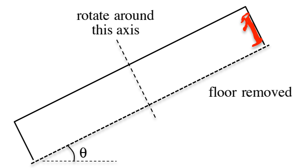
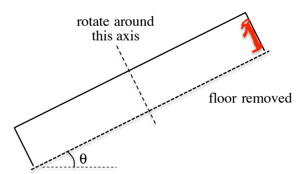
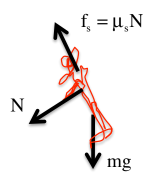
Carnival Ride



A rider stands against the wall of a huge cylinder of radius “R” that is constrained to rotate about its central axis. Once up to speed, the cylinder tilts upward to and angle θ while the rider finds himself pinned against the wall as the floor drops out from under him. If the coefficient of static friction between the rider and the wall is μ_s, what is the minimum speed the cylinder can rotate and keep the man from falling through to the ground?

Clearly, we want to observe the man when he is most vulnerable to falling. That is shown to the right. The f.b.d. that goes with that position is:

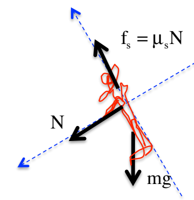


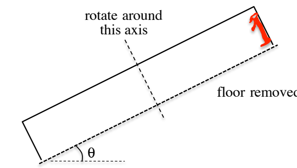


Note 1: As always, the normal force acts away from the support that provides it, and

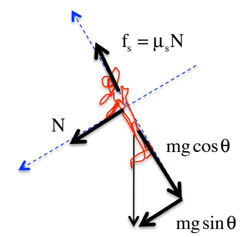
Note 2: The static frictional force is parallel to the surface providing it.

The center seeking direction is toward the center of the arc, so our axis becomes:





We need to break mg into its component parts along out axis, or:



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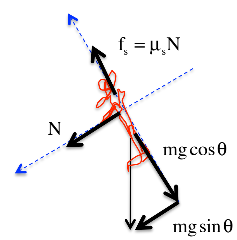

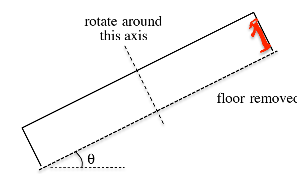

$\sum F_y$:

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

$$\Rightarrow \quad N = \frac{mg\cos\theta}{\mu_s}$$

and

$\sum F_{c.s.}$:

$$N + mg\sin\theta = ma_{c.s.}$$

$$\Rightarrow \quad \left(\frac{mg\cos\theta}{\mu_s}\right) + mg\sin\theta = m\left(\frac{v^2}{R}\right)$$

$$\Rightarrow \quad v = \left(\left(\frac{Rg\cos\theta}{\mu_s}\right) + Rg\sin\theta\right)^{1/2}$$