1) Area under graph represents displacement

$$\text{Area} = \frac{1}{2} \times 40 \times V + 40V + \frac{1}{2} \times 20 \times V$$

$$= 20V + 40V + 10V$$

$$\text{Area} = 70V$$

$$\therefore \quad 1400 = 70V$$

$$V = 20 \text{ ms}^{-1}$$

2) $x = 12t - t^3$

for $-10 \le t \le 10$

$$v = \frac{dx}{dt} = 12 - 3t^2$$

when $v = 0$, $\quad 12 - 3t^2 = 0$

$$3t^2 = 12$$
$$t^2 = 4$$
$$t = \pm 2$$

when $t = 2$, $\quad x = 12 \times 2 - 2^3$

$$x = 24 - 8 = 16 \text{ m}$$

when $t = -2$ $\quad x = 12(-2) - (-2)^3$

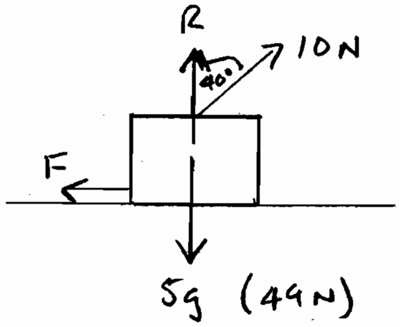
$$x = -24 + 8 = -16 \text{ m}$$

Velocity is 0 when $x = 16$m and $x = -16$m

3) i) Normal reaction $= 5g$

$$= 49 \text{ N}$$

3 ii)



3 iii) Vertically $\quad R + 10\cos 40° = 49$

$$R = 49 - 10\cos 40°$$

$$R = 41.3 \text{ N} \quad \text{to 3 s.f.}$$

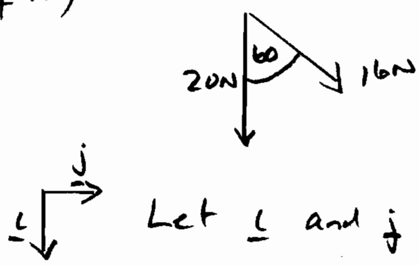
Horizontally, $\quad F = 10\sin 40°$

$$F = 6.43 \text{ N} \quad \text{to 3 s.f.}$$

4) i) Component of resultant in direction of 20 N force

$$= 20 + 16\cos 60 = 28 \text{ N}$$

4 ii)



Let $\underline{i}$ and j be as shown

Resultant is $\quad 28\underline{i} + 16\sin 60° j$

$$\text{Magnitude} = \sqrt{28^2 + (16\sin 60)^2}$$

$$= 31.24 \text{ N}$$

$$= 31.2 \text{ N} \quad \text{to 3 s.f.}$$

4iii) $\underline{F} = m\underline{a}$

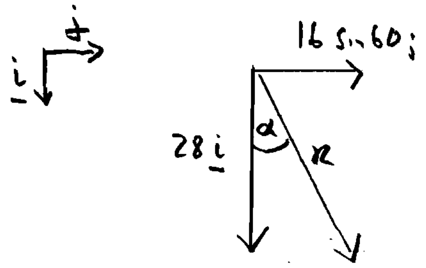
$|\underline{F}| = m|\underline{a}|$

$31.24 = 2|\underline{a}|$

$|\underline{a}| = 15.6 \text{ ms}^{-2}$

Since resultant force was

$28\underline{i} + 16\sin 60 \underline{j}$

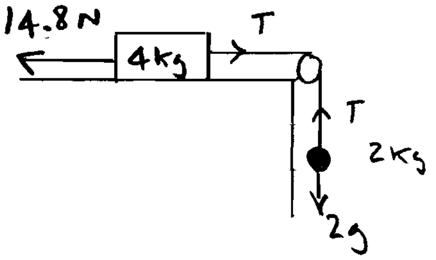


Force and $\therefore$ acceleration makes angle α with the 20N force

$$\alpha = \tan^{-1}\left(\frac{16\sin 60}{28}\right)$$

$\alpha = 26.3°$

5) i)



For block $F = ma$

$T - 14.8 = 4a$ (1)

For sphere $F = ma$

$2g - T = 2a$ (2)

(1) + (2) $2g - 14.8 = 6a$

ii) $19.6 - 14.8 = 6a$

$a = \frac{4.8}{6} = 0.8 \text{ ms}^{-2}$

Subst in (1)

$T - 14.8 = 4 \times 0.8$

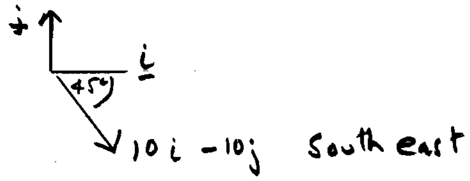
$T = 3.2 + 14.8 = 18\text{N}$

$a = 0.8 \text{ ms}^{-2}$, $T = 18\text{N}$

6) i) $\underline{v} = \begin{pmatrix} -5 \\ 10 \end{pmatrix} + t\begin{pmatrix} 6 \\ -8 \end{pmatrix}$

when $t = 2.5$

$\underline{v} = \begin{pmatrix} -5 \\ 10 \end{pmatrix} + \begin{pmatrix} 15 \\ -20 \end{pmatrix} = \begin{pmatrix} 10 \\ -10 \end{pmatrix}$



Speed $= \sqrt{10^2 + (-10)^2}$

$= 14.14 \text{ ms}^{-1}$

$= 14.1 \text{ ms}^{-1}$ to 3 s.f.

6ii) $\underline{r} = \int \underline{v}\, dt$

$\underline{r} = \int \begin{pmatrix} -5 + 6t \\ 10 - 8t \end{pmatrix} dt$

$\underline{r} = \begin{pmatrix} -5t + 3t^2 + C \\ 10t - 4t^2 + D \end{pmatrix}$

6ii) cont) At $\begin{pmatrix}0\\0\end{pmatrix}$ when $t=0$

$\therefore C = D = 0$

$$\underline{r} = \begin{pmatrix}-5t+3t^2\\10t-4t^2\end{pmatrix}$$

When $t = 2.5$

$$\underline{r} = \begin{pmatrix}-5\times2.5+3\times2.5^2\\10\times2.5-4\times2.5^2\end{pmatrix}$$

$$\underline{r} = \begin{pmatrix}6.25\\0\end{pmatrix}$$

Boat is due East of O

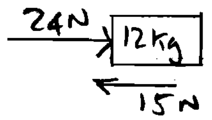
Bearing $= 090°$

7) i) $F = ma$

$\Rightarrow 24 = 12a$

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

7ii)



$F = ma$

$24 - 15 = 12a$

$9 = 12a$

$\Rightarrow a = 0.75\ ms^{-2}$

First model

$s_1 = ut + \frac{1}{2}at^2$

$s_1 = 0 + \frac{1}{2}\times2\times4^2$

$s_1 = 16m$

2nd model $s_2 = ut + \frac{1}{2}at^2$

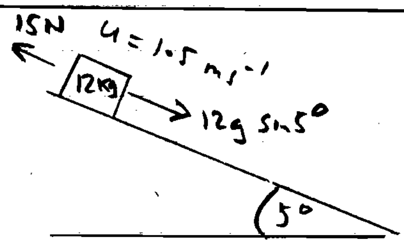
$s_2 = 0 + \frac{1}{2}\times0.75\times4^2$

$s_2 = 6m$

$s_1 - s_2 = 16 - 6 = 10m$

New model predicts block moves 10 m less

7iii)



Using $F = ma$

$12g\sin5° - 15 = 12a$

$$a = \frac{12\times9.8\sin5° - 15}{12} = -0.3959$$

$a = -0.396\ ms^{-2}$

7iv) Using $v = u + at$

Stops when $v = 0$

$\Rightarrow 0 = 1.5 - 0.3959t$

$$\Rightarrow t = \frac{1.5}{0.3959}$$

$t = 3.79\ s$ to 3s.f.

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

$s = 1.5\times3.79 - \frac{1}{2}\times0.3959\times3.79^2$

$s = 2.84m$

v) Using $v = u + at$

Stops at $t = 3.5$ s

$\Rightarrow \quad 0 = 1.5 + 3.5a$

$\Rightarrow \quad a = \frac{-1.5}{3.5}$

$a = -0.42857 \text{ ms}^{-2}$

Now $F = ma$

$\therefore \quad 12g\sin 5^\circ - R = -12 \times 0.42857$

$R = 12 \times 0.42857 + 12g\sin 5^\circ$

$R = 15.39$ N

$R = 15.4$ N to 3 s.f.

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

$y = 10t - \frac{1}{2} \times 10 \times t^2$

$y = 10t - 5t^2$

where y is height above projection point

8ii) For A find time of flight

when $y=0$ $\quad 10t - 5t^2 = 0$

$5t(2-t) = 0$

$\Rightarrow t = 0, t = 2$

$\therefore$ time of flight $t = 2$ s

Range $= u_x \times t = 20 \times 2 = 40$ m

which is less than 70m, so hits ground between initial positions of A and B

8iii) B hits ground when $y = -15$ m

$-15 = 10t - 5t^2$

$5t^2 - 10t - 15 = 0$

$t^2 - 2t - 3 = 0$

$(t-3)(t+1) = 0$

$\Rightarrow \cancel{t = -1}$ or $t = 3$

Time of flight $t = 3$ s

Range $= u_x \times t = 20 \times 3 = 60$ m

8iv) Paths cross since $60 + 40 > 70$m

However, B is always 15m above A until A lands, if they are projected at same time.

8v) Given A projected 2 s after B

Consider A at time 0.75 s

$y = 10 \times 0.75 - 5 \times 0.75^2$

$y = 4.6875$ m

Consider B at time 2.75 s

$y = 10 \times 2.75 - 5 \times 2.75^2$

$y = -10.3125$ m

Height above ground $= 15 - 10.3125$

$= 4.6875$ m

$\therefore$ particles at same height

Horizontally

A has travelled 20×0.75
$= 15$ m

B has travelled 20×2.75
$= 55$ m

A and B have therefore closed horizontally by

$$55 + 15 = 70\text{m}$$

which was their original horizontal separation

A and B $\therefore$ collide at an x coord 15m from A's original position and 4.6875m above the ground