



Mocha the Mammoth has a total mass of  $m$  kg and is initially standing still on the ice. If a force  $F$  N is applied on Mocha as shown above, determine if she will remain still, begin sliding, or tip over. Mocha's center of gravity is indicated by **G**. Assume  $g = 9.81$  N/kg.

What is the largest static friction force that can be applied on Mocha by the surface? Assume that she would not tip.

$$+ \uparrow \Sigma F_y = 0 \rightarrow N - mg = 0$$

$$\Rightarrow N = mg$$

$$F_{max} = \mu_s N = \mu \cdot mg$$

What is the largest force  $F$  that can be applied on Mocha before she tips over? Assume that she would not slide.

Assume a pivot point  $B$  where friction and normal forces act on.

$$\Sigma M_B = 0 \rightarrow b \cdot mg - d \cdot F = 0$$

$$\Rightarrow F_{tip} = \frac{b \cdot mg}{d}$$

Will Mocha remain still, slide, or tip over?

If  $F \leq F_{max}$  and  $F \leq F_{tip}$ ,

Mocha will remain still.

If  $F \leq F_{max}$  and  $F > F_{tip}$ ,

Mocha will tip over.

If  $F > F_{max}$  and  $F \leq F_{tip}$ ,

Mocha will slide.

If  $F$  is greater than both then:

If  $F_{max} \leq F_{tip}$ , Mocha will slide, otherwise, Mocha will tip over.