HW8

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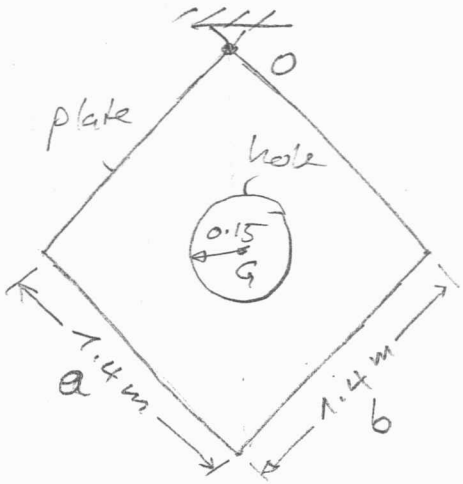
$\rho = 50\ kg/m^3$

thickness $= 0.05\ m$



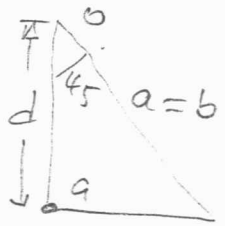
$$I_G = \frac{1}{12} m_p (a^2+b^2) - \frac{1}{2} m_h r^2$$

$$= \frac{1}{12}[50(1.4)(1.4)(0.05)](1.4^2+1.4^2) - \frac{1}{2}[50(\pi)(0.15)^2(0.05)](0.15)^2$$

$$I_G = 1.5987\ kg\,m^2$$

$$I_O = I_G + md^2$$

$$d = a\cos 45 = 1.4/\sqrt{2}$$



$$m = m_p - m_h$$

$$= 50(1.4)(1.4)(0.05) - 50(\pi)(0.15)^2(0.05) = 4.7233\ kg$$

$$I_O = 1.5987 + (4.7233)\left(\frac{1.4}{\sqrt{2}}\right)^2 = 6.23\ kg$$

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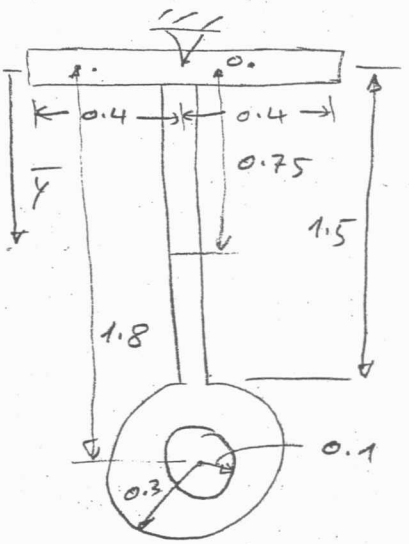

$$\bar{y} = \frac{0 + 0.75(3)(1.5) + \pi(0.3)^2(12)(1.5) - \pi(0.1)^2(12)(1.8)}{3(0.8) + 3(1.5) + \pi(0.3)^2(12) - \pi(0.1)^2(12)}$$

$$\bar{y} = 0.8878 = 0.888\ m$$

$$I_O = \frac{1}{12}[3(0.8)](0.8)^2 + \frac{1}{3}[3(1.5)](1.5)^2$$

$$+ \frac{1}{2}[12(\pi)(0.3)^2](0.3)^2 + [12(\pi)(0.3)^2](1.8)^2$$

$$- \frac{1}{2}[12(\pi)(0.1)^2](0.1)^2 - [12(\pi)(0.1)^2](1.8)^2$$

$$= 13.43\ kg\,m^2$$

$$I_O = I_G + md^2 = I_G + (9.916)(0.8878)^2$$ (m_{total})

$$\hookrightarrow I_G = I_O - md^2 = 5.61\ kg\,m^2$$

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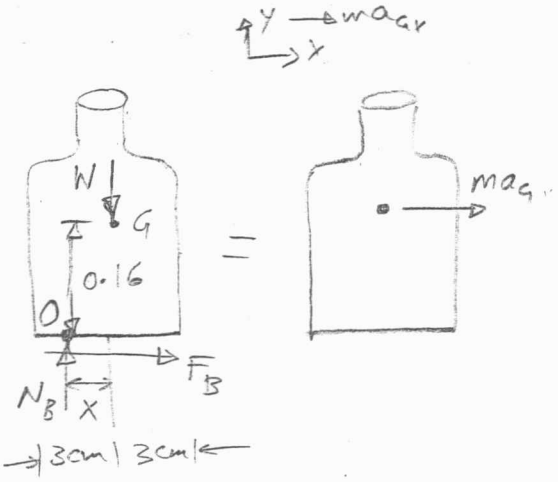

$\rightarrow \sum F_x = ma_{Gx}$: $F_B = 2a_G$ (1)

$\uparrow \sum F_y = ma_{Gy}$: $N_B - 20N = 0$ (2)

$\curvearrowleft \sum M_{(O)} = \sum (M_k)_{(O)}$

$Wx = 0.16\, ma_G$ (3)

(2) $\rightarrow$ $\boxed{N_B = 20N}$

Assum bottle is about to slip

$\hookrightarrow F_B = \mu_s N_B = 0.2(20) = 4N$

$\hookrightarrow a_G = \frac{F_B}{2} = 2\ m/s$

$\hookrightarrow x = \frac{0.16\, ma_G}{W} = \frac{0.16(2)}{20}(2) = 0.032 = 3.2\ cm > 3cm$ ↯

$\hookrightarrow$ The bottle will tip before slipping

$\hookrightarrow$ set $x = 3cm = 0.03m$ $\quad m = \frac{W}{g} = \frac{20}{9.81} = 2.04\ kg$

(3): $a_G = \frac{Wx}{0.16m} = \frac{20(0.03)}{0.16(2.04)} = 1.838\ m/s^2$

$N_B = 20N$

(1) $F_B = ma_G = 3.75 < 4 = \mu_s N_B$ OK✓

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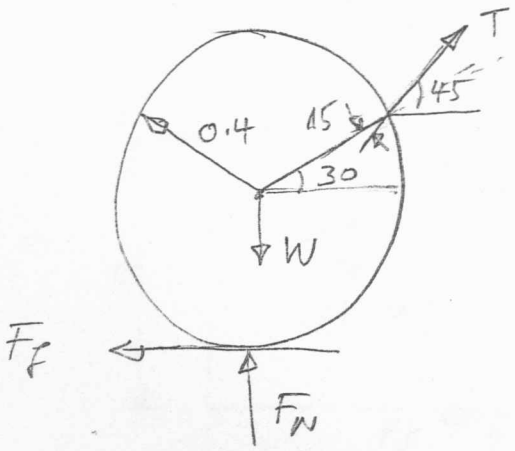
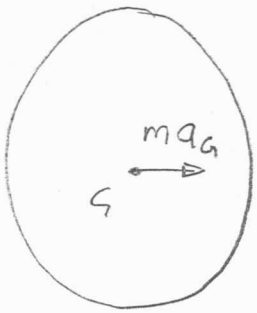
FBD



KD



$a_t = a_G$

$F_f = \mu_k F_N = 0.1\, F_N$ $\qquad W = mg$

$\rightarrow \Sigma F_x = ma_G$

$T\cos 45 - 0.1 F_N = 800 a_G \quad (1)$

$\uparrow \Sigma F_y = 0$

$F_N - W + T\sin 45 = 0 \quad (2)$

$\Sigma M_G = 0$, No rotation

$T\sin 15\,(0.4) - 0.1 F_N\,(0.4) = 0 \quad (3)$

Solving (1) through (3) yields

$F_N = 6163.37\,N$

$T = 2381.575\,N$

$\hookrightarrow$ $\boxed{a_G = 1.3345\ m/s^2}$

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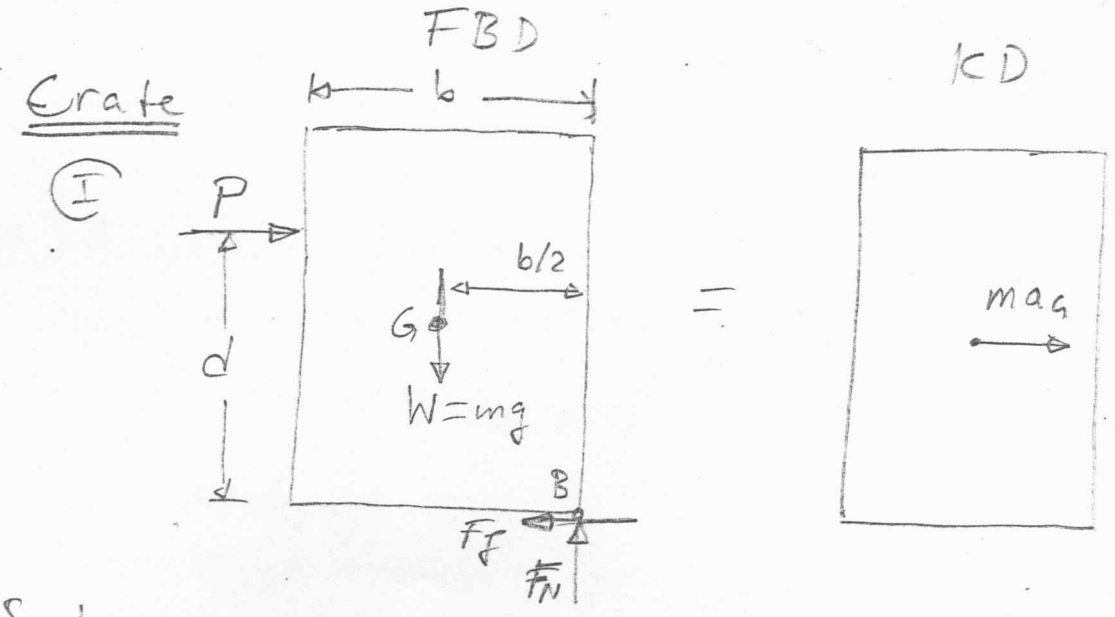
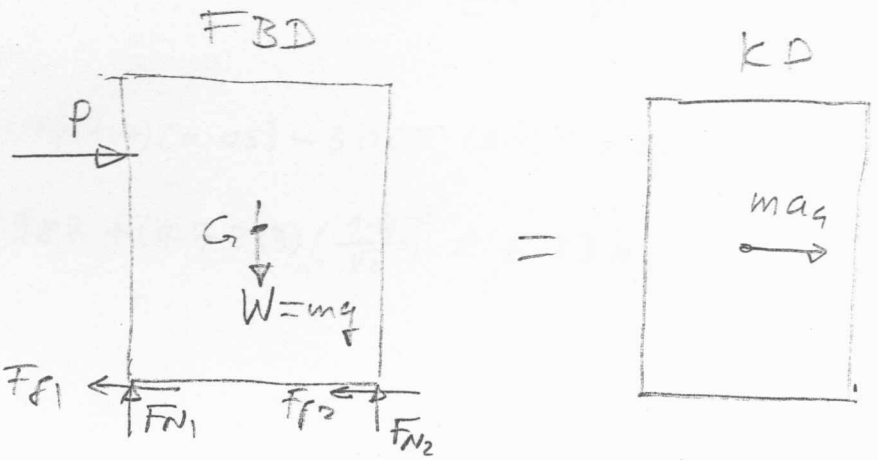
Crate



System



Require F_N to act at corner B for tipping

(I) $\curvearrowright \Sigma M_B = \Sigma (M_k)_B$

$$Pd - mg\left(\frac{b}{2}\right) = ma_G\left(\frac{h}{2}\right) \quad (1)$$

(II): $\Sigma F_x = ma_G$: $P = ma_G$ (2)

(2) in (1) and solving for $P = P_{max}$ yields

$$\boxed{P_{max} = \frac{mgb}{2(d - \frac{h}{2})}}$$