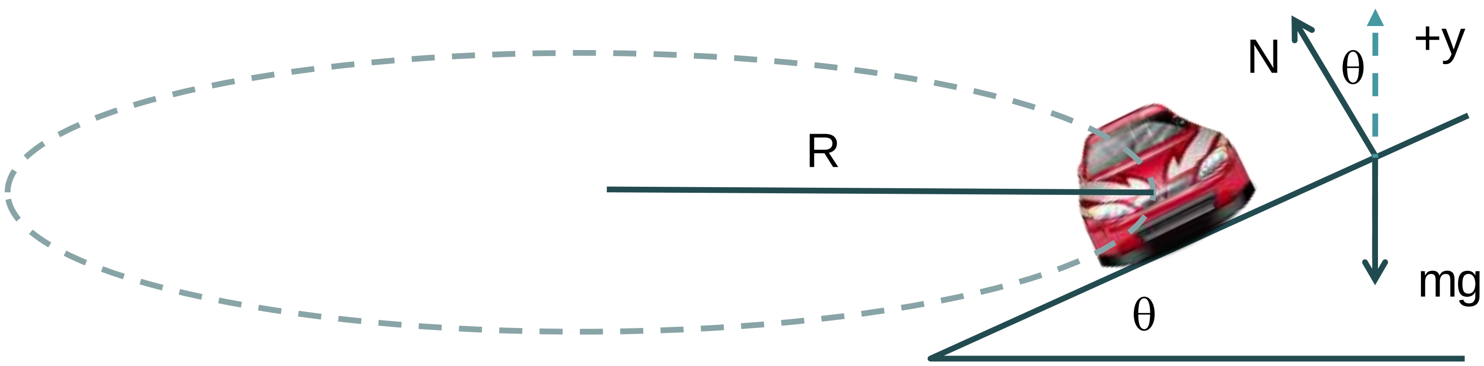
Fred, a NASCAR driver, is traveling at 160 MPH (72 m/s) around a track with radius 0.5 mile (800 m). Unfortunately, a previous car blew its engine and there is oil all over the track, reducing friction almost to zero. If Fred makes it around without sliding up or down, what is the track's bank angle from horizontal?



$$N\cos\theta - mg = ma_y = 0$$

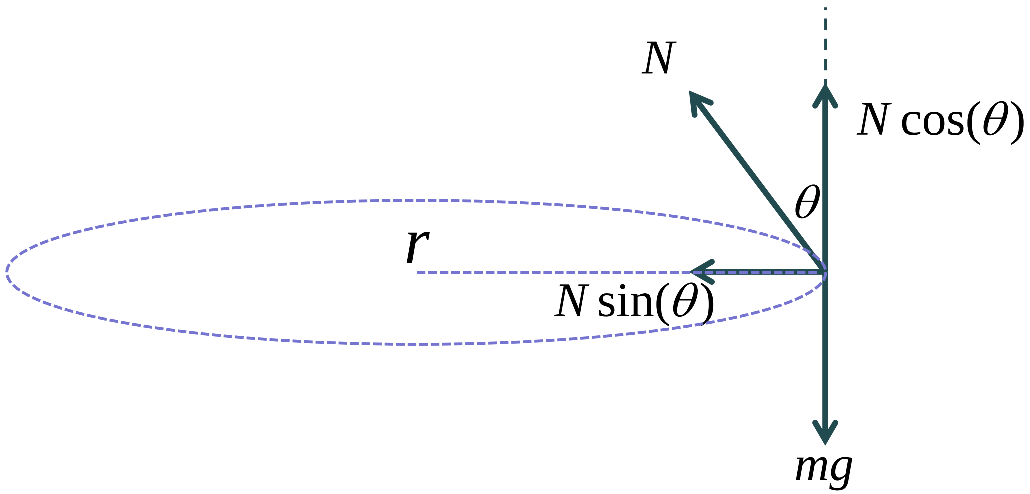
$$N = \left(\frac{mg}{\cos\theta}\right)$$

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

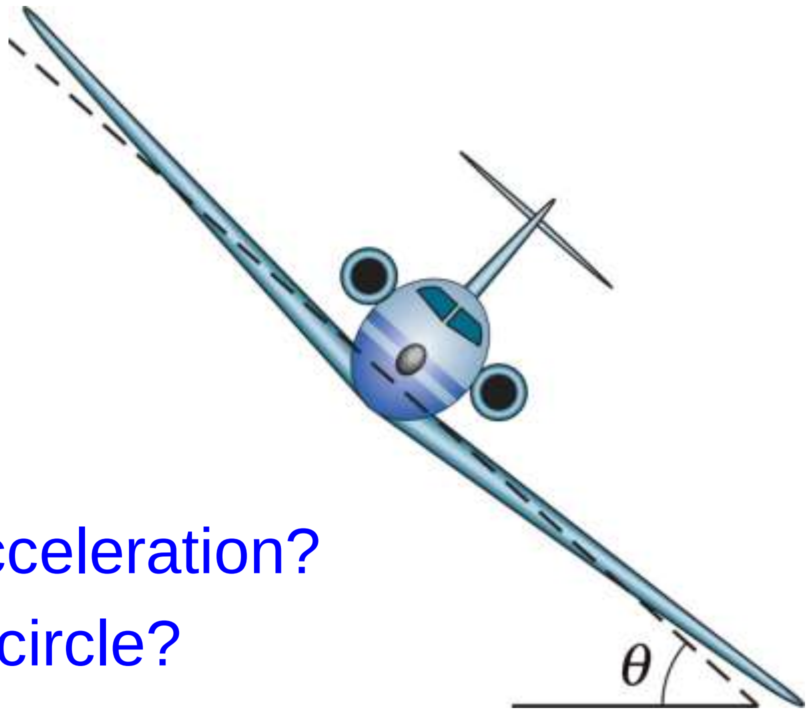
$$\left(\frac{mg}{\cos\theta}\right)\sin\theta = \left(\frac{mv^2}{r}\right)$$

$$\tan\theta = \left(\frac{v^2}{rg}\right) = \left(\frac{(72\,m)^2}{(800\,m)(9.8\,m/s^2)}\right)$$

$$\theta \approx 33^0$$



An airplane is flying in a horizontal circle at 480 MPH (215m/s) with its wings banked at $\theta = 60^0$ with respect to horizontal, as shown below.



1. What is the centripetal acceleration?
2. What is the radius of the circle?

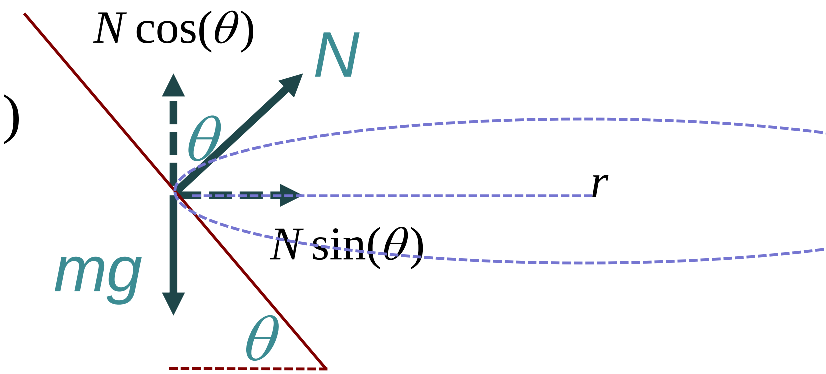
$$N\cos\theta - mg = ma_y = 0 \qquad (Y \;\; force\ equation)$$

$$N = \left(\frac{mg}{\cos\theta}\right)$$

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

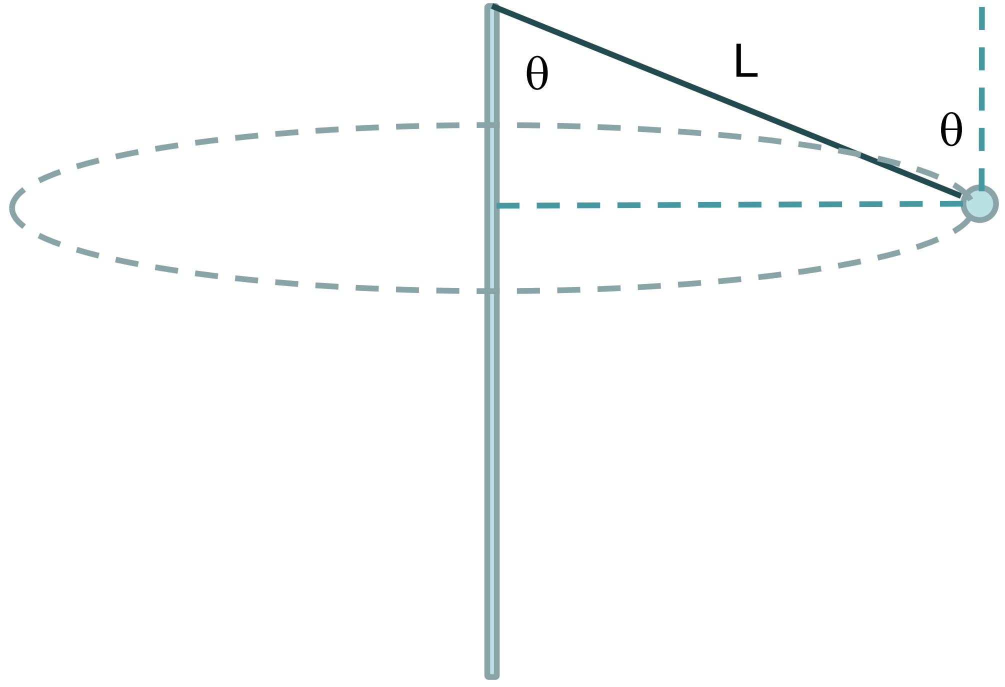
$$a = \frac{v^2}{r} = g\tan\theta = \left(9.8\,m/s^2\right)\left(\tan 60^0\right) = 16.97\,m/s^2$$

$$r = \frac{v^2}{g\tan\theta} = \frac{(215\,m)^2}{\left(9.8\,m/s^2\right)\left(\tan 60^0\right)} = 2.72\times10^3\ m$$



A small ball with m = 2 kg is attached to a string (L=1 m), which is attached to the end of a vertical stick.
The ball is moving around the stick in a uniform circular motion at an angle 60° from vertical.

What is the linear speed of the ball circling around the rod?



A small ball with m = 2 kg is attached to a string (L=1 m), which is attached to the end of a vertical stick.
The ball is moving around the stick in a uniform circular motion at an angle 60° from vertical.

What is the linear speed of the ball circling around the rod?

$$T\cos\theta - mg = ma_y = 0$$

$$T = \left(\frac{mg}{\cos\theta}\right)$$

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

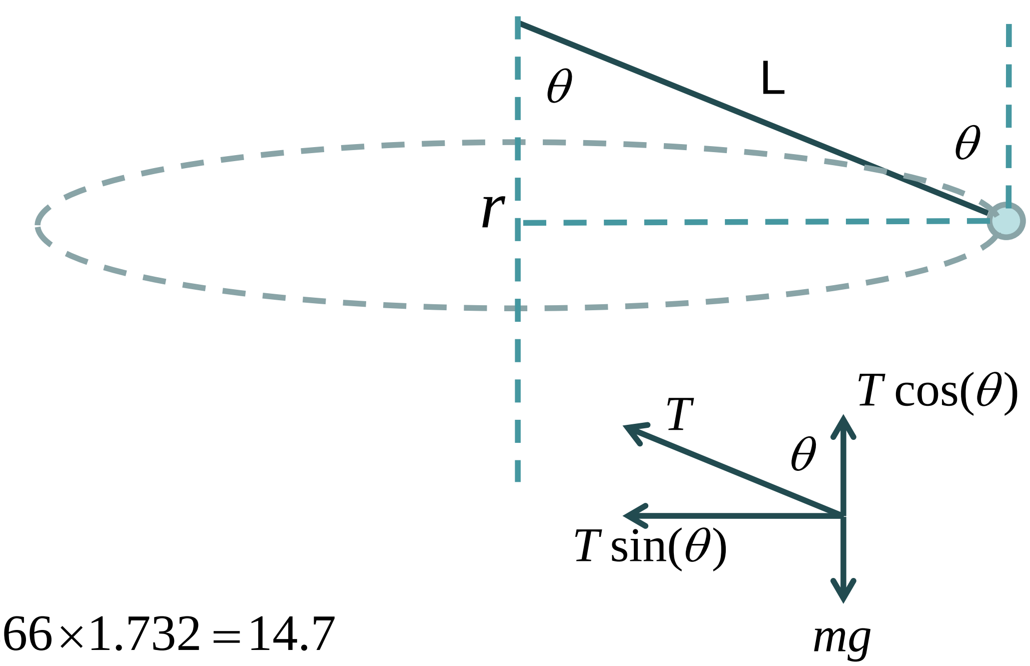
$$\left(\frac{mg}{\cos\theta}\right)\sin\theta = \left(\frac{mv^2}{r}\right)$$

$$\tan\theta = \frac{v^2}{rg} = \frac{v^2}{L\sin(\theta)g}$$

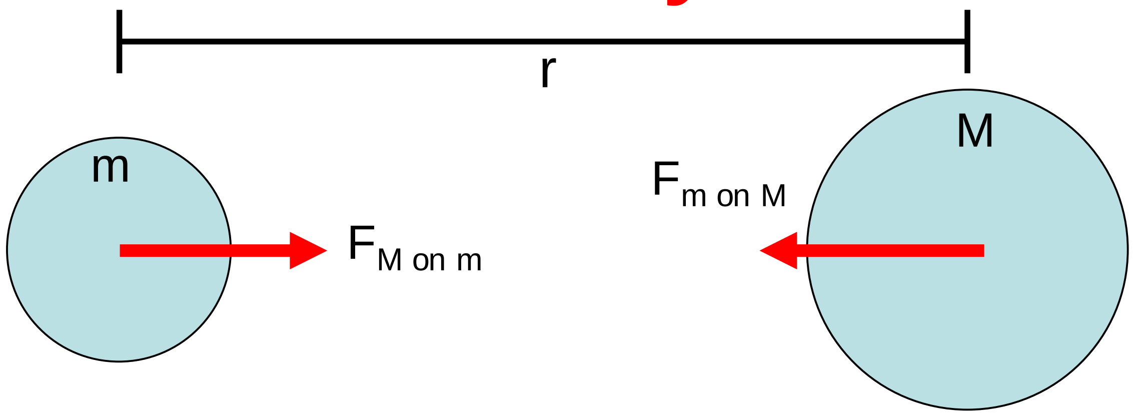
$$v^2 = gL\sin(\theta)\tan(\theta) = 9.8\times1\times0.866\times1.732 = 14.7$$

$$v = 3.83m/s$$

$$r = L\sin(\theta)$$



Gravity



Newton's 3rd Law states: $F_{M\ on\ m} = F_{m\ on\ M}$

Generic Definition for Force due to Gravity:

$$F_{Monm} = \frac{GMm}{r^2}$$

G = Gravitational Constant = 6.67×10^{-11} N m^2/kg^2

r = distance between two centers of mass

Old definition of force due to gravity:

w=mg ; g=9.8 m/s^2

Where does g=9.8 m/s^2 come from?

$$F_{M_e on m} = \frac{GM_e m}{R_e{}^2} = mg$$

$$\frac{GM_e}{R_e{}^2} = g_{surface} = 9.8\frac{m}{s^2}$$

$G = 6.67 \times 10^{-11}\ N\ m^2 / kg^2$

M_e = Mass of the Earth= 5.98×10^{24} kg

$R_e = 6.37 \times 10^6$ m

Example : Fatal Attraction!!!

If Brutus’s mass is 70 kg and the wolverine’s is 18 kg and they are 1 m apart, what is their attraction, a.k.a. force due to gravity? How does it change if they are 2 m apart?