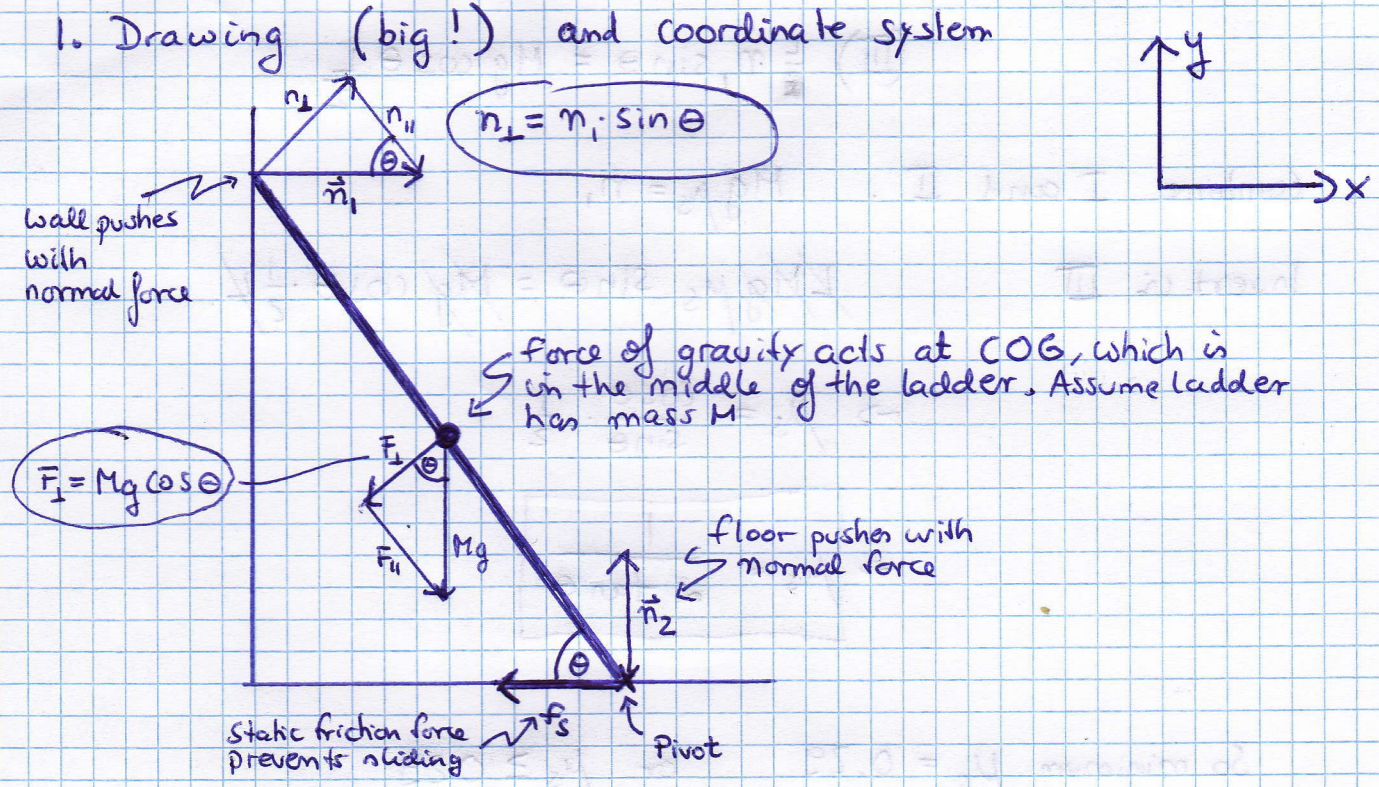
Example

What is the static friction coefficient needed between a ladder and a floor to ensure a $L = 3m$ long ladder leaned against a wall with $\theta = 60°$ does not slip?

1. Drawing (big!) and coordinate system



2. Force diagram - add forces to drawing
3. Decompose forces into $\perp$ and $\parallel$ components for rotation around pivot (see triangles above)

   <u>and</u> into x, y components (not necessary here)

4. Setup 3 equations

(1) $F_{x\,net} = 0 \longrightarrow -f_s + n = 0 \Rightarrow \boxed{f_s = n_1}$ I

(2) $F_{y\,net} = 0 \longrightarrow n_2 - Mg = 0 \Rightarrow \boxed{n_2 = mg}$ II

(3) $\tau_{net} = 0 \longrightarrow F_\perp \cdot \frac{L}{2} - n_\perp L = 0$

$\Rightarrow \boxed{Mg\cos\theta\frac{L}{2} - n_1 \cdot \sin\theta L = 0}$ III

5. Solve, and use $f_s = n_2 \cdot \mu_s$ for maximum f_s (to get minimum μ_s)

with that we have (I) $n_2 \mu_s = n_1$

(II) $n_2 = Mg$

(III) $L\, n_1 \sin\theta = Mg \cos\theta \frac{L}{2}$

Combine I and II : $Mg\mu_s = n_1$

Insert in III $\cancel{L}\cancel{Mg}\mu_s \sin\theta = \cancel{Mg} \cos\theta \cdot \frac{1}{2}\cancel{L}$

$$\rightarrow \mu_s = \frac{\cos\theta}{\sin\theta} \cdot \frac{1}{2}$$

$$\rightarrow \boxed{\mu_s = \frac{1}{2\tan\theta}}$$

So minimum $\mu_s = 0.29$ or $\mu_s \geq 0.29$