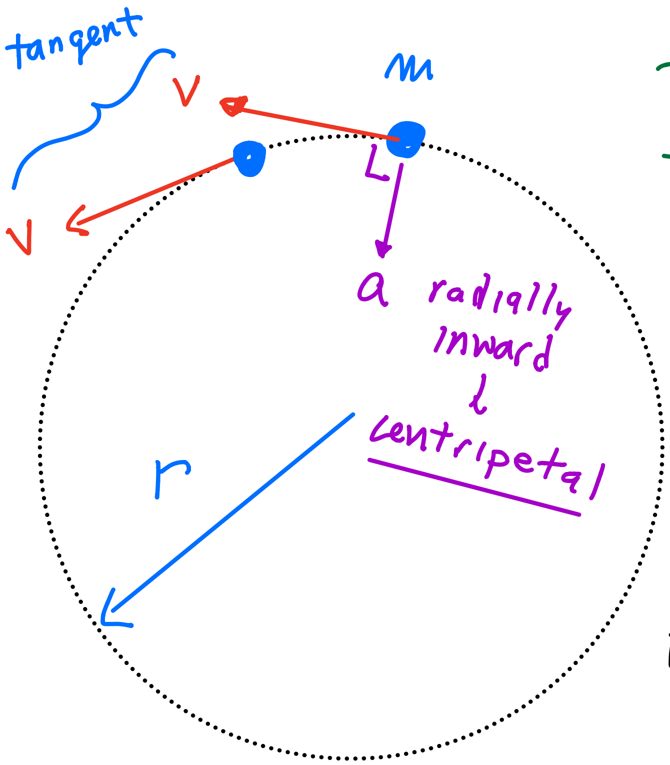


to move in a circle the object must be continually PUSHED (or PULLED) to change its direction

for speed to remain constant we must push $\perp$ to the velocity

$$a \perp v$$

Calculating speed

$$V = \frac{\text{distance}}{\text{time}} = \frac{2\pi r}{T}$$

period: time to go around once

Calculating the acceleration

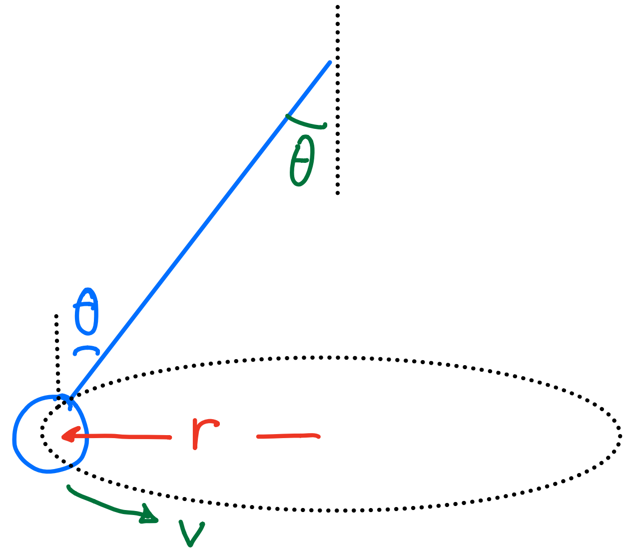
centripetal accel.

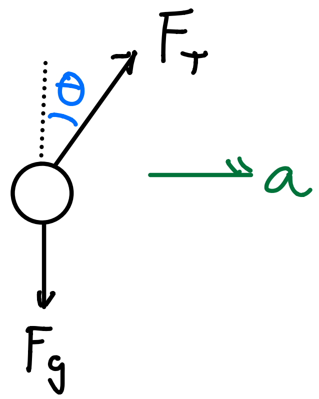
$$\boxed{a = \frac{v^2}{r}}$$

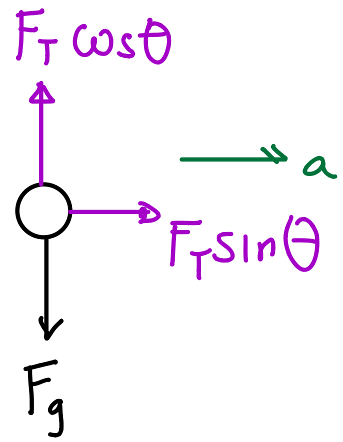
the rate of change of direction

a points toward the center of the circle

Conical pendulum







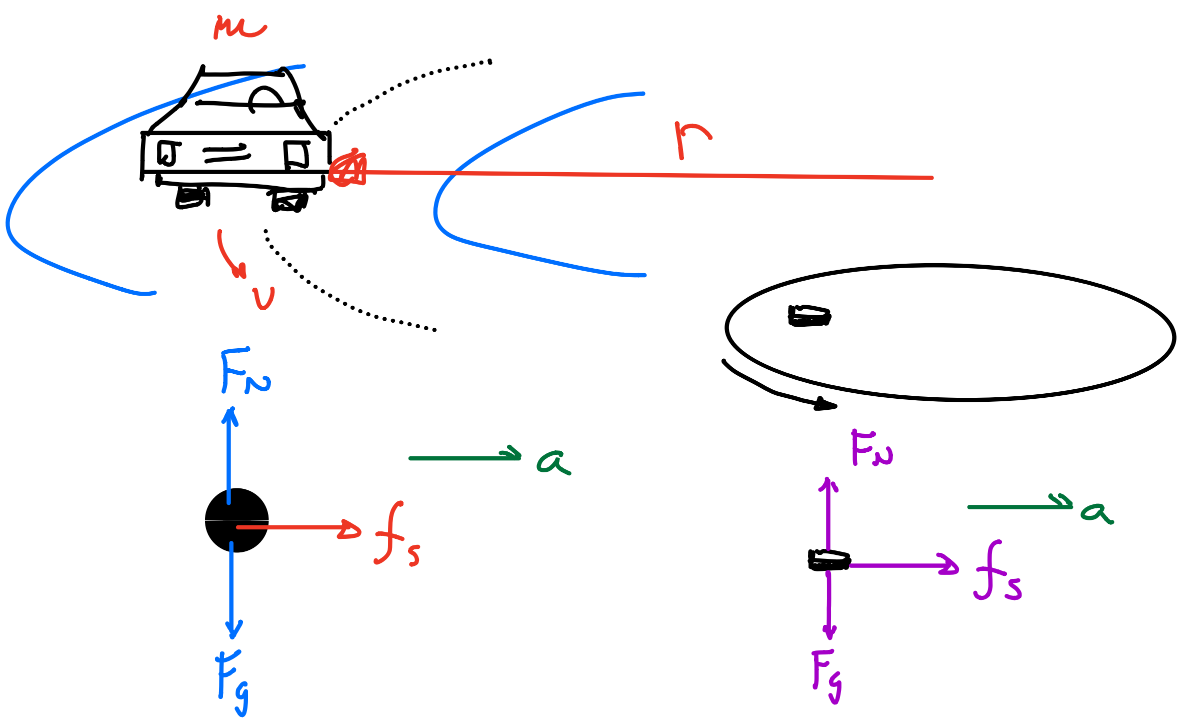
$$\Sigma F_y = 0$$

$$F_T \cos\theta = F_g$$

$$\Sigma F = ma$$

$$F_T \sin\theta = ma$$

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



a) what is the f_s on these objects?

$$\Sigma F_x = m a_x$$

$$\boxed{f_s = m\frac{v^2}{r}}$$

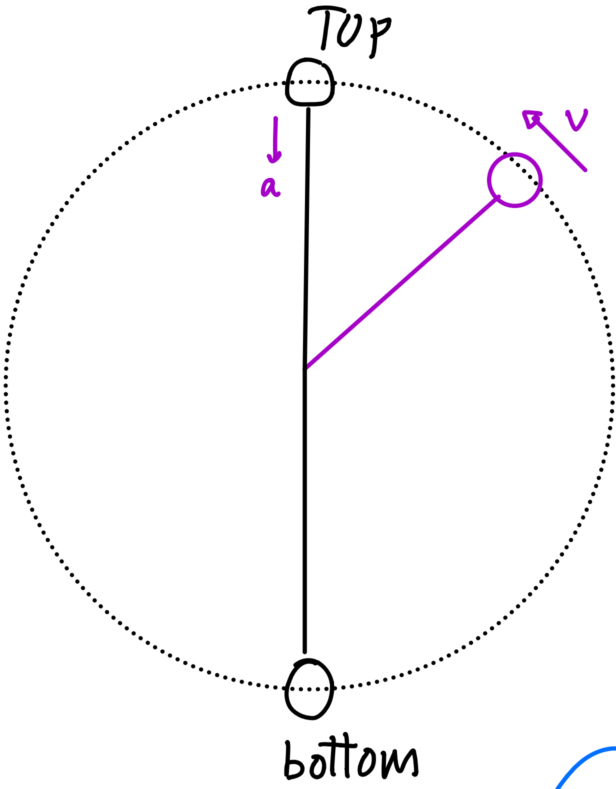
b) what minimum μ is required to keep the objects from sliding?

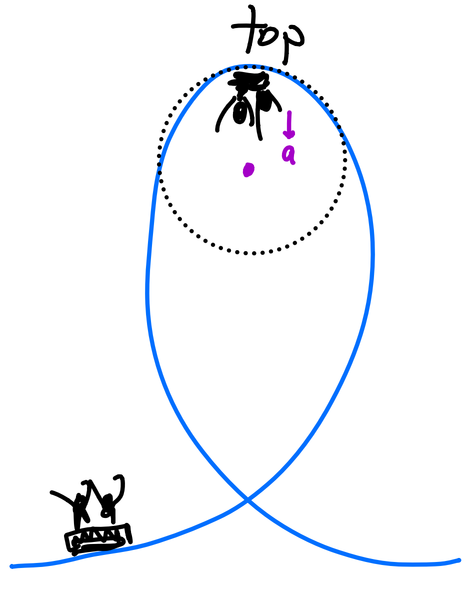
$$f_s = f_{s\,max}$$

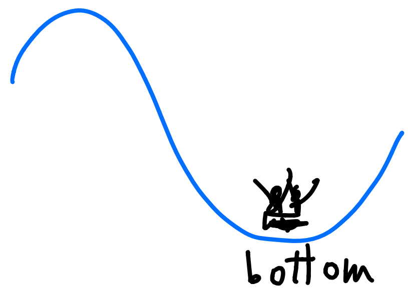
$$\frac{\cancel{m}v^2}{r} = \mu_s F_N = \mu_s \cancel{m} g$$

$$\frac{v^2}{r} = \mu_s g \qquad \boxed{\mu_s = \frac{v^2}{gr}}$$

Vertical circle

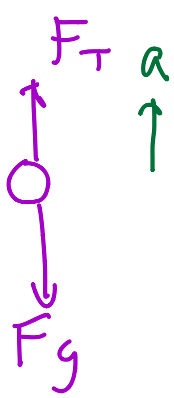


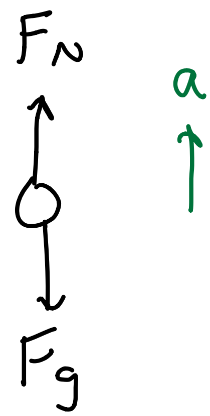




Bottom:

up force > down force





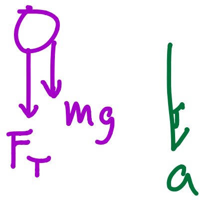
$$\Sigma F = ma$$

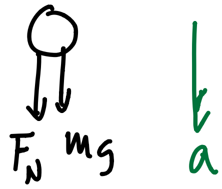
$$F_T - mg = m\frac{v^2}{r}$$

$$\Sigma F = ma$$

$$F_N - mg = m\frac{v^2}{r}$$

TOP



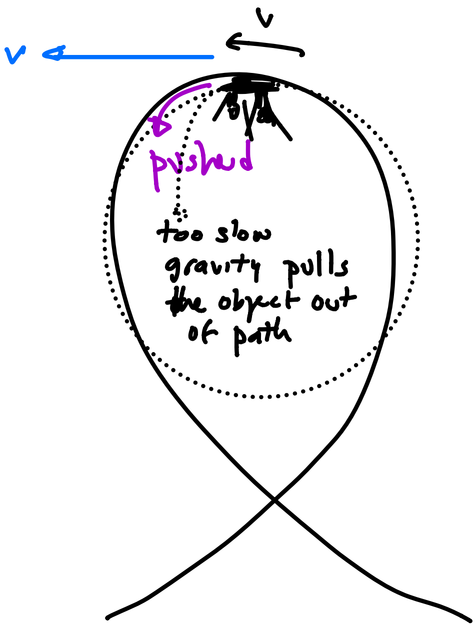


$$\Sigma F = ma$$

$$F_T + mg = m\frac{v^2}{r}$$

$$\Sigma F = ma$$

$$F_N + mg = m\frac{v^2}{r}$$



top of vertical circle

What is the minimum speed to continue the circular path?

$$F_N \to 0 \quad (\text{or } F_T = 0)$$

or F_g provides all $\frac{mv^2}{r}$

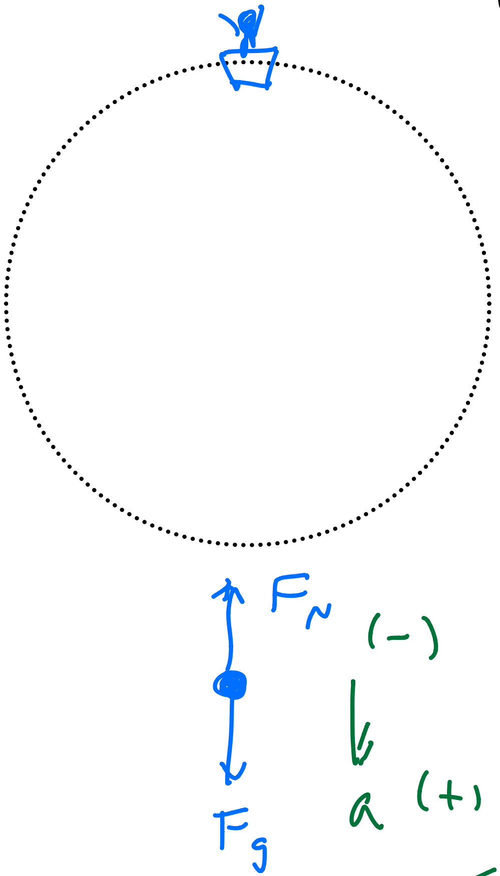
$$F_g = m\frac{v^2}{r}$$

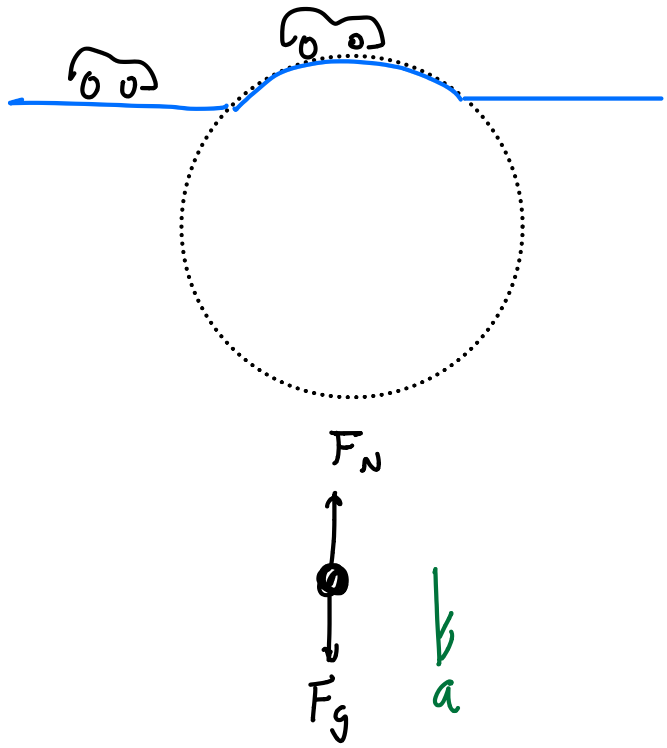
$$\cancel{m}g = \cancel{m}\frac{v^2}{r}$$

$$gr = v^2$$

$$v = \sqrt{gr}$$

Ferris wheel or car over hill (top)





$$\Sigma F = ma$$

$$F_g - F_N = m\frac{v^2}{r}$$