1) i) $a = \frac{v-u}{t} = \frac{-5-10}{6}$

$a = -2.5 \text{ ms}^{-2}$

1) ii) Distance travelled is represented by area under graph between $t=0$ and $t=4$

$= \frac{1}{2} \times 4 \times 10 = 20\text{m}$

1) iii) After $t=4$, particle is closest to A when $t=9$, since beyond that time v is positive again

Distance travelled from $t=4$ to $t=9$ is represented by area above graph

$= \frac{1}{2} \times -5 \times 5 = -12.5\text{ m}$

'$-$' sign indicates motion back towards A.

Closest distance to A

is $20 - 12.5 = 7.5\text{m}$

2)

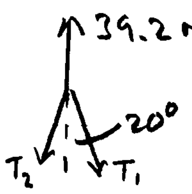
i) The pulley is smooth (and string is light)

2) ii) Tension supports the 4 kg mass

so $T = 4g$

$T = 39.2 \text{ N}$

2) iii)



Due to symmetry $T_1 = T_2$

$2 T_1 \cos 20 = 39.2$ resolving vertically

$T_1 = \frac{19.6}{\cos 20°} = 20.858 \text{ N}$

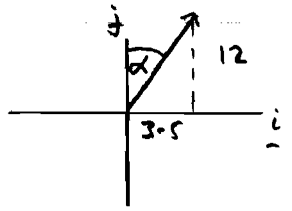
Tension in BC and BD $= 20.9\text{N}$ to 3 s.f.

3)

i) $\underline{F} = 3.5\underline{i} + 12\underline{j}$

$|\underline{F}| = \sqrt{3.5^2 + 12^2}$

$|\underline{F}| = 12.5 \text{ N}$



Bearing $= \alpha = \tan^{-1}\left(\frac{3.5}{12}\right)$

$\alpha = 16.26°$

Bearing $= 016.3°$

3) ii) $\underline{G} = 7\underline{i} + 24\underline{j}$

$= 2(3.5\underline{i} + 12\underline{j}) = 2\underline{F}$

$\therefore$ $\underline{G}$ and $\underline{F}$ are in same direction and the magnitude of $\underline{G}$ is twice the magnitude of $\underline{F}$

3) iii) $\underline{F}_1 = \begin{pmatrix} 9 \\ -18 \end{pmatrix}$ $\underline{F}_2 = \begin{pmatrix} 12 \\ 9 \end{pmatrix}$

We require $\underline{F}_1 + \underline{F}_2 = k\underline{F}$

3 iii) (cont)

$$\begin{pmatrix} 9 \\ -18 \end{pmatrix} + \begin{pmatrix} 12 \\ q \end{pmatrix} = k\begin{pmatrix} 3.5 \\ 12 \end{pmatrix}$$

$$\begin{pmatrix} 21 \\ q-18 \end{pmatrix} = k\begin{pmatrix} 3.5 \\ 12 \end{pmatrix}$$

Since $21 = 3.5k$ then $k = 6$

$$\Rightarrow \quad q - 18 = 72$$

$$\therefore \quad q = 90$$

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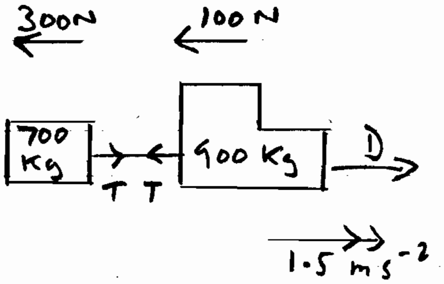
4) i)



For whole system $F = ma$

$$D - 300 - 100 = 1600 \times 1.5$$

$$D = 2400 + 300 + 100$$

$$D = 2800 \text{ N}$$

Drive force $= 2800$ N

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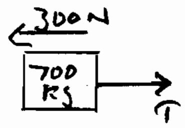
4) ii) For trailer



$$F = ma$$

$$T - 300 = 700 \times 1.5$$

$$T = 1050 + 300$$

$$T = 1350 \text{ N}$$

Force in coupling $= 1350$ N

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5) i) $\underline{a} = 9\underline{i} - 4t\underline{j}$ ms^{-2}

When $t = 0$, $\underline{a} = 9\underline{i}$ ms^{-2}

When $t = 3$ $\underline{a} = 9\underline{i} - 12\underline{j}$ ms^{-2}

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5 ii)

$$\underline{F} = m\underline{a}$$

$$\underline{F} = 4(9\underline{i} - 12\underline{j})$$

$$\underline{F} = 36\underline{i} - 48\underline{j} \text{ N}$$

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5 iii) $\underline{v} = 4\underline{i} + 2\underline{j}$ ms^{-1} when $t = 1$

$$\underline{v} = \int \underline{a}\, dt$$

$$\underline{v} = \int \begin{pmatrix} 9 \\ -4t \end{pmatrix} dt$$

$$\underline{v} = \begin{pmatrix} 9t + C \\ -2t^2 + D \end{pmatrix}$$

At $t = 1$

$$\begin{pmatrix} 4 \\ 2 \end{pmatrix} = \begin{pmatrix} 9 \times 1 + C \\ -2(1)^2 + D \end{pmatrix} = \begin{pmatrix} 9 + C \\ -2 + D \end{pmatrix}$$

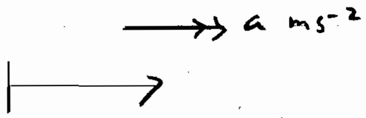
$$\therefore C = -5, \quad D = +4$$

$$\therefore \underline{v} = \begin{pmatrix} 9t - 5 \\ 4 - 2t^2 \end{pmatrix}$$

or

$$\underline{v} = (9t - 5)\underline{i} + (4 - 2t^2)\underline{j}$$

6)i)



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

$14 = 2u + \frac{1}{2}a(2)^2$

$14 = 2u + 2a$

$7 = u + a$ ①

Also

$v = u + at$

$19 = u + 5a$ ②

From ① $u = 7 - a$

Subst for u in ②

$19 = 7 - a + 5a$

$12 = 4a$

$\Rightarrow a = 3$ and $u = 4$

$a = 3\ ms^{-2}$, $u = 4\ ms^{-1}$

6)ii) When $t = 5$

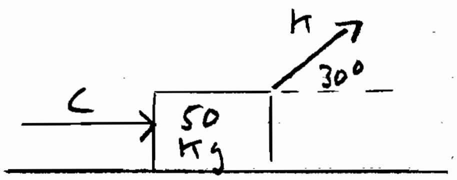
$s = ut + \frac{1}{2}at^2$

$s = 4 \times 5 + \frac{1}{2} \times 3 \times 5^2$

$s = 20 + \frac{75}{2}$

$s = 57.5\ m$

7)



7i) In equilibrium so resistance opposes Clive's push

Resistance = 60 N

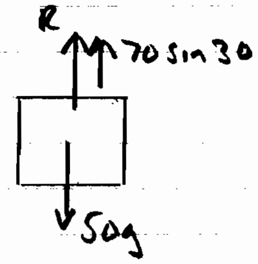
7ii)

$F = 60 + 70\cos 30$

$F = 120.62\ N$

$F = 121\ N$ to 3s.f.

7iii)

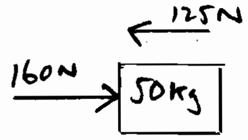


$R + 70\sin 30 = 50g$

$R = 50 \times 9.8 - 70\sin 30$

$R = 455\ N$

7iv)



Using $F = ma$, $160 - 125 = 50a$

$35 = 50a$

$a = \frac{35}{50} = 0.7\ ms^{-2}$

7v) Using $F = ma$

$-125 = 50a$

$a = \frac{-125}{50} = -2.5\ ms^{-2}$

7v) cont)

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

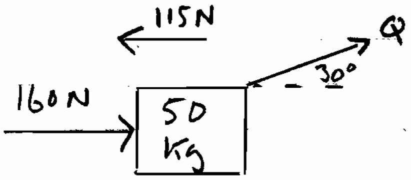
When box stops, $v = 0$

$$0 = 1.5^2 - 2 \times 2.5s$$

$$5s = 2.25$$

$$s = \frac{2\cdot 25}{5} = 0.45\,m$$

7vi)



Horizontally, $F = ma$

$$160 + Q\cos 30 - 115 = 50 \times 3$$

$$Q\cos 30 + 45 = 150$$

$$Q = \frac{150 - 45}{\cos 30^\circ}$$

$$Q = 121.24$$

$Q = 121\,N$ to 3 s.f.

8) i)

$$x = u\cos\theta \times t$$

$$x = 14\cos 60 \times t = 7t$$

$$x = 7t$$

Vertically $y = u\sin 60 \times t - \frac{1}{2}gt^2 + 1$

$$y = 14 \times \frac{\sqrt{3}}{2} \times t - 4.9t^2 + 1$$

$$y = 7\sqrt{3}\,t - 4.9t^2 + 1$$

8ii) A)

Using $v = u + at$

$$v_y = u_y - 9.8t$$

$$v_y = 14\sin 60 - 9.8t$$

At highest point $v_y = 0$

$$\Rightarrow \quad 0 = 14\sin 60 - 9.8t$$

$$t = \frac{14\sin 60}{9.8} = 1.2372\,s$$

$t = 1.24\,s$ to 3 s.f.

8ii) B)

$$x = 7t$$

$$x = 7 \times 1.2372$$

$$x = 8.66\,m$$

8ii) c)

Height after $1.2372\,s$

$$y = 7\sqrt{3} \times 1.2372 - 4.9 \times 1.2372^2 + 1$$

$$y = 8.50\,m$$

Clearance over wall $= 8.50 - 6$

$= 2.50\,m$

8 iii)

$$x = 7t \Rightarrow t = \frac{x}{7}$$

$$y = 7\sqrt{3}\,t - 4.9t^2 + 1$$

Subst for t gives

$$y = 7\sqrt{3}\,\frac{x}{7} - 4.9\,\frac{x^2}{49} + 1$$

8iii cont) $y = \sqrt{3}x - \frac{x^2}{10} + 1$

8iv) If stone just clears wall

$y = 6$ m

Solve $6 = \sqrt{3}x - \frac{x^2}{10} + 1$

$60 = 10\sqrt{3}x - x^2 + 10$

$x^2 - 10\sqrt{3}x + 50 = 0$

Solution by calculator

$x = 13.66$ m
$x = 3.66$ m

Since she has moved further away than original 8.66m

Distance from wall $= 13.66$m

$\therefore$ extra distance moved away $= 13.66 - 8.66$

$= 5.00$ m