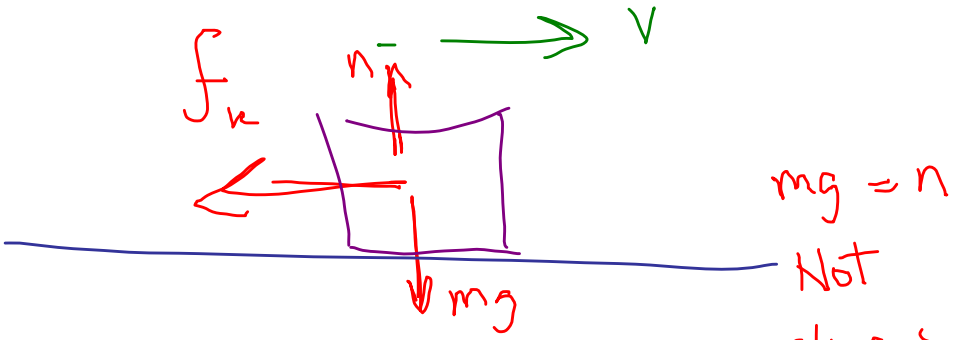
Phys 2110-4 2/20/13

Note Title 2/20/2013

Friction forces:

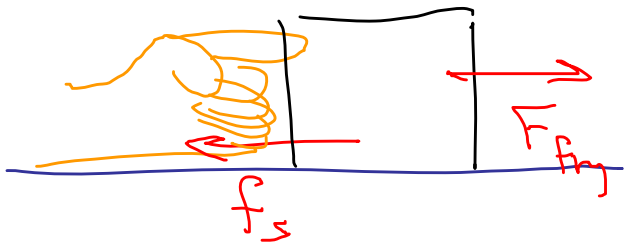


mg = n Not always

Kinetic friction

$$f_k = \mu_k n$$

Static friction



Until it starts to move

$$F_{fm} = f_s$$

Static fric force has a maximal value

$\longrightarrow f_s^{(max)}$

What could this value depend on?

Kinds materials.

$\Longrightarrow$ normal force

$f_s \leq \mu_s n$ p. 75

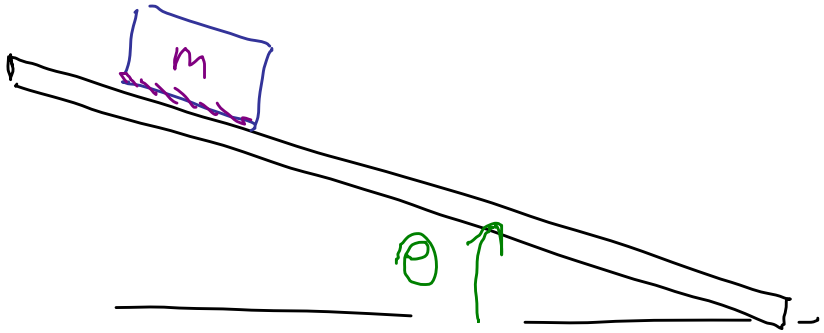
Compare with

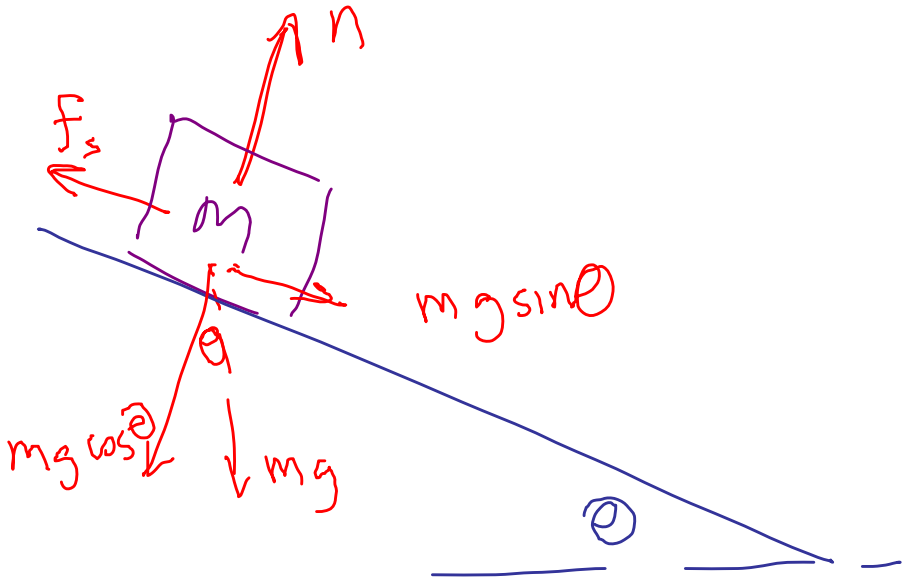
$f_k = \mu_k n$

μ_s coefficient of static friction.

Generally $\mu_s > \mu_k$

Examples





$$n = mg\cos\theta$$

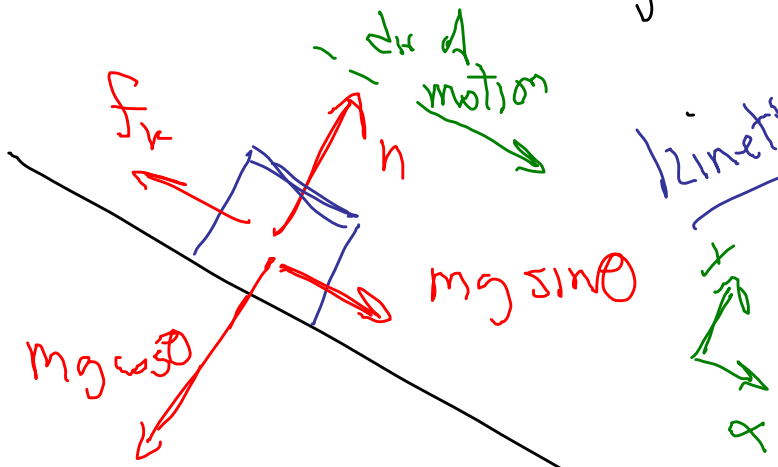
$$f_s = mg\sin\theta$$

Starts to slide

$$f_s = f_s^{(max)} = \mu_s n = \mu_s mg\cos\theta = mg\sin\theta$$

$$\mu_s = \frac{\sin\theta}{\cos\theta} = \tan\theta$$

Example Block slides down a rough surface, slope θ. Find acceleration.



kinetic friction opposes motion

$$n = mg\cos\theta$$ y forces cancel

$$F_{net,x} = mg\sin\theta - f_k$$

$$f_k = \mu_k n = \mu_k mg\cos\theta$$

$$F_{net} = mg\sin\theta - f_k = mg\sin\theta - \mu_k mg\cos\theta$$

$$= mg(\sin\theta - \mu_k\cos\theta) = ma_x$$

$$a_x = g(\sin\theta - \mu_k \cos\theta)$$

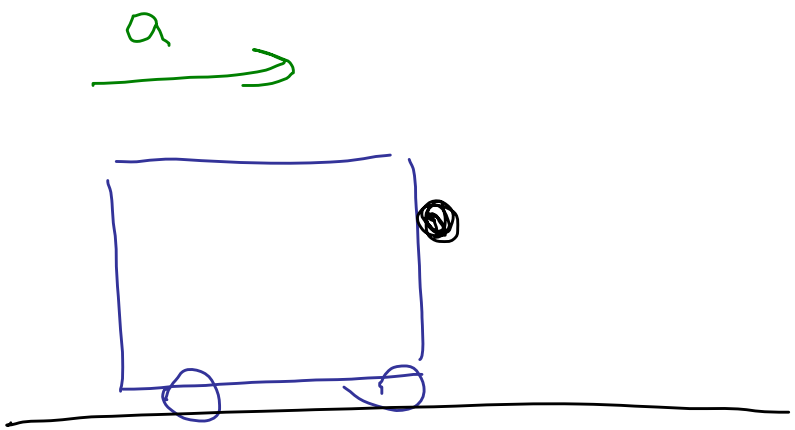
assume positive

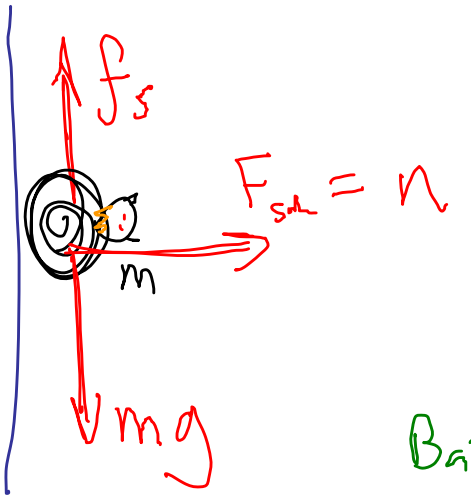
No frict

$a_x = g \sin\theta$

5.46 A bat crashes into vert. front of accelerating subway car. Static fric. coeff between bat & train = 0.86

What's the minimum acceleration of train that will allow bat to remain in place.





Vertical forces cancel

$$f_s = f_s^{(max)} \rightarrow = mg$$

$$\rightarrow = \mu_s n \qquad mg = \mu_s n$$

Bat is also acc'ing horizontally

Horizontal

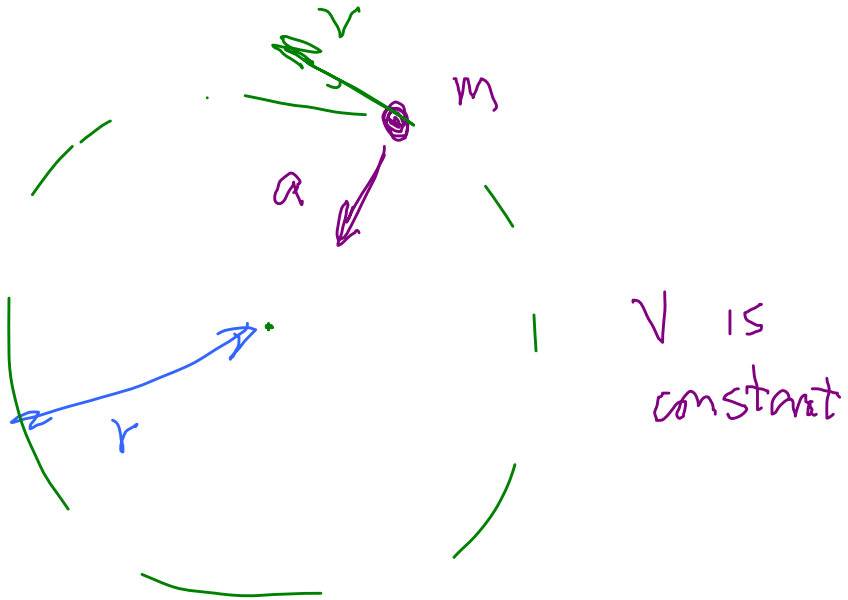
$$F_{tra} = n = ma_x$$

$$mg = \mu_s m a_x$$

$$a_x = \frac{g}{\mu_s} = \frac{9.8\ m/s^2}{0.86}$$

$$= 11\ m/s^2$$

Circular Motion



$$a_c = \frac{v^2}{r}$$

centripetal accel.

$$\vec{F}_{net} = m\vec{a}$$

There is a (net) force on mass

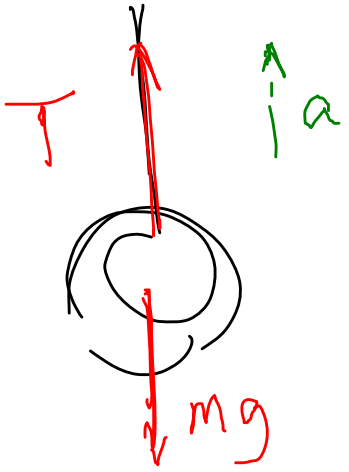
Something is pulling/pushing toward the central

$$|F_{net}| = ma_c = \frac{mv^2}{r}$$

Centripetal force.

Object swings on end of a string, has speed $3\frac{m}{s}$. Length of string is 1m. Find tension in string when mass is at bottom of swing.

Mass is 1.5 kg

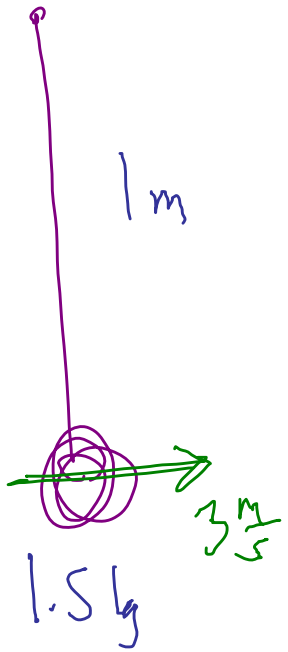


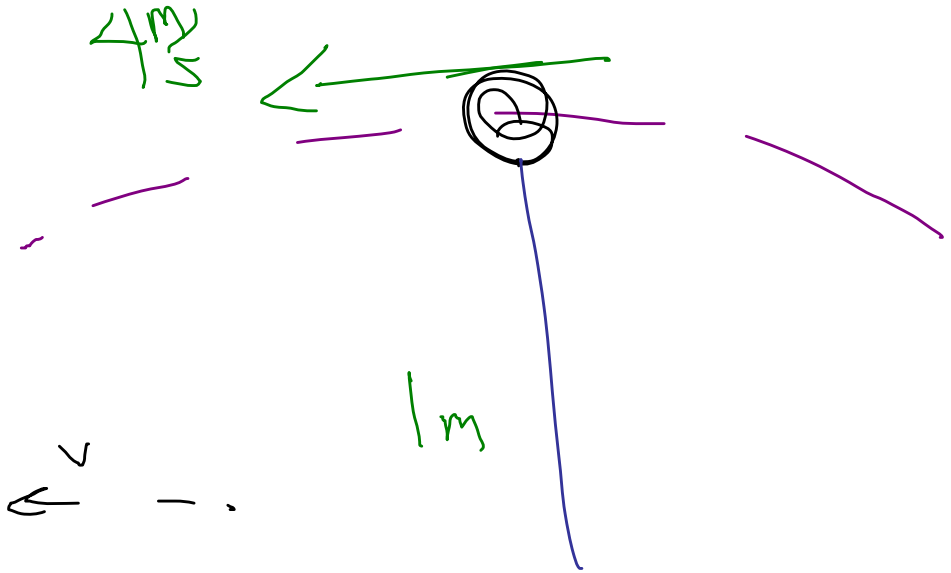
$$T - mg = F_c = \frac{mv^2}{r}$$

$$T = mg + \frac{mv^2}{r} = m\left(9.8\frac{m}{s^2} + \frac{\left(3\frac{m}{s}\right)^2}{1m}\right)$$

$$= (1.5kg)\left(18.8\frac{m}{s^2}\right)$$

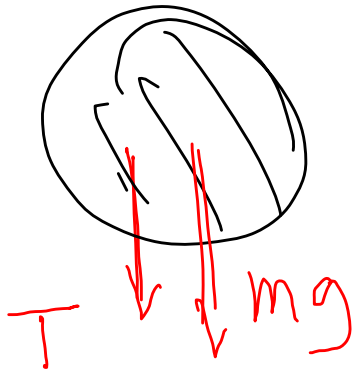
Accel'n upward $= 28.2N$





At top of swing suppose speed is $4\ \frac{m}{s}$

Find T in string



$$T + mg = \frac{mv^2}{r}$$

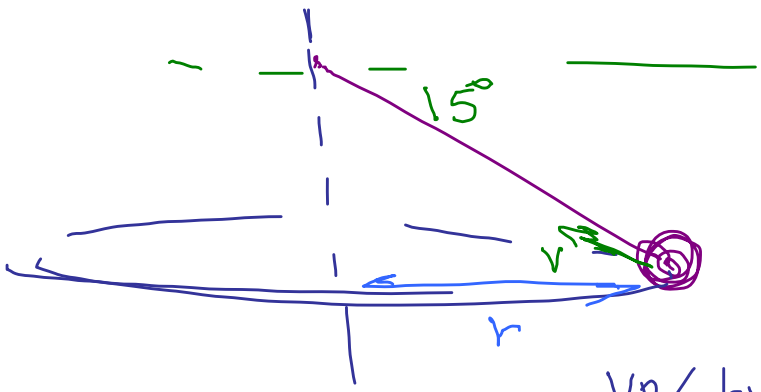
If v were too small

$$T = \frac{mv^2}{r} - mg$$

$$= (1.5\ kg)\left(\frac{(4\ m/s)^2}{1m} - 9.8\ \frac{m}{s^2}\right)$$

$$= 9.7\ N$$

Conical Pendulum

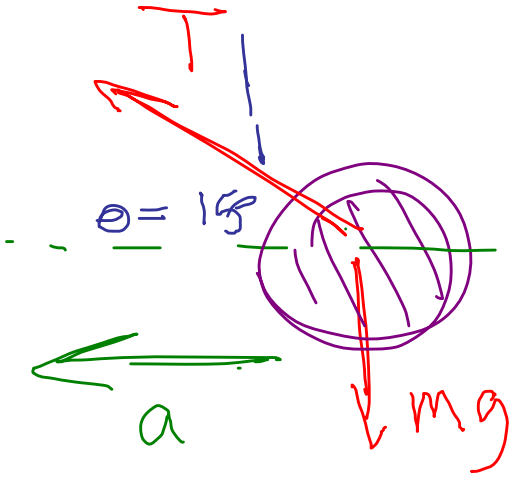


5.26 A tetherball on a 1.7 m rope is struck so it makes motion in horizontal plane Rope makes 15° angle w/ horizontal. What is ball's speed.

Up/down comp comp

$mg = T\sin\theta$

$T = \frac{mg}{\sin\theta}$



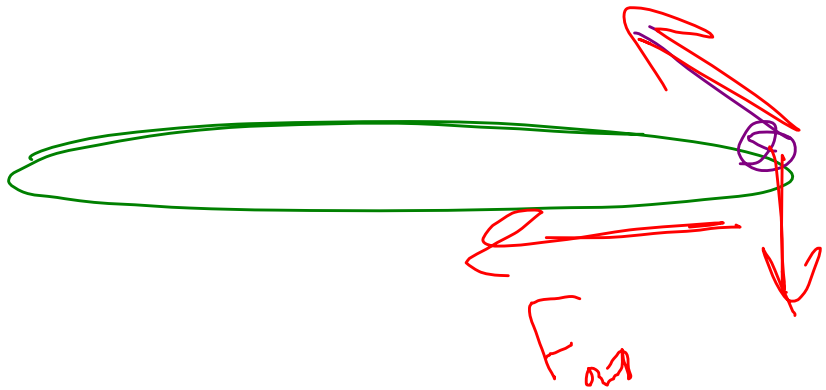
$T\cos\theta = \frac{mv^2}{r}$

$r = (1.7\text{m})\cos 15°$

$= 1.64\text{ m}$

$$T\cos\theta = \frac{mv^2}{r}$$

$$T\sin\theta = mg$$



$$\frac{T\sin\theta}{T\cos\theta} = \frac{mg}{mv^2/r}$$

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

$$v^2 = \frac{gr}{\tan\theta} = \frac{\left(9.8\frac{m}{s^2}\right)(1.64\,m)}{\tan 15^\circ}$$

$$v = 7.74\frac{m}{s}$$