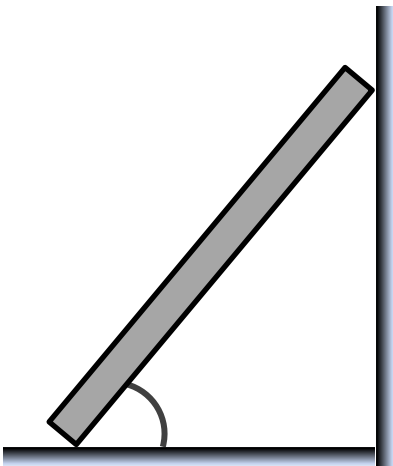


STATIC / COMPLETE EQUILIBRIUM IN 2D

- So far we've solved Equilibrium problems that were essentially 1 dimensional: all forces acted in the same axis (X or Y).
 - More advanced problems have forces in 2 axes, and some will need to be _____.
 - Remember however that Torques are _____, so we will never need to _____ them.

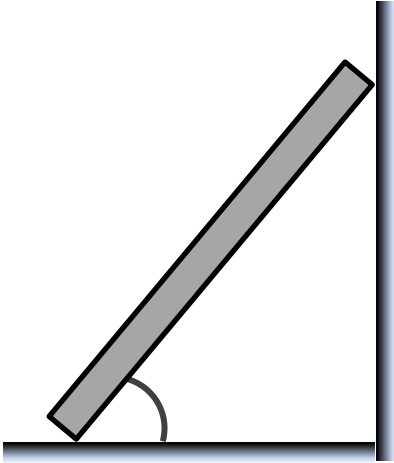
EXAMPLE: A ladder of mass 10 kg (uniformly distributed) and length 4 m rests against a vertical wall while making an angle of 53° with the horizontal, as shown. Calculate the magnitude of the:

- (a) Normal force at the bottom of the ladder;
- (b) Normal force at the top of the ladder;
- (c) Frictional force at the bottom of the ladder;
- (d) Minimum coefficient of static friction needed;
- (e) Total contact force at the bottom of the ladder.



PRACTICE: PERSON ON A LADDER

PRACTICE: A ladder of mass 20 kg (uniformly distributed) and length 6 m rests against a vertical wall while making an angle of $\theta = 60^\circ$ with the horizontal, as shown. A 50 kg girl climbs 2 m up the ladder. Calculate the magnitude of the total contact force at the bottom of the ladder (Remember: You will need first calculate the magnitude of $\mathbf{N}_{\text{BOT}}$ and $\mathbf{f}_s$).



EXAMPLE: MINIMUM ANGLE AND FRICTION ON LADDER

EXAMPLE: A ladder of mass M (uniformly distributed) and length L rests against a vertical wall while making an angle with the horizontal, as shown. Derive an expression for the:

- (a) Minimum coefficient of static friction necessary for the ladder to stay balanced at an angle of θ ;
- (b) Minimum angle at which the ladder can stay balanced, for a coefficient of static friction of μ_s .
- (c) Minimum angle at which the ladder can stay balanced, for any coefficient of friction, if there are no masses on it.

