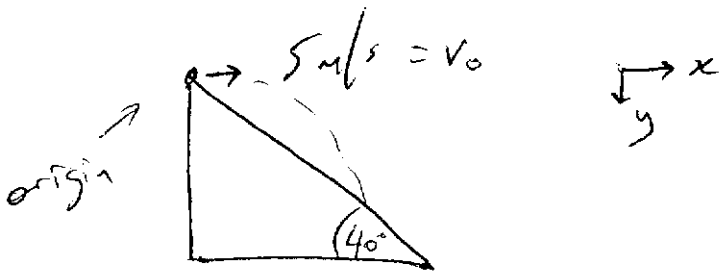
Q1 [8 marks]



incline $y = mx$ when $m = \tan 40^\circ$

$\therefore y = x \tan 40^\circ$

object $y = \frac{1}{2} g t^2$ and $x = v_0 t$

$\therefore y = \frac{1}{2} g \left(x/v_0\right)^2$

$y_{object} = y_{incline}$

$\therefore \frac{x^2 g}{2 v_0^2} = x \tan 40^\circ$

$x = \frac{2 v_0^2 \tan 40^\circ}{g}$

distance down incline $= d$

$d \cos 40^\circ = x$

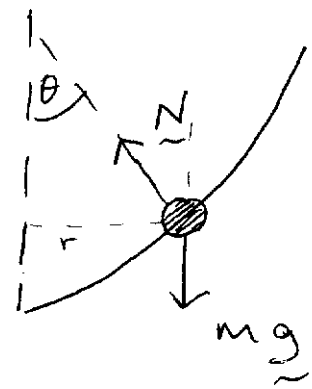
$\therefore d = x / \cos 40^\circ$

$= \frac{2 v_0^2 \sin 40^\circ}{g \cos^2 40^\circ}$

$= 5.59 \text{ m}$

Q2 [9 marks]

a. force diagram



Normal and weight

b. $N\cos\theta = mg$

$N\sin\theta = \frac{mv^2}{r} = m\omega^2 r$

$\omega = 2\ \text{rev/s} = 4\pi\ \text{rad/s}$

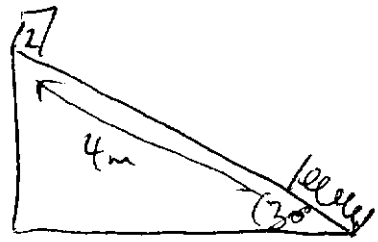
$r = 0.10\sin\theta$

$\therefore \tan\theta = \frac{\omega^2 r}{g}$

$= \frac{16\pi^2 \times 0.1\sin\theta}{9.8}$

$\Rightarrow \theta = 51.6^\circ$

Q3 [10 marks]



$k = 100\ N/m$

no friction

compression $= x$

$$|\Delta U| = mg|\Delta h| = 2 \times 9.8 \times (4+x)\sin 30^\circ$$

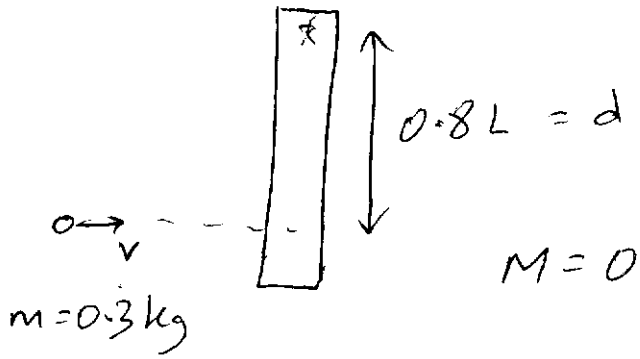
$$= 39.2 + 9.8x \quad \text{Joules}$$

$$\rightarrow \frac{1}{2}kx^2$$

$$\therefore 50x^2 = 39.2 + 9.8x$$

$$\text{sol}^n: \quad x = 0.99\ m$$

Q4 [12 marks]



$M = 0.8\ kg$ and $L = 1.2\ m$

a) $L_i = mvd = 0.3 \times 0.8 \times 1.2 \times v$

$= 0.288\ v \quad kg\ m^2\ s^{-1}$

b) $I = I_{particle} + I_{rod}$

$= md^2 + \frac{1}{3}ML^2$

$= [0.3 \times (0.8 \times 1.2)^2] + \left[\frac{0.8 \times 1.2^2}{3}\right]$

$= 0.66 \quad kg\ m^2$

c). rod + particle swing up to 60°

$K \rightarrow U$

$K = \frac{L_f^2}{2I_{total}} = \frac{L_i^2}{2I_{total}} = \frac{(0.288\ v)^2}{2 \times 0.66}$

$= 0.063\ v^2$

Q4

c) U at 60°

$= mg\Delta h_{particle} + Mg\Delta h_{rod}$

$= [0.3 \times 9.8 \times 0.8 \times 1.2 \times (1 - \cos 60^\circ)]$

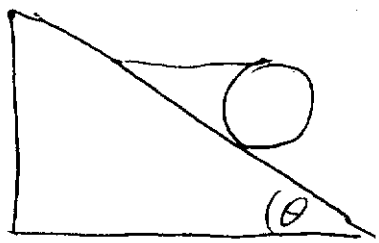
$+ \left[0.8 \times 9.8 \times \frac{1.2}{2} \times (1 - \cos 60^\circ)\right]$

$= 3.76 \text{ J}$

$\therefore \quad 0.063 v^2 = 3.76$

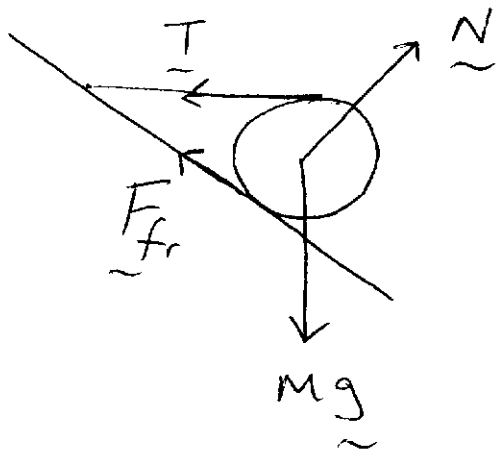
$v = 7.7 \text{ m/s}$

Q5 [12 marks]



$R = 20$ cm
$M = 3$ kg
$\theta = 30°$

a) Force diagram



Weight
Normal
Tension
Friction

b) $Mg\cos\theta + T\sin\theta = N$
$Mg\sin\theta = F_{fr} + T\cos\theta$
} $F_{net} = 0$

$TR = F_{fr}R$ torque $= 0$

$$\Rightarrow T = \frac{Mg\sin\theta}{1+\cos\theta} = 7.88\ N$$

Q5

c) $N = mg\cos\theta + T\sin\theta = 29.4\ N$

d) $F_{fr} = T = 7.88\ N$

Q6 [9 marks]

a). $R_1 = 2.67 \times 10^8$ m $T_1 = 3.58 \times 10^5$ s

$R_2 = 5.86 \times 10^8$ m $T_2 = ?$

Kepler's 3rd Law

$$\frac{R_1^3}{T_1^2} = \frac{R_2^3}{T_2^2}$$

$$\therefore T_2 = T_1 \sqrt{\left(\frac{R_2}{R_1}\right)^3} = 1.16 \times 10^6 \text{ s}$$

b) $$\frac{GM_E m}{R_E^2} = mg$$

$$\Rightarrow M_E = \frac{g R_E^2}{G}$$

$$= \frac{9.8 \times (6370 \times 10^3)^2}{6.67 \times 10^{-11}}$$

$$= 5.96 \times 10^{24} \text{ kg}$$