Rotation

$$\vec{r} \times \vec{F} = \vec{r} \times m\,\vec{a}$$

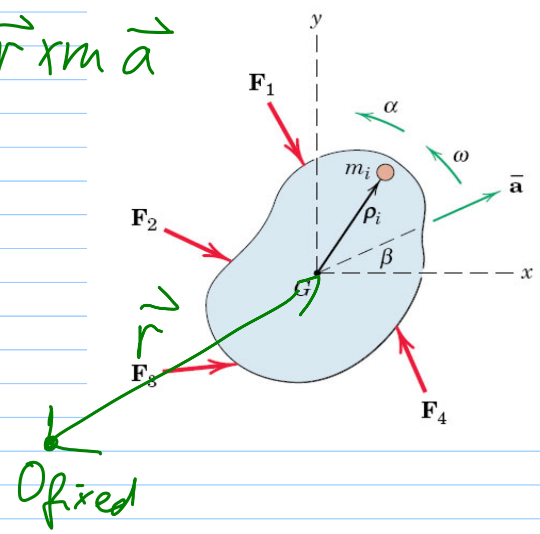
Plane Motion

3 equations:

Σ Forces_x

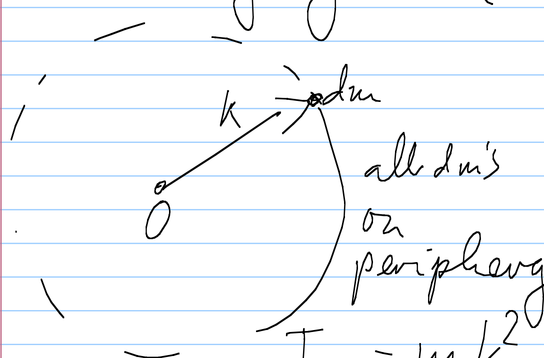
Σ Forces_y

Σ Moments about G



$$I = \int r^2\,dm$$

Radius of Gyration



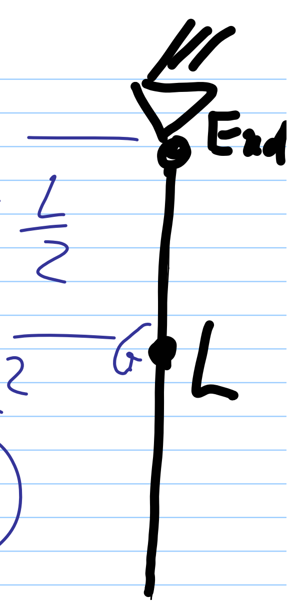
$$I_O = m k^2$$

$$I_G = \frac{1}{12} m L^2$$

$$I_{End} = I_G + m\left(\frac{L}{2}\right)^2 \qquad \frac{L}{2}$$

$$= \left(\frac{1}{12} + \frac{1}{4}\right) m L^2$$

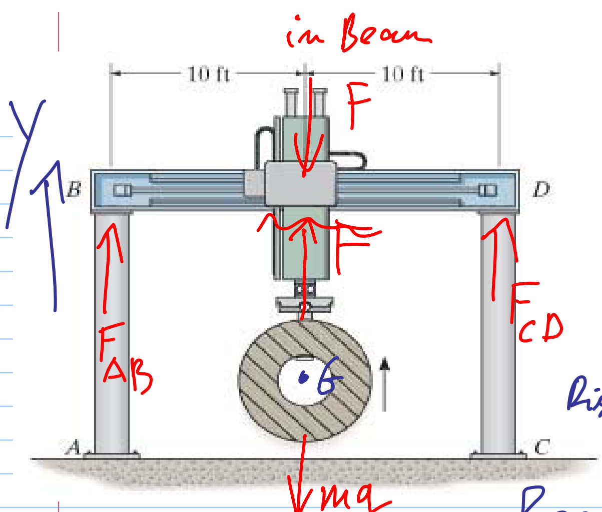
$$= \frac{1}{3} m L^2$$



$$Translation: \sum F_x = m * \ddot{x}$$

$$\sum F_y = m * \ddot{y}$$

$$Rotation: \sum M_G = I_G * \alpha$$



[Problem 17.27]

When the lifting mechanism is operating, the 400-lb load is given an upward acceleration of a=5 ft/s^2. (a) Determine the compressive force the load creates in each of the columns, AB and CD. Assume the columns only support an axial load.

Disk: $\sum F_y = F - 400\,lbf = \frac{400}{32.2} a_y$

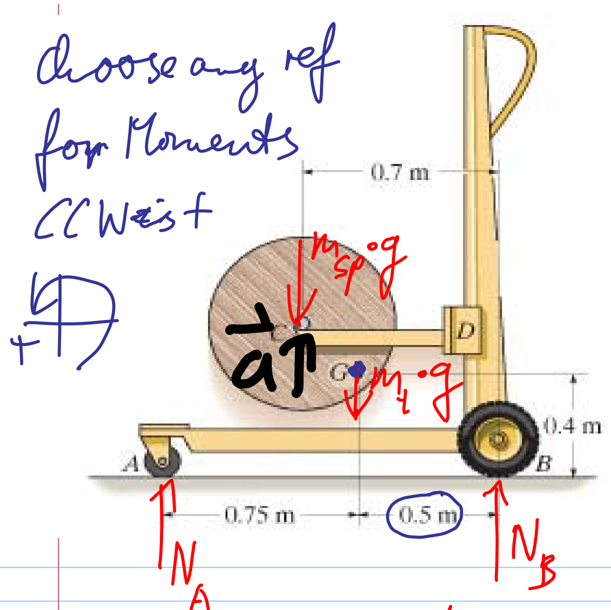
Beam: $\sum F_y = 2F_{AB} - F = 0$ static

$2F_{AB} = F = 400\ lbf$

with accel $F = 400\,lbf + \left(\frac{400}{32.2} \cdot 5\right) \cdot lbf = 462$

$F_{AB} = 200\ lbf$ if v = const

choose any ref for Moments
CCW is +



Problem 17.29 •

The lift truck has a mass of 70 kg and mass center at G. (a) If it lifts the 120kg spool with an acceleration of , determine the reactions on each of the four wheels. The loading is symmetric. Neglect the mass of the

$$\Sigma F_y = N_A + N_B - m_{sp} \cdot g - m_t \cdot g = m_{sp} \cdot a$$

Truck — Spool — Reaction at A — $m_{sp} \cdot a \cdot 0.7m$

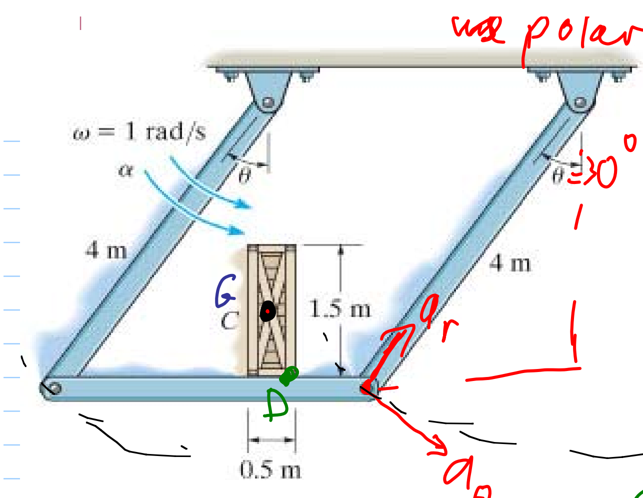
$$(2)\ \Sigma M_B = m_t \cdot g \cdot 0.5 + m_{sp} \cdot g \cdot 0.7 - N_A \cdot 1.25 = -m_{sp} \cdot a_y \cdot 0.7$$

from (2): $N_A = 567.7$ N

from (1): $N_B = 544$ N

Curvilinear Motion

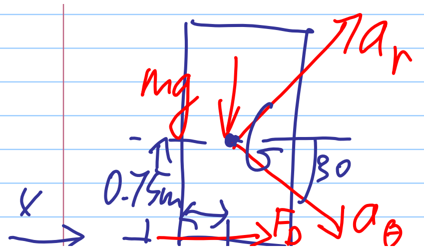
use polar coords



$\bar{a} = (-r\omega^2) u_r + r\alpha \cdot u_\theta$

Problem 17.53 •

The 50-kg uniform crate rests on the platform for which the coefficient of static friction is mu_s = 0.5. (a) If at the instant theta = 30 degree(s) the supporting links have an angular velocity omega = 1 (rad/s) rad/s and angular acceleration alpha =0.5 rad/s^2, determine the frictional force on the crate.



$a_{D,rad} = -1^2 \cdot 4 = -4\ m/s^2$

$a_{D,\theta} = 0.5 \cdot 4 = 2\ m/s^2$

N_D ↑ 0.25 m

Newton: $\sum F_x =$ [illegible] $= 50 \cdot 4 \sin 30^\circ + 50 \cdot 2 \cos 30^\circ$

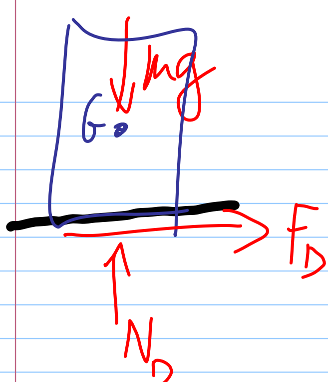
$\sum F_y = N_D - 50 \cdot 9.81 = 50 \cdot 4 \cos 30^\circ - 50 \cdot 2 \cdot \sin 30^\circ$

$F_D = 188.6\ N$ max. F_D for $\mu_s = 0.5 = \mu_s \cdot N_D$

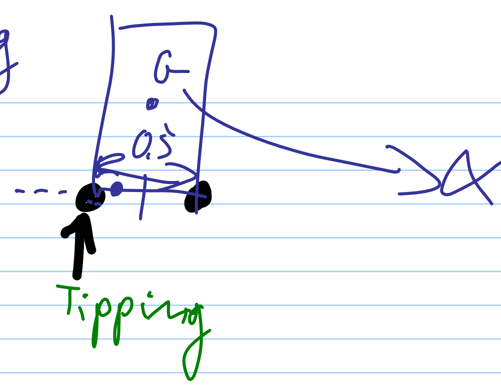
$N_D = 613.7\ N$ $0.5 \cdot 613.7 = 306.9\ N$

for now ok ✓

$\sum M_G$



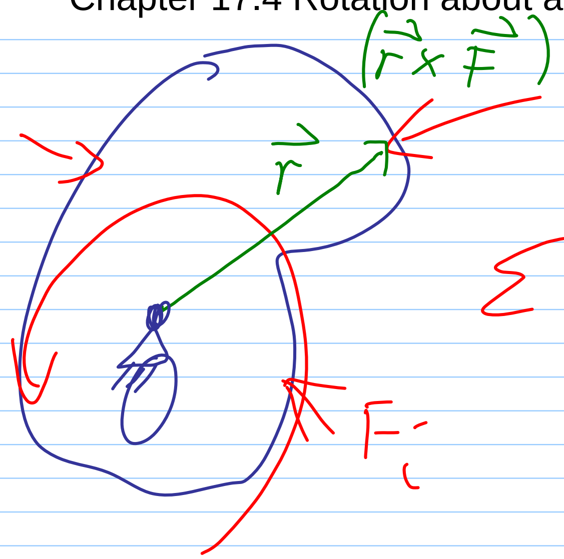
Tipping



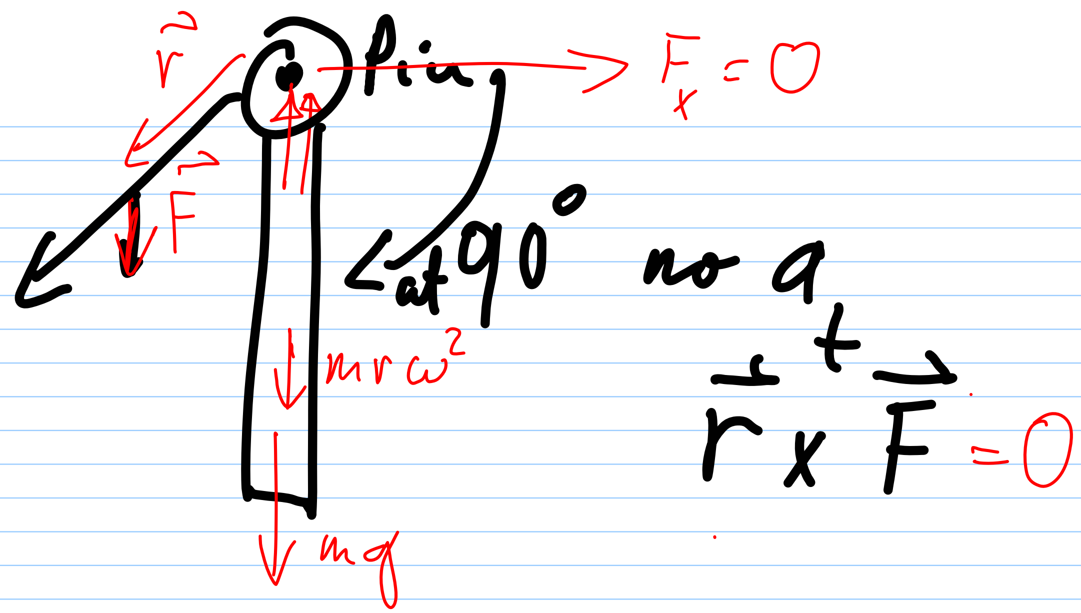
$\sum M_G = N_D \cdot x - F_D \cdot 0.75 = 0$

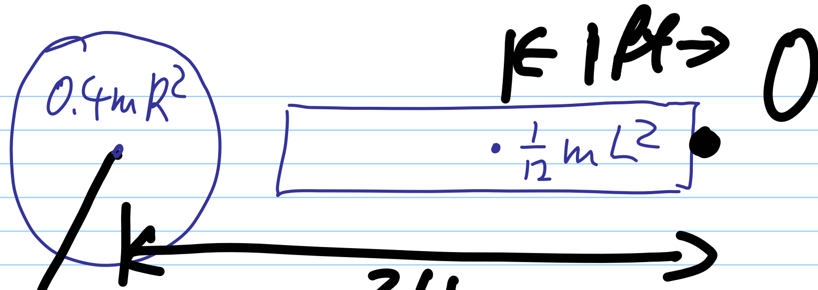
$x = 0.23\ m < 0.25$

Chapter 17.4 Rotation about a Fixed Point



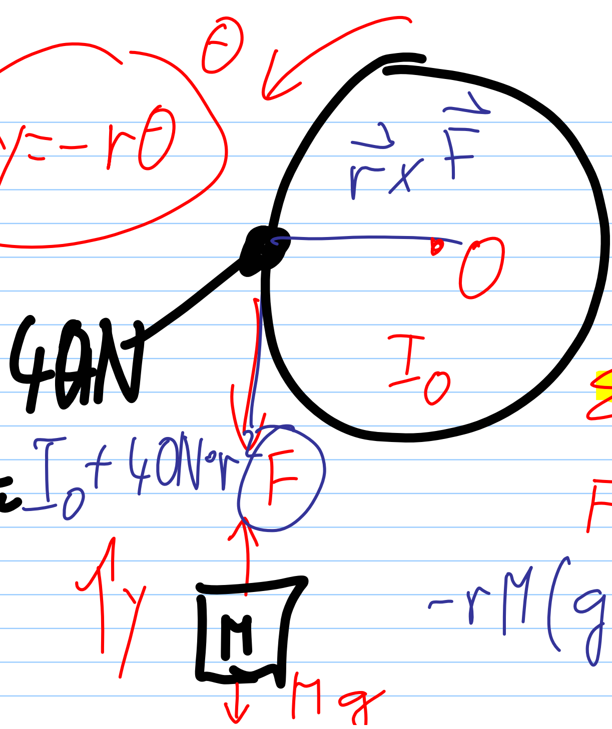
$$\Sigma M_{(O)} = \cdots = I_O \cdot \alpha$$





$$\left(I_G + mL^2\right)_{Sph.} + \left(I_{G,Bar} + mL_2^2\right)_{Rod}$$

$y = -r\theta$



$\sum M_{(O)} = r \cdot F = I_O \cdot \alpha$ (1)   (F = 40N)

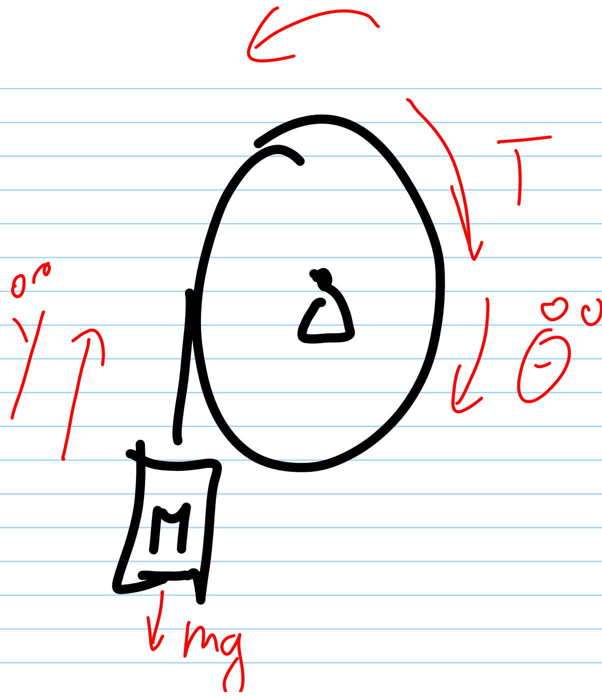
$$\alpha = \frac{r \cdot F}{I_O}$$

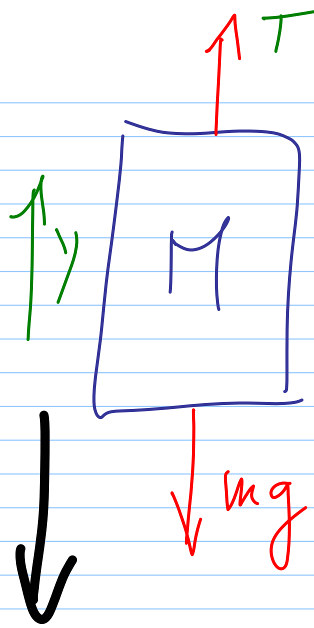
$\sum F_y = F - Mg = M\ddot{y} = -Mr\ddot{\theta}$

$F = -(Mg + Mr\ddot{\theta}) > 40$

$-rM(g + r\ddot{\theta}) = I_O \cdot \alpha$

$I_G = I_O + 40N \cdot r^2$





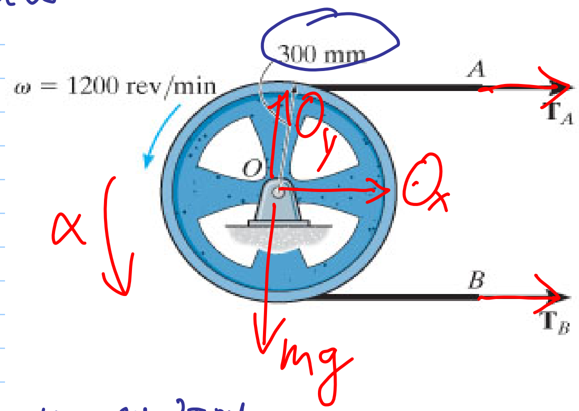
$$\Sigma F_y = T - mg = m\ddot{y}$$

$$\ddot{y} \neq 0$$

$$T = m(g + \ddot{y})$$

$$T < T_{static}$$

1. FBD
2. Newton



Problem 17.69

The [illegible] kg wheel has a radius of gyration about its center of mass O of k_O= [illegible] (a) If it rotates counterclockwise with an angular velocity of omega = 1200 (rev/min) and the tensile force applied to the brake band at A is T_A = 2000 N, determine the tensile force T_B such that wheel stops after 50 revs.

$$\omega = 1200 \frac{rev}{min} \cdot \frac{2\pi\, rad}{1\, rev} \cdot \frac{1\, min}{60\, s} = 40\pi\ rad/s\ ;\ \theta = 50 \cdot 2\pi = 100\pi \cdot rad$$

$$\omega^2 = \omega_0^2 + 2\alpha(\theta - \theta_0)$$

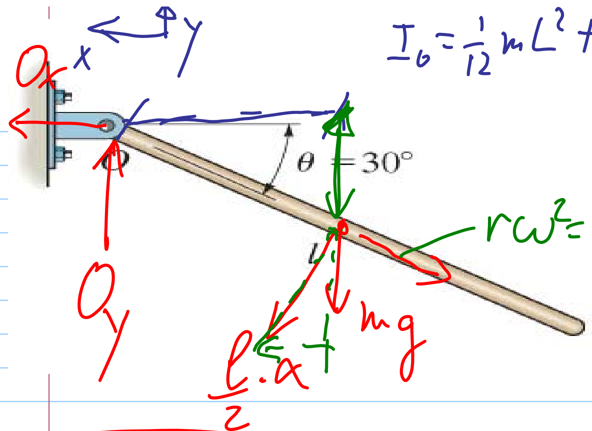
$$0 = (40\pi)^2 + 2\alpha(100\pi - 0) \Rightarrow \alpha = -25.13 \frac{rad}{s^2}$$

$$I_0 = mk^2 = 9.375\, kg \cdot m^2$$

$$\Sigma M_{(O)} = T_B \cdot 0.3 - 2{,}000 \cdot 0.3 = -9.375 \cdot 25.13$$

solve for $T_B = 1.21\ kN$

$I_0 = \frac{1}{12} m L^2 + m\left(\frac{L}{2}\right)^2$



Problem 17.73 •

The bar has a mass m and length l. (a) If it is released [illegible] from the position theta = 30 degree(s), determine its angular acceleration. (b) Determine the horizontal component of reaction at the pin O.

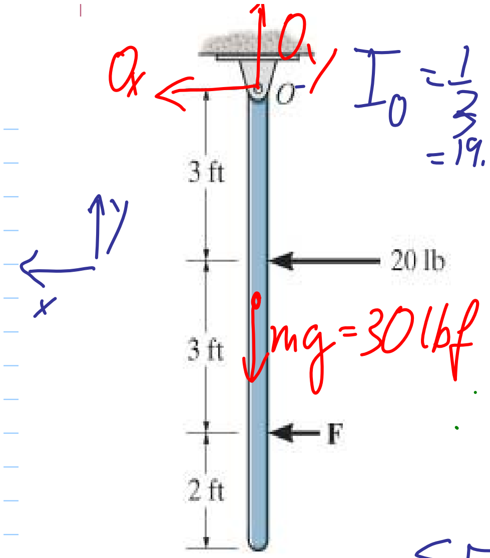
$\omega = 0$

$\sum M_{(O)} = I_O \cdot \alpha$

$$mg \cdot \frac{l}{2} \cos\theta = \frac{1}{3} m l^2 \quad \Rightarrow \quad \alpha = \frac{1.3 g}{l}$$

$$\sum F_x = O_x = m \cdot \frac{l}{2} \cdot \sin\theta \cdot \frac{1.3 g}{l} \Rightarrow O_x = 0.325 mg$$

$$\sum F_y = O_y - mg = -m \frac{l}{2} \cos 30^\circ \cdot \frac{1.3 \cdot g}{l} = 0.438 \cdot mg$$



$I_O = \frac{1}{3} m L^2 = 19.88\ slug\,ft^2$

Problem 17.83

At the instant shown, two forces act on the 30-lbf slender rod which is pinned at O. (a) Determine the magnitude of force F so that the horizontal reaction which the pin exerts on the rod is 5 lbf directed to the right. (b) Determine the initial angular of the rod so that the pin reaction = 5 lbf to the right.

$\sum M_{(O)} = I_O \cdot \alpha$

$-20 \cdot 3 - F \cdot 6 = -19.88 \cdot \quad (1)$

$\sum F_x = 20 + \quad - 5 = \frac{30}{32.2} \cdot 4 \cdot \alpha \quad (2)$

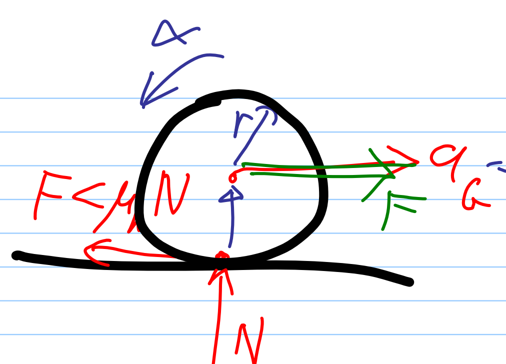
$F = 30\ lbf \qquad \alpha = 12.1\ rad/s^2$

Chapter 17.5 General Plane Motion

$$Translation: \sum F_x = m * \ddot{x}$$

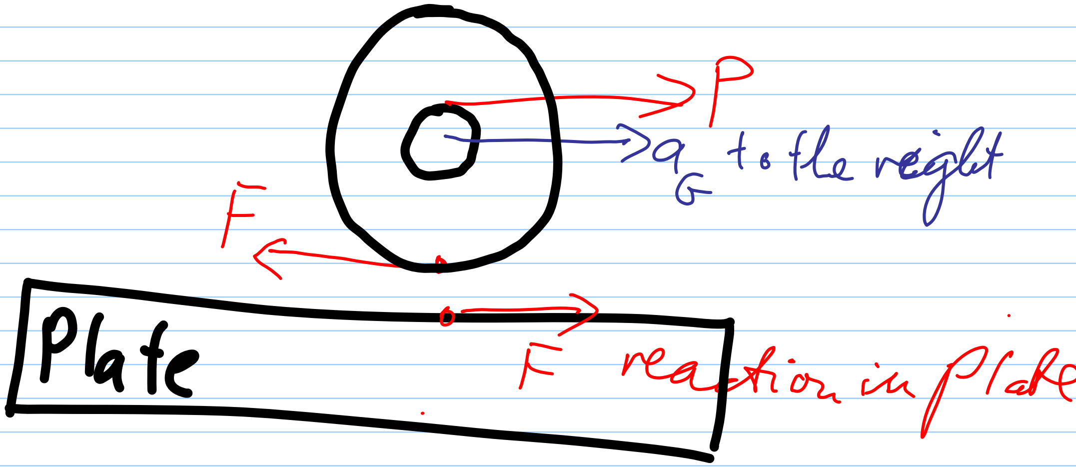
$$\sum F_y = m * \ddot{y}$$

$$Rotation: \sum M_p = I_p * \alpha$$

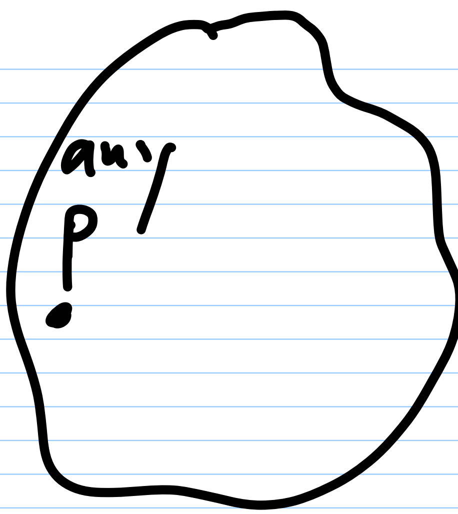


$\vec{a}_G = \alpha \times r = \alpha \cdot r$

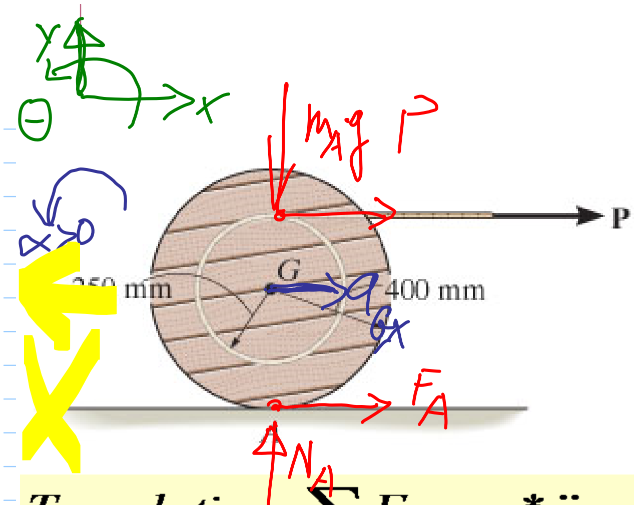
$\sum F_x = F - \mu_s \cdot N = m\, a_G$



P
a_G to the right
F
Plate
F reaction in plate



any P



Problem 17.103

The spool has a mass of m=100 kg and a radius of gyration of k_G = 0.3 m. (a) If the coefficients of static and kinetic friction at A are mu _s = 0.2 and mu _k = 0.15, respectively, determine the angular acceleration of the spool if P = 50 N.

Translation: $\sum F_x = m * \ddot{x} = P + F_A = 100\,kg \cdot a_G$

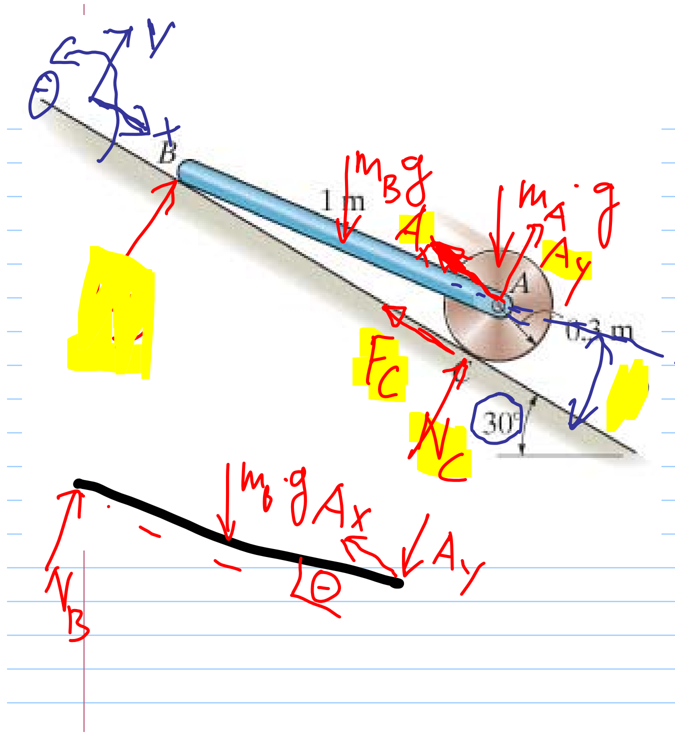
$\sum F_y = m * \ddot{y} = N_A - m_A \cdot g = 0 \Rightarrow N_A = 100 \cdot 9.81\,N$

Rotation: $\sum M_G = I_G * \alpha = -P \cdot 0.25 + F_A \cdot 0.4 = 100k \cdot 0.3^2 \cdot \alpha$

$a_G = -0.4 \cdot \alpha$ $\qquad \alpha = -1.3\ rad/s^2 \cdot k$

$N_A = 981\,N$ $\qquad a_G = 0.52\ \frac{m}{s^2} \rightarrow$

$F_A = 2\,N < F_{A,max} = 0.2 \cdot 981 \approx 196\,N$

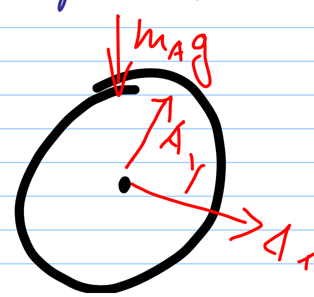


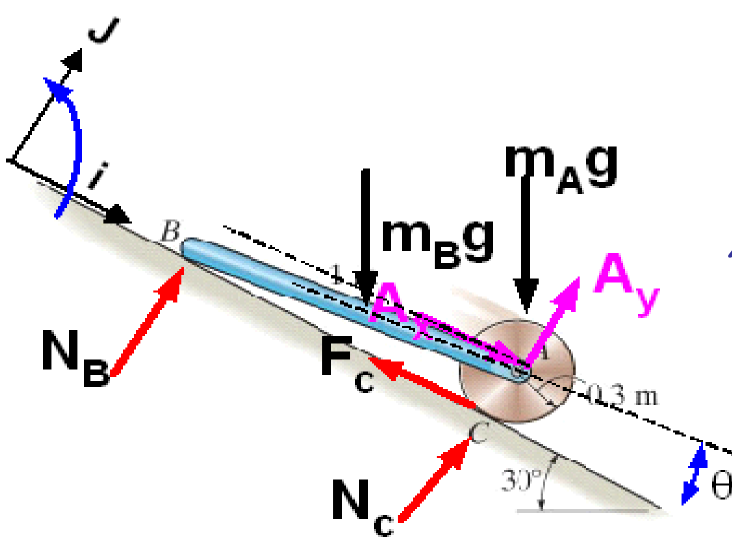
Problem 17.112

The assembly consists of an 8-kg disk and a 10-kg bar which is pin connected to the disk. (a) If the system is released from rest, determine the angular acceleration of the disk. The coefficients of static and kinetic friction between the disk and...

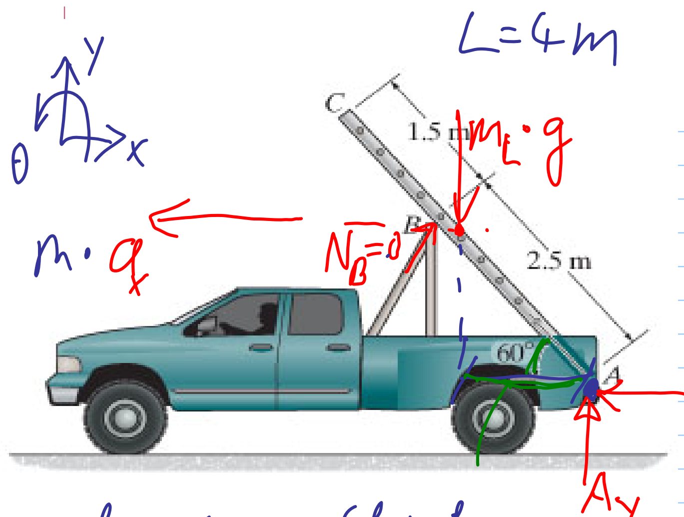
No friction at B

Steps: 1. Frame





Why computer tools?
efficient.
Look at web sites for engineering
Must be familiar with
FEA
CAD
specialized tools



Problem 17.120
(a) If the truck accelerates at a constant rate of 6 m/s^2, starting from rest, determine the initial angular acceleration of the 20 kg ladder. The ladder can be considered as a uniform slender rod. The support at B is smooth.

$$\sum M_A = mg\frac{L}{2}\cos 60^\circ = I_A\cdot\alpha$$

$$= I_A\cdot\frac{L}{2}\cdot\sin 60\cdot a_x$$

for min. accel for rot.

Numbers: $20\cdot 9.81\cdot 2\cdot\cos 60 = 20\cdot a_{min}\cdot 2\cdot\sin 60^\circ$

$$a_{min} = 5.66\ m/s^2 < 6\ m/s^2 \checkmark$$