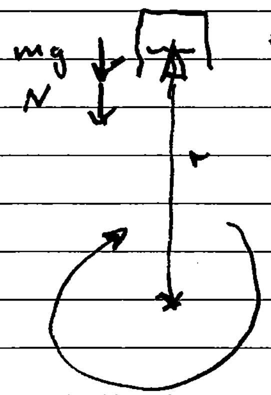
Problem Set 10

6-12



seen at rest in rotating frame.

$\vec{\omega}$ $\underline{\text{out}}$

$$a_I = \underbrace{\ddot{R}}_{=0} + \underbrace{\vec{a}}_{=0} + 2\underbrace{\omega \times v}_{=0} + \omega \times (\omega \times r) + \underbrace{\dot{\omega} \times r}_{=0}$$

$$a_I = \omega \times \underbrace{(\omega \times r)}_{\text{To left}} = -\omega^2 \vec{r} \qquad \text{(down)}$$

$$m a_I = -m\omega^2 \vec{r}$$

$$-mg - N = -m\omega^2 r$$ same as from intro.

N ↑ Normal force from bottom

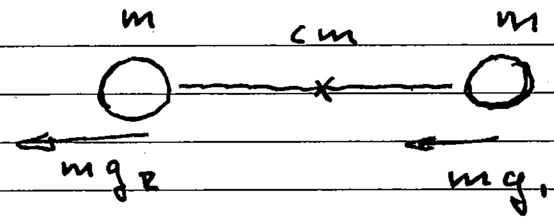
Note: N must be pos. limit $N=0$

$$mg = m\omega^2 r \qquad \text{for min } \omega$$

$$\sqrt{\frac{g}{r}} = \omega$$

6-14

a)



$$F_{cm} = (2m)\, a_{cm}$$

$$mg_2 + mg_1 = 2m\, a_{cm}$$

$$m(g_1 + g_2) = 2m\, a_{cm}$$

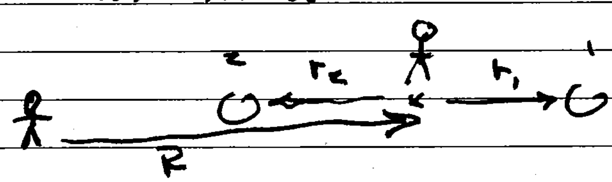
$$a_{cm} = \frac{g_1 + g_2}{2}$$

Seen from cm.

$$a_I = \ddot{R} + \vec{a} + \underbrace{2\omega \times v}_{=0} + \underbrace{\omega \times (\omega \times r)}_{=0} + \underbrace{\dot{\omega} \times r}_{=0}$$

Seen from inertial frame.

$\omega = 0$



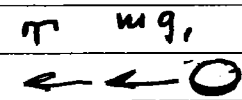
want object to stay together.

$a = 0$

object 1

$$a_I = \ddot{R} = \frac{g_1 + g_2}{2}$$

$$\frac{F_1}{m} = \frac{g_1 + g_2}{2}$$



$$\frac{mg_2 + T}{m} = \frac{g_1 + g_2}{2}$$

T to hold it together.

$$\frac{T}{m} = \frac{g_1 - g_2}{2}$$

So the difference in g is what determines the internal tension.

b)

$$F = \frac{GMm}{r^2}$$

$$\Delta F = -2\frac{GMm}{r^3}\Delta r$$

$$+\underset{\substack{\uparrow \\ 3}}{\frac{\Delta F}{m}} = -2\frac{GM}{r^3}\underset{\substack{\uparrow \\ 7}}{\Delta r}$$

interested in mag.

$$3 = \frac{\Delta F}{m} = \frac{2GM}{r^3}\,7$$

Solve for r

$$r^3 = \frac{2GM}{3}7. = 2(6.67\times10^{-11})\frac{1.4\times2\times10^{30}\times7}{3}$$

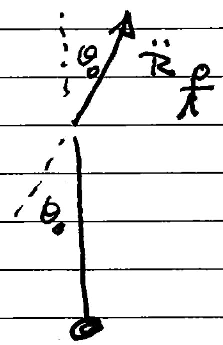
$$r^3 = 8.7\times10^{20}$$

$$r = 9.55\times10^{6}\ m$$

$$r - r_0 = 9.55\times10^{6} - 1.4\times \cancel{\ } 6.4\times10^{6}$$

$$= .59\times10^{6}\ m.$$

6 - 16



No rotation

$a_I = \ddot{R} + a$

$ma_I = m\ddot{R} + ma$

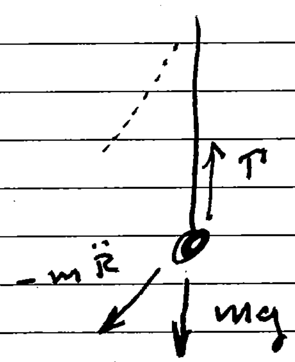
~~$ma_I =$~~

$ma_I - m\ddot{R} = ma$

In acc. frame there is an extra "force"

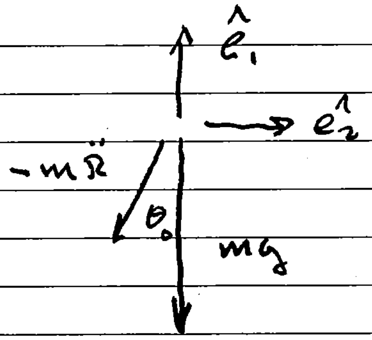
$-m\ddot{R}$

Now ma_I is from mg & T tension in the string.



In the acc. coor. frame $mg - m\ddot{R}$ will correspond to 'down' & the equilibrium for the pendulum will be when

$\bar{T} + \overline{mg} - m\ddot{R} = 0$



$$mg = -mg\,\hat{e}_1$$

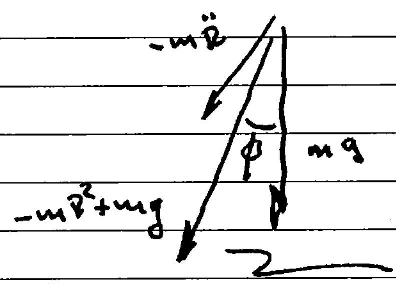
$$-m\ddot{R} = -m\ddot{R}\cos\theta_0\,\hat{e}_1 - m\ddot{R}\sin\theta_0\,\hat{e}_2$$

$$\simeq -m\ddot{R}\,\hat{e}_1 - m\ddot{R}\,\theta_0\,\hat{e}_2$$

So

$$mg + (-m\ddot{R}) = -(mg + m\ddot{R})\hat{e}_1 - m\ddot{R}\,\theta_0\,\hat{e}_2$$

$$= -m(g+\ddot{R})\hat{e}_1 - m\ddot{R}\,\theta_0\,\hat{e}_2$$



$$\tan\phi = \frac{m\ddot{R}\,\theta_0}{m(g+\ddot{R})} = \frac{\ddot{R}\,\theta_0}{g+\ddot{R}}$$

This ~~corres-~~ corresponds to the new 'down' & the equilibrium position -

So initially the pendulum is at the angle ϕ.

For part b the pendulum will go back to swinging about the vertical, $\hat{e}_1$ after the accel. has stopped,