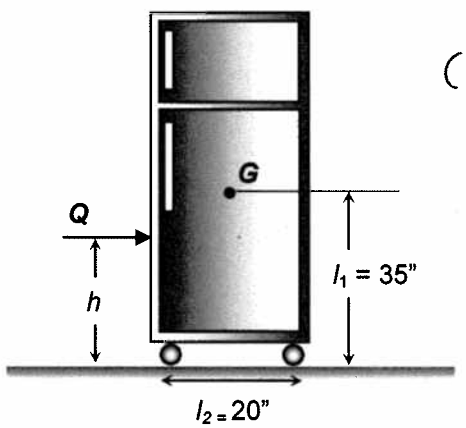
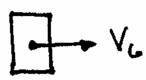
Example

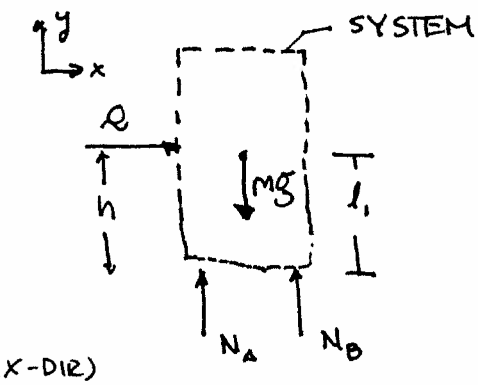
A super-light space-age refrigerator developed by Thomco Industries, Inc. rests on two frictionless casters as shown in the figure. A force of Q = 50 lbf is applied a distance h above the ground. If the fridge only weighs an incredible 80 lbf,

a) find the acceleration of the fridge and the range of h for which the fridge will not tip.
b) Repeat part a) if the casters are locked and the fridge moves relative to the ground with $\mu_k = 0.25$.



(a)





Cons. Linear Mom. (x-DIR)

$$\frac{d}{dt}(P_{sys,x}) = \sum F_x + \sum \dot{m}_{in} V_x - \sum \dot{m}_{out} V_x$$

$$\frac{d}{dt}(\quad) =$$

$$m\frac{dV_G}{dt} = Q \qquad m \qquad = Q \qquad a_x = \frac{Q}{m} = \frac{50\ \text{lbf}}{80\ \text{lbm}}$$

$$\left(\text{OR } a_x = \frac{Q}{W/g} = \frac{50\ \text{lbf}}{80\ \text{lbf}/32.2\ \text{ft/s}^2}\right)$$

=

FOR TIPPING ABOUT A $N_B \rightarrow$

Cons. Linear Mom (y-DIR)

$$\frac{d}{dt}(P_{sys,y}) = \sum F_y + 0 - 0$$

=

$$N_A = mg$$

Con. Angular Mom @ A

$$(+)\ \frac{d}{dt}(L_A) = \sum M_A + \sum(\vec{r}\times\vec{V})\dot{m}_{in} - \sum(\vec{r}\times\vec{V})\dot{m}_{out}$$

$$\frac{d}{dt}(\quad) =$$

$$l_1 m a_x = h Q + \frac{l_2}{2} m g$$

$$h = \frac{l_1 m a_x - l_2/2\, m g}{Q} = \frac{\frac{35'' \cdot 80\,\text{lbf}}{32.2\,\text{ft/s}^2} \cdot 20.1 \frac{\text{ft}}{\text{s}^2} - 10'' \cdot 80\,\text{lbf}}{50\ \text{lbf}}$$

$$= 19''$$

FOR TIPPING ABOUT B $N_A \longrightarrow$

Cons. Linear Mom. (y-DIR)

$$\frac{d}{dt}(\mathbb{P}_{sys,y}) = \sum F_y + \angle_0 - \angle_0$$

$$=$$

$$N_B = mg$$

Cons. Angular Mom. @ B

$$\frac{d}{dt}(L_B) = \sum M_B + \angle_0 - \angle_0$$

$$\frac{d}{dt}(\quad) =$$

$$h = \frac{\frac{l_2}{2} m g + l_1 m a_x}{Q} = \ldots = 51''$$

$$< h <$$

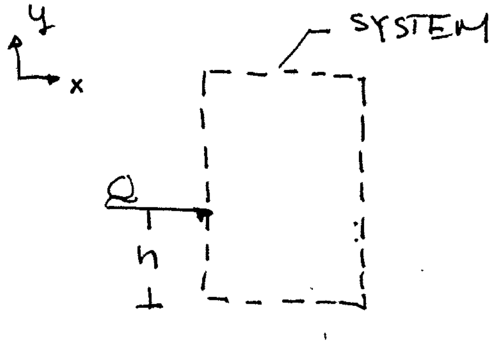
Repeat Con. Angular Mom. @ G

$$\frac{d}{dt}(L_G) = \sum M_G + \angle_0 - \angle_0$$

$$\frac{d}{dt}(\quad) =$$

$$h = \frac{\frac{l_2}{2} N_B + Q l_1}{Q} = \frac{\frac{l_2}{2} \qquad + Q l_1}{Q} = \ldots = 51''$$

(b)



FOR TIPPING @ A $\underline{N_B \rightarrow 0}$ & ∴ $\underline{\quad\quad \rightarrow 0}$

COLM (X DIR)

$$\frac{d}{dt}(\mathbb{P}_{sys,x}) = \sum F_x + \quad -$$

$$\frac{d}{dt}(\quad) =$$

$$m\frac{d}{dt}(\quad) =$$

COLM (y-DIR)

$$\frac{d}{dt}(\mathbb{P}_{sys,y}) = \sum F_y + \quad -$$

$$=$$

$$N_A = mg$$

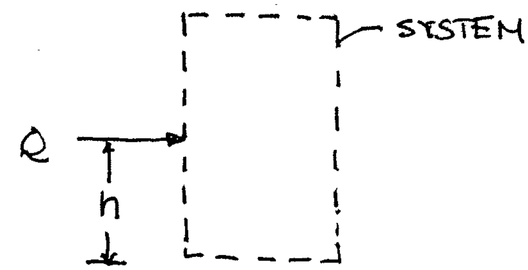
$$m a_x = \mu_k m g + Q \qquad a_x = \mu_k g + \frac{Q}{m} = \ldots =$$

CoAM @ A

$$\frac{d}{dt}(L_A) = \sum M_A + \cancel{L_o} \quad - \cancel{L_o}$$

$$\frac{d}{dt}\left[\quad\right] =$$

$$h = \frac{l_1 m a_x - \frac{l_2}{2} m g}{Q} = \ldots = 5''$$



FOR TIPPING @ B $\underline{N_A \rightarrow}$ ϵ: $\underline{\quad \rightarrow 0}$

CoLM (x-DIR)

$$\frac{d}{dt}(\mathbb{P}_{x,sys}) = \sum F_x + \cancel{\mathcal{L}}_{\rightarrow 0} - \cancel{\mathcal{L}}_{\rightarrow 0}$$

$$\frac{d}{dt}(\quad) =$$

$$m a_x = \mu_k N_B + Q$$

$$a_x = \mu_k g + \frac{Q}{m}$$

$$= \ldots = \boxed{\quad}$$

CoLM (y-DIR)

$$\frac{d}{dt}(\mathbb{P}_{sys,y}) = \sum F_y + \cancel{\mathcal{L}}_{\rightarrow 0} - \cancel{\mathcal{L}}_{\rightarrow 0}$$

$$\frac{d}{dt}(\quad) =$$

$$N_B = mg$$

CoAM @ B

$$(+)\ \frac{d}{dt}(L_{sys,B}) = \sum M_B + \cancel{\mathcal{L}}_{\rightarrow 0} - \cancel{\mathcal{L}}_{\rightarrow 0}$$

$$\frac{d}{dt}(\quad) =$$

$$-\ell_1 m a_x = -hQ + \frac{\ell_2}{2} mg$$

$$h = \frac{\ell_1 m a_x + \frac{\ell_2}{2} mg}{Q} = \ldots = \boxed{\quad}$$

$$\boxed{\quad < h < \quad}$$