$R = 3g + 20\sin 30$ (vertical).

$20\cos 30 = 3a$ (horizontal) ($F = ma$)

$\therefore a = \dfrac{20\cos 30}{3} = \overset{5.77}{\cancel{8.66}}$ (3sf)

(ii) If in limiting equilibrium $R = 3g + 20\sin 30 = 39.4N$

Using $F = \mu R$ $\mu = \dfrac{F}{R} = \dfrac{20\cos 30}{39.4} = 0.4396 = 0.440$ (3sf)

5. $0 \le t \le 6$ $a = 0.8t$ m/s$^2$

(i) $V = \dfrac{0.8t^2}{2} + c$ when $t=0$ $v = 13$ m/s (at point A)

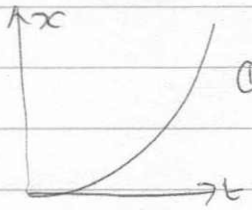
$\therefore 13 = \cancel{\dfrac{0.8t^2}{2}} + c$

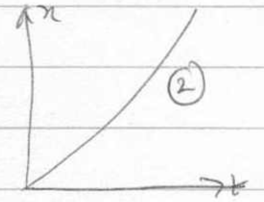
$\therefore V = 0.4t^2 + 13$ when $t = 6$ $V = 27.4$ m/s

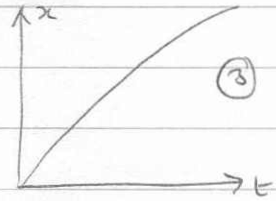
(ii) $x = \dfrac{0.4t^3}{3} + 13t + k$ when $t=0$ $x = 0$ so $k=0$

$\therefore x = \dfrac{0.4}{3}6^3 + 13\times 6 = 106.8$ m

(iii)




a) the acceleration $= 0.8t$

Velocity $= 0.4t^2 + 13$

displacement $= \dfrac{4}{30}t^3 + 13t$

So best represented by Fig 2

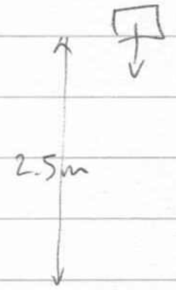
Fig 1 shows hardly any increase in x although should be cubic

Fig 3 is negative cubic

b) Velocity in 1 not modelled by $t^2$

acceleration in 3 is not positive.

6(i)




$u = 0$.

$v =$

$a = 9.8 \downarrow$

$s = 2.5$

$t = ?$

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

$2.5 = 0 + \frac{1}{2} \times 9.8 \times t^2$

$\therefore t^2 = \frac{5}{9.8}$ so $t = 0.714$ sec (3sf)

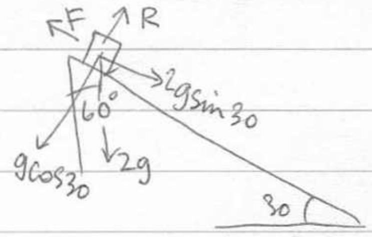
(b) $v^2 = u^2 + 2as$

$v^2 = 0 + 2(9.8)2.5$

$v^2 = 49$

$v = 7$ m/s.

(ii)




$\mu = 0.2$ want $v$.

$R = 2g\cos 30$ $F = \mu R$ $F = 0.2 \times 2g\cos 30$

$2g\sin 30 - F = 2a$

$2g\sin 30 - 0.4g\cos 30 = 2a$

$\therefore a = 3.2026$ m/s$^2$

distance down ramp $= x$ where $\sin 30 = \frac{2.5}{x}$ so $x = \frac{2.5}{\sin 30} = 5$m

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

$v^2 = 0^2 + 2 \times (3.2026) \times 5$

$v = 5.659$

$v \simeq 5.66$ m/s (3sf)

7.

$\xrightarrow{4\text{m/s}}$ $\xleftarrow{1\text{m/s}}$

O P 0.7g $v_1 \rightarrow$ O Q 0.3g $\leftarrow v_2$

$a = -0.4$ m/s for each particle

(i) meet after 2secs so assume $t_1$ for P and $t_2$ for Q where $t_1 + t_2 = 2$.

$v_1 = u_1 + at_1$ so $v_1 = 4 - 0.4t_1$ Actually $\Rightarrow t_1 = t_2 = 2$

$v_2 = u_2 + at_2$ so $v_2 = 1 - 0.4t_2$ (not like distances)

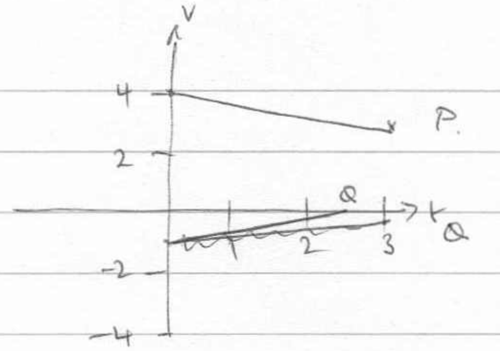
so $v_1 = 4 - 0.8 = 3.2$ m/s and $v_2 = 1 - 0.8 = 0.2$ m/s

so before collision $0.7 \times 3.2 + 0.3(-0.2)$

after collision $(0.7 + 0.3)V$

$\therefore 2.24 - 0.06 = V = 2.18$ m/s.

(ii) (a)




$v_P = 4 - 3\times 0.4 = 4 - 1.2 = 2.8$ m/s

$v_Q = 1 - 3\times 0.4 = 1 - 1.2 = -0.2$ m/s

But does not suddenly change direction so stops between 2s & 3s

(b) Since Q come to stop need to know when ?

$v = u + at \qquad 0 = 1 - 0.4t \qquad t = \frac{1}{0.4} = 2.5$ secs.

but P is moving for 3 seconds Q for 2.5 secs.

$s = ut + \frac{1}{2}at^2$ = will give distance.

$S_p = 4\times 3 + \frac{1}{2}(-0.4)\times 9$

$S_p = 12 - 1.8$

$S_p = 10.2$ m.

$S_Q = 1\times 2.5 + \frac{1}{2}(-0.4)\times 2.5^2$

$S_Q = 2.5 - 1.25$

$S_Q = 1.25$ m

total distance between P & Q at start $= 10.2 + 1.25 = 11.45$ m.