Exercise 13.2:

FBD

$F_r = m a_r = -72N$

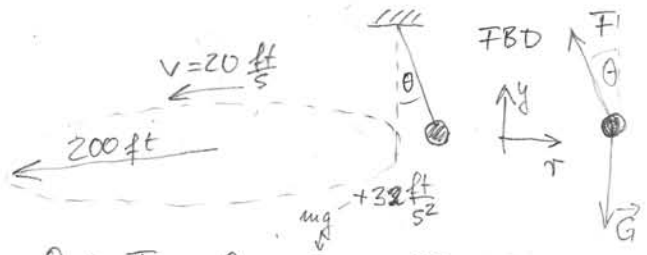
on the other hand: $a_r = \frac{d^2 r}{dt^2} - r\omega^2$

circle $\Rightarrow \frac{dr}{dt} = 0 \Rightarrow \frac{d^2 r}{dt^2} = 0$

$\Rightarrow F_r = -m r \omega^2 = -m r \frac{4\pi^2}{T^2}$

$\Rightarrow T = 2\pi \sqrt{-\frac{m r}{F_r}} = 2\pi \sqrt{-\frac{4kg \cdot 2m}{72\ kg\ m/s^2}} = 2.1s$

Exercise 13.3



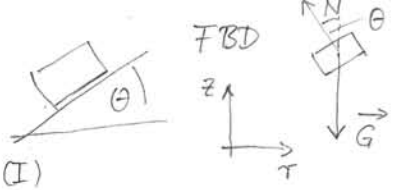
$m a_y = 0 = F\cos\theta - G, \Rightarrow F\cos\theta = mg$

$m a_r = -m r \omega^2$ (c.f. Ex 13.2)

$m a_r = -F\sin\theta = -m r \omega^2$ $\quad v = r\omega$

$\Rightarrow \frac{F\sin\theta}{F\cos\theta} = \frac{m r \omega^2}{mg} \Rightarrow \tan\theta = \frac{r\omega^2}{g} = \frac{v^2}{rg}$

Exercise 13.6:



$0 = m a_z = -G + N\cos\theta$

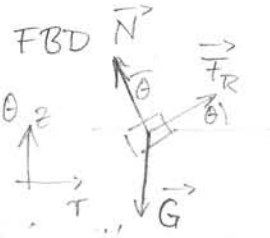
$\Rightarrow N\cos\theta = mg$ (I)

$m a_r = -m \frac{v^2}{R} = -N\sin\theta$ (II)

$dr/dt = 0$

$\frac{(II)}{(I)} \Rightarrow \frac{N\sin\theta}{N\cos\theta} = \frac{m v^2/R}{mg} \Rightarrow \tan\theta = \frac{v^2}{Rg}$

Exercise 13.7:



$0 = m a_z = -G + N\cos\theta + F_R\sin\theta$

$\Rightarrow N\cos\theta = G - F_R\sin\theta$

$= G - \mu N\sin\theta$

$\Rightarrow N\cos\theta + \mu N\sin\theta = G$ (I)

$F_r = m a_r = -m \frac{v^2}{R}$

$\Rightarrow -N\sin\theta + F_R\cos\theta = -m \frac{v^2}{R}$

$\Rightarrow -N\sin\theta + \mu N\cos\theta = -m \frac{v^2}{R}$ (II)

$\frac{(I)}{(II)} \Rightarrow \frac{\cos\theta - \mu\sin\theta}{\sin\theta - \mu\cos\theta} = \frac{gR}{v^2} \Rightarrow v^2\cos\theta - v^2\mu\sin\theta = gR\sin\theta - \mu gR\cos\theta$

$\Rightarrow v^2\cos\theta + \mu gR\cos\theta = gR\sin\theta + v^2\mu\sin\theta \Rightarrow \dots$

Exercise 13.8

- If block does not fall off at top then it falls off nowhere (Why?)
- If block does not fall off at top then normal force $|\vec{N}| \geq 0$!

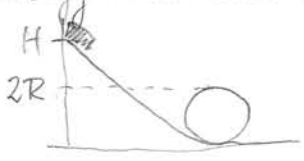
$m a_r = -N - mg$

$m a_r = -m \frac{v^2}{R}$

$\Rightarrow N + mg = m \frac{v^2}{R}$ $\quad |\vec{N}| \geq 0 \Rightarrow mg \leq m \frac{v^2}{R}$

$\Rightarrow v^2 \geq g \cdot R$ (*)

How do we get v? Energy Conservation!



$\frac{1}{2} m v^2 = mg(H - 2R)$

$\Rightarrow v^2 = 2g(H - 2R)$

$\overset{(*)}{\Rightarrow} 2g(H-2R) \geq gR \Rightarrow H \geq \frac{5}{2}R$