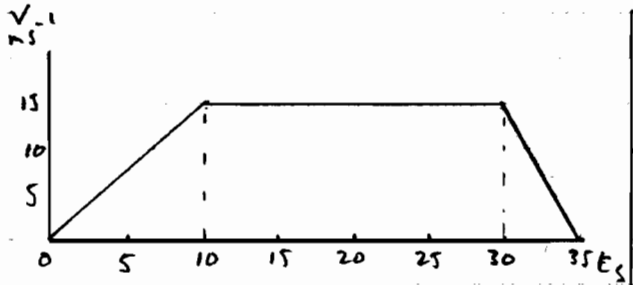
1) i)



ii)

Distance = area under graph

$= \frac{1}{2}(35+20) \times 15$

$= 412.5$ m

2) i)

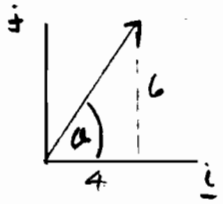
$\underline{F} = \begin{pmatrix} 6 \\ 9 \end{pmatrix}$ N

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

$\begin{pmatrix} 6 \\ 9 \end{pmatrix} = 1.5 \begin{pmatrix} a_1 \\ a_2 \end{pmatrix}$

$\underline{a} = \begin{pmatrix} 4 \\ 6 \end{pmatrix}$

ii)



$\theta = \tan^{-1}\left(\frac{6}{4}\right) = 56.3°$

iii)

$\underline{s} = \underline{u}t + \frac{1}{2}\underline{a}t^2$

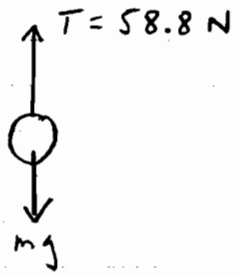
$\underline{s} = \begin{pmatrix} -2 \\ 3 \end{pmatrix} t + \frac{1}{2}t^2 \begin{pmatrix} 4 \\ 6 \end{pmatrix}$

When $t = 2$

$\underline{s} = 2\begin{pmatrix} -2 \\ 3 \end{pmatrix} + 2\begin{pmatrix} 4 \\ 6 \end{pmatrix}$

$\underline{s} = \begin{pmatrix} 4 \\ 18 \end{pmatrix}$

3) i)



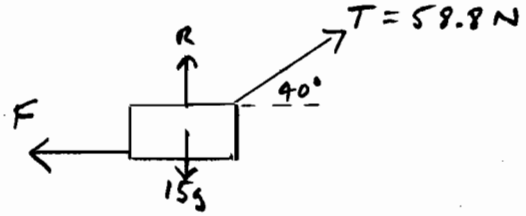
In equilibrium so

$T = mg$

$\Rightarrow m = \frac{58.8}{9.8} = 6$ kg

$m = 6$ kg

ii)



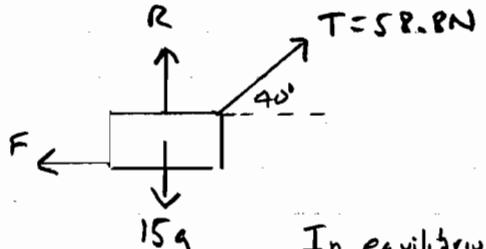
In equilibrium so

$F = T\cos 40°$

$F = 58.8 \cos 40°$

$F = 45.0$ N to 3 s.f.

iii)



In equilibrium so

$R + T\sin 40° = 15g$

$R = 15 \times 9.8 - 58.8 \sin 40° = 109$ N to 3 s.f.

4) $\underline{F} = \begin{pmatrix} 4 \\ 1 \\ 2 \end{pmatrix}$ $\underline{G} = \begin{pmatrix} -6 \\ 2 \\ 4 \end{pmatrix}$

i) $\underline{F} + \underline{G} = \begin{pmatrix} -2 \\ 3 \\ 6 \end{pmatrix}$ N

$|\underline{F}+\underline{G}| = \sqrt{(-2)^2 + 3^2 + 6^2}$

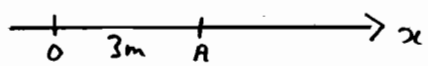
$= 7$ N.

ii) $\underline{F} + 2\underline{G} + \underline{H} = \underline{0}$

$\begin{pmatrix} 4 \\ 1 \\ 2 \end{pmatrix} + 2\begin{pmatrix} -6 \\ 2 \\ 4 \end{pmatrix} + \begin{pmatrix} h_1 \\ h_2 \\ h_3 \end{pmatrix} = \begin{pmatrix} 0 \\ 0 \\ 0 \end{pmatrix}$

$\underline{H} = \begin{pmatrix} 8 \\ -5 \\ -10 \end{pmatrix}$

5)



$v = 2 + 12t - 3t^2$

$a = \frac{dv}{dt} = 12 - 6t$

$a = 0 \Rightarrow 12 - 6t = 0$

$\Rightarrow t = 2$ s

Find s when $t = 2$

$s = \int v\,dt = \int (2 + 12t - 3t^2)\,dt$

$s = 2t + 6t^2 - t^3 + c$

When $t = 0$, $s = 3 \Rightarrow c = 3$

$\therefore s = 2t + 6t^2 - t^3 + 3$

When $t = 2$

$s = 2(2) + 6(2)^2 - (2)^3 + 3$

$s = 4 + 24 - 8 + 3$

$s = 23$m

Distance from O = 23m

6)

i) $v = u + at$

$\frac{v - u}{a} = t$

$t = \frac{3.5 - 0.5}{1.5} = 2$s

Takes 2s to accelerate

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

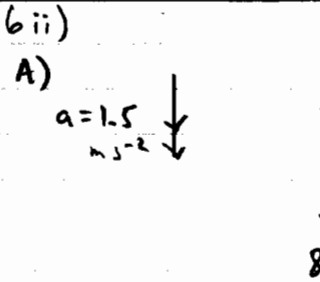
$s = 0.5 \times 2 + \frac{1}{2} \times 1.5 \times 2^2$

$s = 4$m

Descends 4m

6 ii)

A)



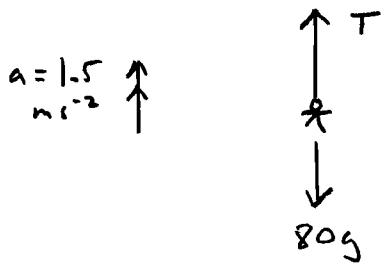
N2L $F = ma$

$80g - T = 80 \times 1.5$

$80g - 120 = T$

$T = 664$ N

B)



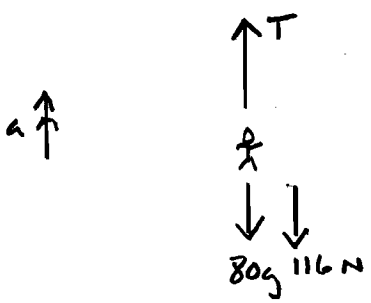
N2L $F = ma$

$T - 80g = 80 \times 1.5$

$T = 120 + 80g$

$T = 904$ N

6iii)



2NL $F = ma$

$T - 80g - 116 = 80a$

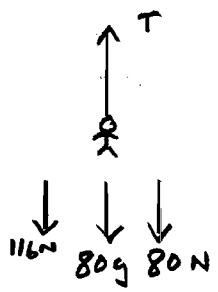
At max tension allowed

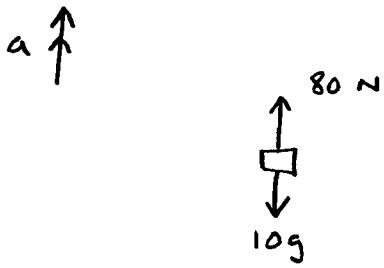
$2500 - 80 \times 9.8 - 116 = 80a$

$1600 = 80a$

$a = 20\ ms^{-2}$

6iv)





N2L for equipment $F = ma$

$80 - 10g = 10a$

$\Rightarrow \quad a = \frac{-18}{10} = -1.8\ ms^{-2}$

For man N2L $F = ma$

$T - 116 - 80g - 80 = 80 \times -1.8$

$T = 116 + 80g + 80 - 80 \times 1.8$

$T = 836$ N

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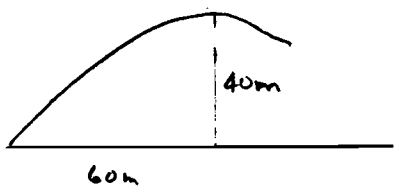
7)

i)



$u_x = 21\ ms^{-1}$

$x = u_x t$

$\therefore$ when $x = 60$

$60 = 21t \quad \Rightarrow t = 2.857$

7i cont) Highest point when $t = 2.86$ s to 3 s.f.

Vertically using $v = u + at$

$v_y = u_y - 9.8t$

At highest point $v_y = 0$, $t = 2.857$

$\Rightarrow 0 = u_y - 9.8 \times 2.857$

$u_y = 9.8 \times 2.857$

$u_y = 28.0 \text{ ms}^{-1}$ to 3 s.f.

ii)

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

$y = u_y t - 4.9t^2$

$y = 28t - 4.9t^2$

iii)

Same height because both parts start with the same vertical component of velocity (ie 0 ms^{-1}) and are subject to the same vertical acceleration due to gravity

Horiz vely of 1st part $= 21 \text{ ms}^{-1}$
of 2nd part $= 5.25 \text{ ms}^{-1}$

Relative velocity of 1st to 2nd $= 21 - 5.25 = 15.75 \text{ ms}^{-1}$

This is constant so distance apart d after t seconds is given by

$d = 15.75t$

iv)

A) Time for descent = time for rise $= 2.857$ s

$\therefore d = 15.75 \times 2.857$

$d = 45.0$ m to 3 s.f

B)

Find time to fall 30m under gravity

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

$30 = 0 + \frac{1}{2} \times 9.8t^2$

(Taking downwards to be +ve direction)

$30 = 4.9t^2$

$\Rightarrow t = \sqrt{\frac{30}{4.9}} = 2.474$ s

$\therefore d = 15.75 \times 2.474$

$d = 38.9655$

$d = 39.0$ m to 3 s.f.

v)

$x = 21t \Rightarrow t = \frac{x}{21}$

$y = 28t - 4.9t^2$

Subst for t $y = 28 \times \frac{x}{21} - 4.9\left(\frac{x}{21}\right)^2$

$y = \frac{4x}{3} - \frac{4.9x^2}{441}$

$y = \frac{4x}{3} - \frac{x^2}{90}$

$y = \frac{1}{90}\left(120x - x^2\right)$