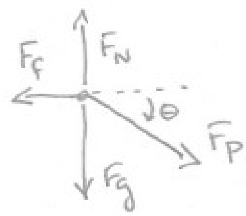
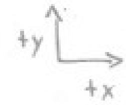
(10)

PUSH

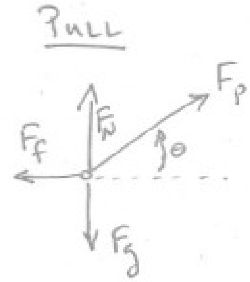


Want $|F_p|$ ~~is constant~~



$\sum \vec{F} = m\vec{a}$

PULL



μ_s is the same for both cases

$X \Rightarrow \quad F_p\cos\theta - F_f = ma_x = 0$ "Static"

$Y \Rightarrow \quad F_N - F_g - F_p\sin\theta = 0$

$F_N = F_g + F_p\sin\theta$

$F_p\cos\theta - F_f = ma_x = 0$

$F_N - F_g + F_p\sin\theta = 0$

$F_N = F_g - F_p\sin\theta$

The normal force and hence the frictional force are diffent.

$F_f = \mu_s F_N$

Want to know $|F_p|$ required to get the box to start moving.

$F_p\cos\theta - \mu_s(F_g + F_p\sin\theta) = 0$

$F_p(\cos\theta - \mu_s\sin\theta) - \mu_s mg = 0$

$$F_p = \frac{\mu_s mg}{(\cos\theta - \mu_s\sin\theta)}$$

$F_p\cos\theta - \mu_s(F_g - F_p\sin\theta) = 0$

$F_p(\cos\theta + \mu_s\sin\theta) - \mu_s mg = 0$

$$F_p = \frac{\mu_s mg}{(\cos\theta + \mu_s\sin\theta)}$$

☑ units
☐ $\mu_s \uparrow$ $F_p \uparrow$
☐ $m \uparrow$ $F_p \uparrow$
☑ $\theta = 0$ $F_{push} = F_{pull}$

Force required to push 75 kg at $\theta = 40$

$$F_{push} = \frac{(0.8)(75\,kg)(9.8\,m/s^2)}{(\cos(40) - 0.8\sin(40))} = 2.33\,kN$$

$$F_{pull} = \frac{(0.8)(75\,kg)(9.8\,m/s^2)}{(\cos(40) + 0.8\sin(40))} = 0.46\,kN$$

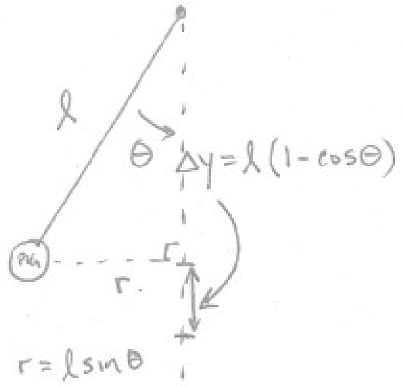
PUSHING OR PULLING at $\theta = 0°$ is the same since $\cos 0° = 1$ and $\sin 0° = 0$

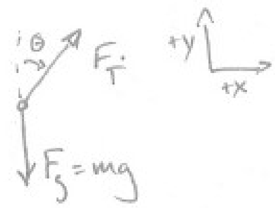
$$F_{STRAIGHT} = (0.8)(75\,kg)(9.8\,m/s^2) = 0.59\,kN$$

Much easier to pull...

Q: I wonder what the "ideal" angle to pull an object is?...

(11)





Need to find θ.

$$y \Rightarrow F_T \cos\theta - mg = 0$$

$$x \Rightarrow F_T \sin\theta = m\frac{v^2}{r}$$

$$F_T = \frac{mg}{\cos\theta}$$

$$\left(\frac{mg}{\cos\theta}\right)\sin\theta = \frac{mv^2}{r}$$

$$\tan\theta = \frac{v^2}{gr}$$

$$v = \frac{2\pi r}{T} \text{ and } r = l\sin\theta$$

$$\frac{\sin\theta}{\cos\theta} = \tan\theta = \frac{(2\pi)^2}{T^2}\frac{r}{g} = \frac{(2\pi)^2}{T^2 g} l\sin\theta$$

So...

$$\cos\theta = \frac{T^2 g}{(2\pi)^2 l}$$

$$\theta = \cos^{-1}\left(\frac{(1.7\,s)^2(9.8\,m/s^2)}{(2\pi)^2(0.7\,m)}\right)$$

↑ 0.8 m

oops

$$\Delta PE = mg\Delta y = mgl(1-\cos\theta)$$

$$KE = \frac{1}{2}mv^2 = \frac{1}{2}m\left(\frac{2\pi l\sin\theta}{T}\right)^2$$

$$v = \frac{2\pi r}{T} = \frac{2\pi l \sin\theta}{T} \qquad \sin^2\theta = 1-\cos^2\theta$$

$$\Delta PE = mgl\left(1 - \frac{T^2 g}{(2\pi)^2 l}\right)$$

$$KE = \frac{2m\pi^2 l^2}{T^2}\left(1 - \frac{T^4 g^2}{(2\pi)^4 l^2}\right)$$