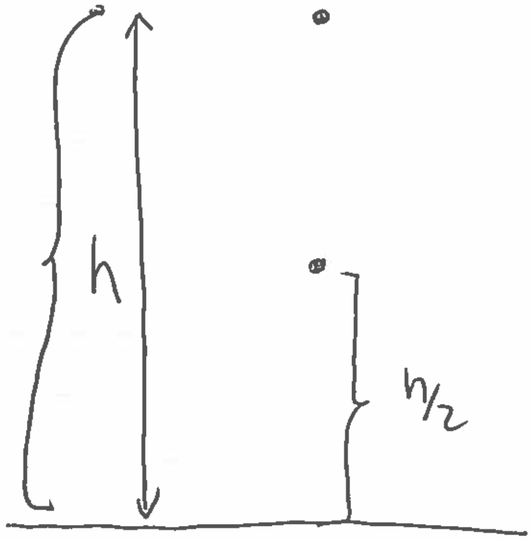
Problem 1

Version 1



top $\frac{1}{2} g t^2 = \frac{h}{2}$ $\rightarrow$ $t^2 = \frac{h}{g}$

bottom $v_i t - \frac{1}{2} g t^2 = \frac{h}{2}$

$$v_i t - \frac{h}{2} = \frac{h}{2}$$

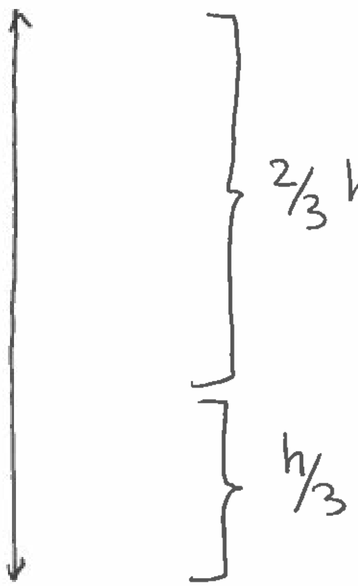
$$v_i t = \frac{h}{2} + \frac{h}{2}$$

$$v_i t = h$$

$$v_i \sqrt{\frac{h}{g}} = h$$

$$v_i = \sqrt{\frac{g}{h}}\, h = \sqrt{g h}$$

Version 2



top ball

$$\frac{1}{2} g t^2 = \frac{2}{3} h \qquad t^2 = \frac{4}{3}\frac{h}{g}$$

bottom ball

$$v_i t - \frac{1}{2} g t^2 = h/3$$

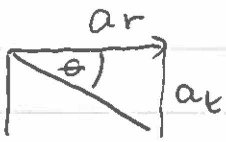
$$v_i t - \frac{2}{3} h = h/3$$

$$v_i \cdot t = h$$

$$v_i \sqrt{\frac{4}{3}\frac{h}{g}} = h$$

$$\underline{\underline{v_i = \sqrt{\frac{3}{4} g h}}}$$

Problem 2



$$\tan\theta = \frac{a_t}{a_r}$$

Version 1

Using kinematic equation we can write

$$v_f^2 - v_i^2 = 2a_t(\Delta s)$$

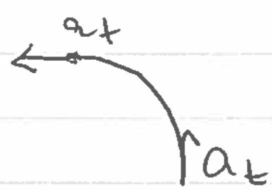
$$v_f^2 = 2a_t(\pi r)$$

$$a_r = \frac{v_f^2}{r} = \frac{2a_t(\pi \cancel{r})}{\cancel{r}}$$

$$a_r = 2\pi a_t$$

$$\tan\theta = \frac{a_t}{2\pi a_t} = \frac{1}{2\pi}\,; \quad \underline{\theta = \tan^{-1}\frac{1}{2\pi}}$$

Version 2



$$v_f^2 = 2a_t\left(\tfrac{1}{2}\pi r\right) = \pi a_t r$$

$$a_r = \frac{v^2}{r} = \pi a_t$$

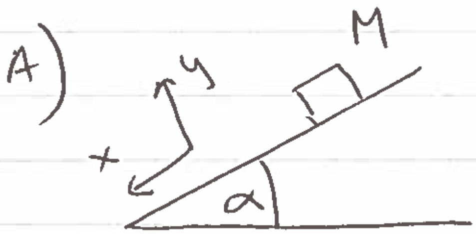
$$\tan\theta = \frac{a_t}{a_r} = \frac{a_t}{\pi t} = \frac{1}{\pi}$$

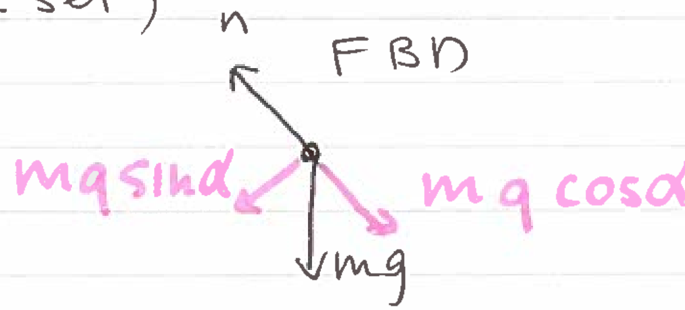
$$\theta = \tan^{-1}\left(\frac{1}{\pi}\right)$$

Problem 3

Version 1 (only 1 set)

A)



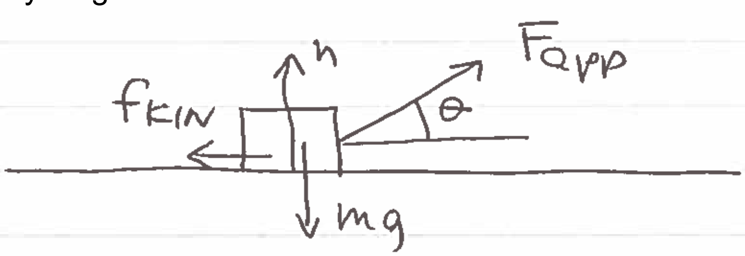


this object will not be in equilibrium ⇒ there is acceleration a down the ramp

$$\sum F_y = 0 \Rightarrow n - Mg\cos\alpha = 0$$

$$\sum F_x = Ma_x \Rightarrow Mg\sin\alpha = Ma_x$$

B) My diagram ans solution is for theta above the horizontal. It was below in the problem



V = CONST ⇓ a = 0 ⇓ equilibrium

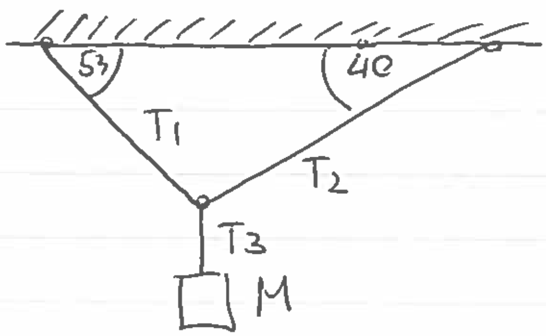
$$\begin{cases} \sum F_x = 0 & F_{app}\cos\theta - f_{KIN} = 0 \\ \sum F_y = 0 & n + F_{app}\sin\theta - mg = 0 \end{cases}$$

also ($f_{KIN} = \mu_{KIN}\, n$)

nice if you write it
no penalty if you don't

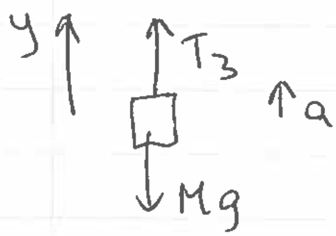
Problem 3

c)

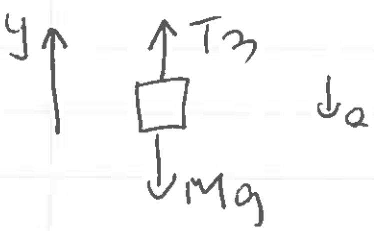


Let's say a is up

$\uparrow a$



$\sum F_y = Ma \Rightarrow \underline{T_3 - Mg = Ma}$



$\sum F_y = -Ma$

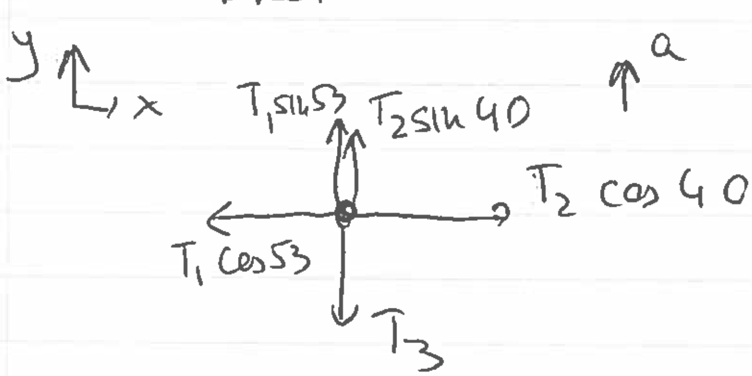
Let's say a is down

$\downarrow a$

$T_3 - Mg = -Ma$

1 $\underline{T_3 = Mg - Ma}$

knot



$\sum F_y = \overset{0}{m_{knot}}\, a$

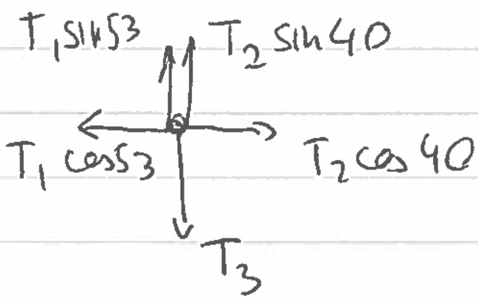
$\sum F_x = 0$

$\sum F_y = 0$

$$\begin{cases} 2)\ T_1 \sin 53 + T_2 \sin 40 - T_3 = 0 \\ 3)\ T_2 \cos 40 - T_1 \cos 53 = 0 \end{cases}$$

Problem 3

c) Knot $\qquad \downarrow d$ is down

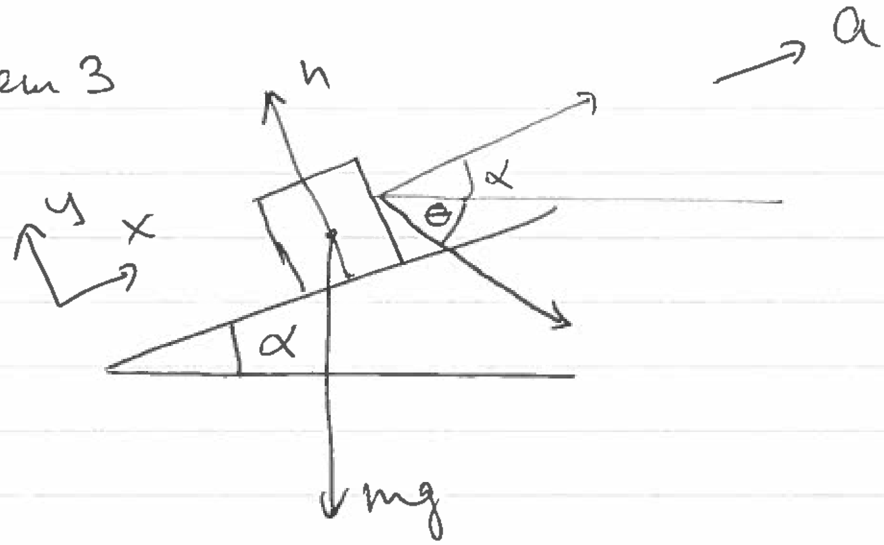


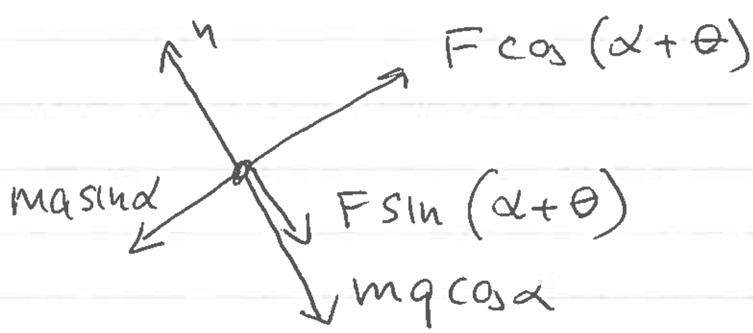
$$\begin{cases} T_1 \sin 53 + T_2 \sin 40 - T_3 = 0 \\ T_2 \cos 40 - T_1 \cos 53 = 0 \end{cases}$$

For full merits students need to consider only one eventuality ($a\uparrow$ or $a\downarrow$) <u>not both</u>

Problem 3

d)





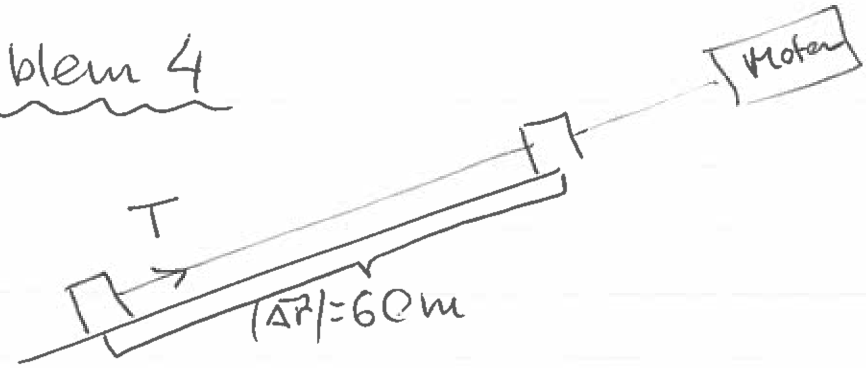
$$\sum F_x = ma \quad \Rightarrow \quad F\cos(\alpha+\theta) - mg\sin\alpha = ma$$

$$\sum F_y = 0 \quad \Rightarrow \quad n - F\sin(\alpha+\theta) - mg\cos\alpha = 0$$

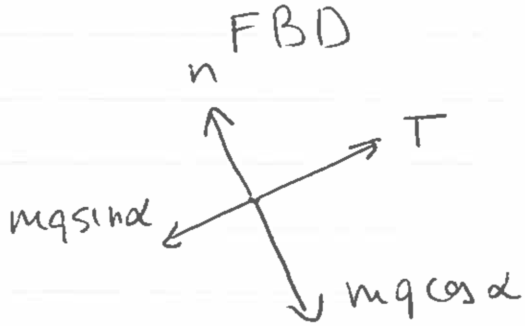
there is a possibility that the angle is 100 degees below horizontal so the object is pulled down the slope

Problem 4

a)



$v = const$



$T - mg\sin\alpha = 0$

$T = mg\sin\alpha$

$W = \vec{T}\cdot\vec{\Delta r}$

$W = (mg\sin\alpha)|(\vec{\Delta r})|\cos 0$

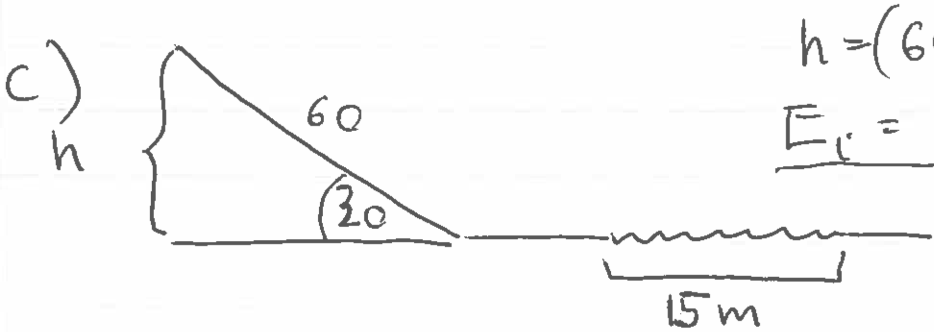
$W = [(70)(9.8)(\sin 30)(60)] J$

$W = 20580 J$

b) $P = \vec{F}\cdot\vec{v} = \vec{T}\cdot\vec{v} = (mg\sin\alpha)\, v\cos 0$

$P = 686\ W$

c)



$h = (60m)\sin 30 = 30m$

$E_i = mgh = 20580 J$

$E_f = 0$

$E_f - E_i = -20580 J = W_{fric} = \mu mg\cos$

Problem 2/ cont

c)

$$-\mu \, m g \Delta r = -20580$$

$$\mu = \frac{20580}{(70)(9.8)(15)} = 2$$

ANS $\underline{\mu = 2}$ ← strange isn't it?

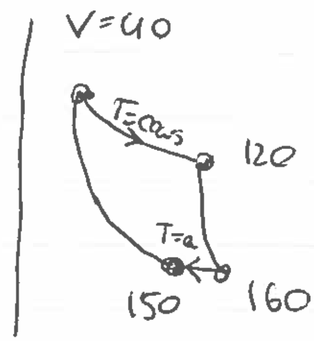
d) $\Delta S = \dfrac{\Delta E}{T} = \dfrac{20580}{280} =$

Problem 5 version (A)

a) $$\epsilon = 1 - \frac{|T_c|}{|T_H|}$$ Carnot's Engine (Carnot's Theorem)

$$\epsilon = 1 - \frac{300K}{500K} = 1 - 0.6 = 0.4$$

b) $$\Delta S = \Delta S_{\substack{isotherm \\ 1}} + \Delta S_{\substack{isotherm \\ 2}}$$



$$\Delta S = nR \ln \frac{V_f}{V_i}$$

$$\Delta S_1 = nR \ln \frac{V}{V} = nR \ln \frac{120}{40}$$

$$\Delta S_2 = nR \ln \frac{V}{V} = nR \ln \cancel{\frac{40}{150}}$$ 150/160

$$\Delta S_{tot} = nR \ln \frac{120}{40} + nR \ln \cancel{\frac{40}{150}}$$ 150/160

$$\Delta S_{tot} = nR \ln \cancel{\frac{120}{150}} = nR \ln \cancel{\frac{12}{15}}$$ 45/16