



ME 201

Engineering Mechanics: Statics

Chapter 8

Friction – Part II

Example Problem

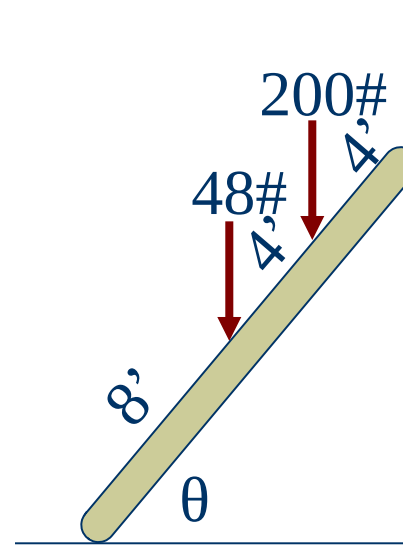
Given:

$$\mu_w = 0.25$$

$$\mu_{fl} = 0.4$$

Find:

θ such that it
causes motion to
impend



Given:

$$\mu_w = 0.25$$

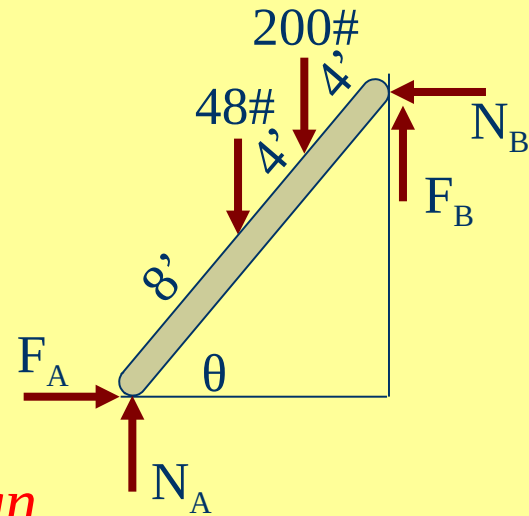
$$\mu_{fl} = 0.4$$

Find:

θ for impending motion

Solution:

Example Problem Solution



Solve Simult. Eqn.

$$F_A = \mu_{fl} N_A = .4 N_A$$

$$F_B = \mu_w N_B = .25 N_B$$

$$\sum F_{x'} = 0$$

$$F_A - N_B = 0$$

$$0.4 N_A - N_B = 0$$

$$\sum F_{y'} = 0$$

$$N_A + F_B - 48 - 200 = 0$$

$$N_A + 0.25 N_B = 248$$

$$0.4 N_A - N_B = 0$$

$$N_A + 0.25 N_B = 248$$

$$N_A = 225.5 \text{ lb}$$

$$N_B = 90.2 \text{ lb}$$

$$\sum M_A = 0$$

$$- 8 \cos \theta * 48 - 12 \cos \theta * 200$$

$$+ 16 \cos \theta * 22.5 + 16 \sin \theta * 90.2 = 0$$

$$2422 \cos \theta = 1443 \sin \theta$$

$$\tan \theta = \frac{2422}{1443} \quad \theta = 59.2^\circ$$

$$F_A = .4 N_A$$

$$F_A = 90.2 \text{ lb}$$

$$F_B = .25 N_B$$

$$F_B = 22.5 \text{ lb}$$

Example Problem

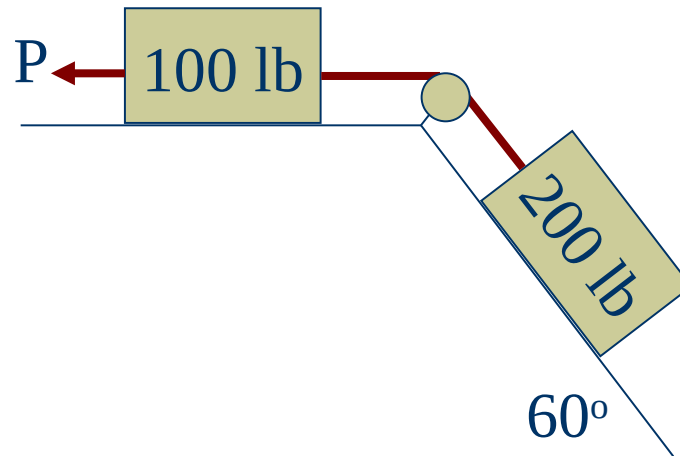
Sliding Block System

Given:

$$\mu = 0.25$$

Find:

P to cause motion
to impend



Example Problem Solution

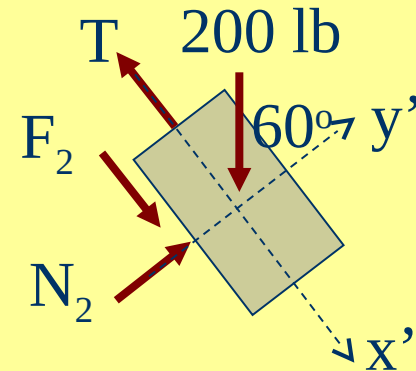
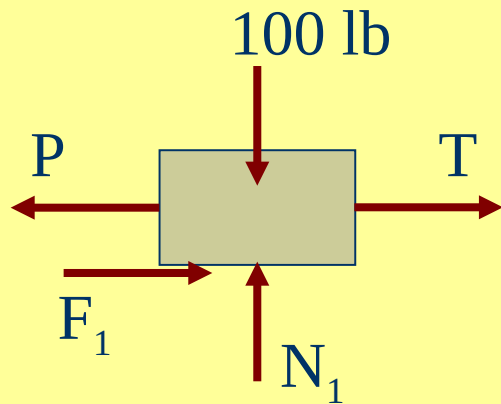
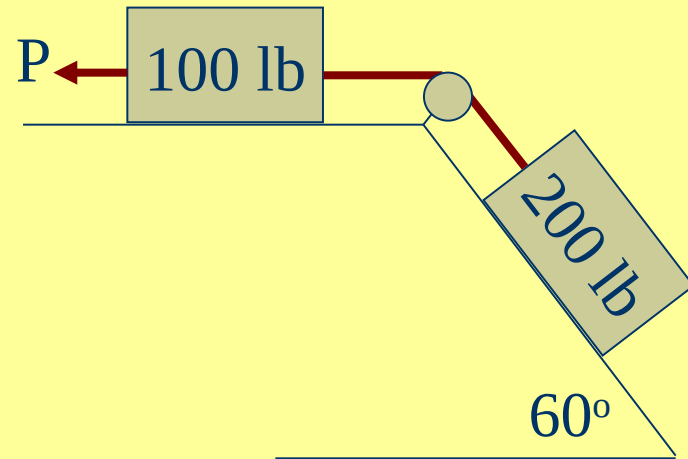
Sliding Block System

Given:

$$\mu = 0.25$$

Find:

P for impending motion



Example Problem Solution

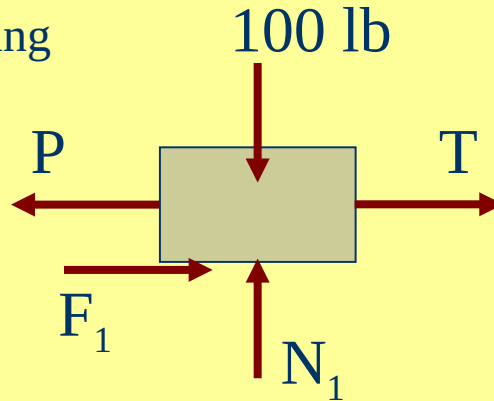
Sliding Block System

Given:

$$\mu = 0.25$$

Find:

P for impending motion



$$\sum F_y = 0$$

$$N_1 - 100 = 0$$

$$N_1 = 100 \text{ lb}$$

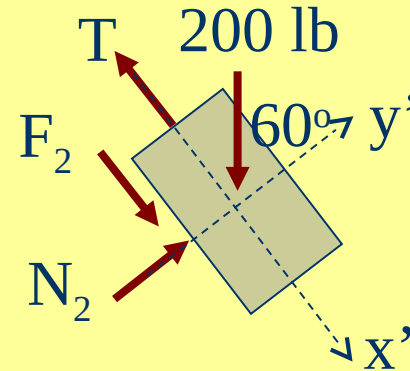
$$F_1 = \mu N_1$$

$$F_1 = 0.25 \times 100 = 25 \text{ lb}$$

$$\sum F_x = 0$$

$$F_1 + T - P = 0$$

$$P = 223.2 \text{ lb}$$



$$\sum F_{y'} = 0$$

$$N_2 - 200 \cos 60^\circ = 0$$

$$N_2 = 100 \text{ lb}$$

$$F_2 = \mu N_2$$

$$F_2 = 0.25 \times 100 = 25 \text{ lb}$$

$$\sum F_{x'} = 0$$

$$F_2 - T + 200 \sin 60^\circ = 0$$

$$T = 198.2 \text{ lb}$$

Example Problem

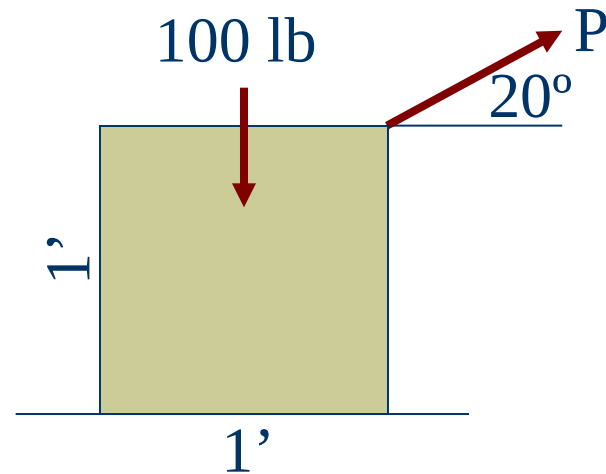
Sliding vs. Tipping

Given:

$$\mu = 0.4$$

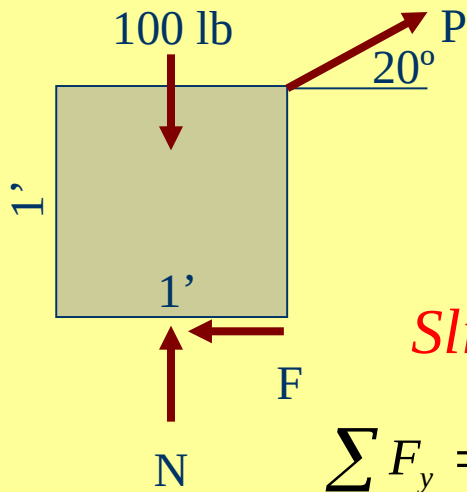
Find:

P_{slide} and P_{tip}



Example Problem Solution

Sliding vs. Tipping



Sliding

$$\sum F_y = 0$$

$$N + P \sin 20^\circ - 100 = 0$$

$$\sum F_x = 0$$

$$F + P \cos 20^\circ = 0$$

$$F = \mu N = .4N$$

$$-.4N + P \cos 20^\circ = 0$$

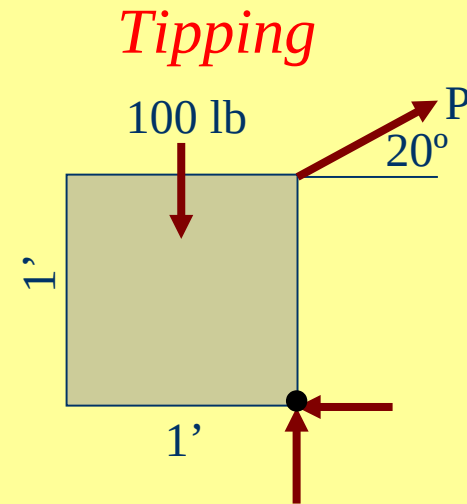
Solve Simult. Eqn.

$$N + P \sin 20^\circ - 100 = 0$$

$$-.4N + P \cos 20^\circ = 0$$

$$P = 37.2 \text{ lb}$$

$$N = 87.3 \text{ lb}$$



Tipping

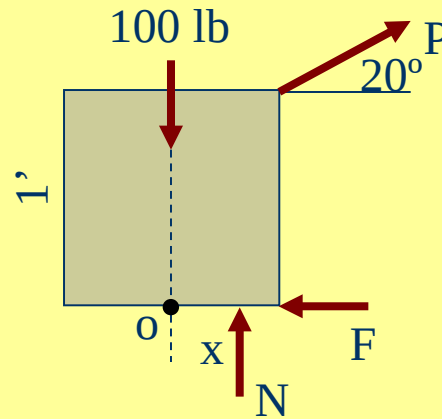
$$\sum M_0 = 0$$

$$100 * .5 - P \cos 20^\circ * 1 = 0$$

$$P = 53.2 \text{ lb}$$

*37.2 (Slide) < 53.2 (Tip)
Therefore, box will Slide*

Example Problem Alternate Solution Sliding vs. Tipping



$$\sum F_y = 0$$

$$N + P \sin 20^\circ = 100$$

$$\sum F_x = 0$$

$$-0.4N + P \cos 20^\circ = 0$$

$$\sum M_0 = 0$$

$$N \cdot x - P \cos 20^\circ \cdot 1 + P \sin 20^\circ \cdot 0.5 = 0$$

$$x = 0.327 \text{ ft}$$

Solve Simult. Eqn.

$$P = 37.2 \text{ lb}$$

$$N = 87.3 \text{ lb}$$

$$0.327 < 0.5$$

Therefore, box will Slide

Example Problem

Introducing an Incline

Given:

$$m_{\text{cyl}} = 100 \text{ kg.}$$

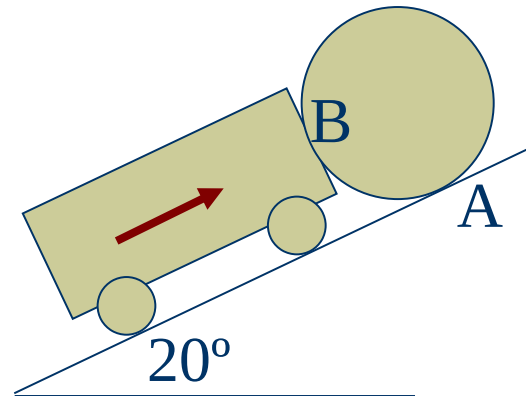
$$\mu_{sA} = 0.18 \quad \mu_{kA} = 0.15$$

$$\mu_{sB} = 0.45 \quad \mu_{kB} = 0.4$$

Find:

Force to push cyl up hill

Does it roll or slide?



Given:

$$m_{\text{cyl}} = 100 \text{ kg.}$$

$$\mu_{sA} = 0.18 \quad \mu_{kA} = 0.15$$

$$\mu_{sB} = 0.45 \quad \mu_{kB} = 0.4$$

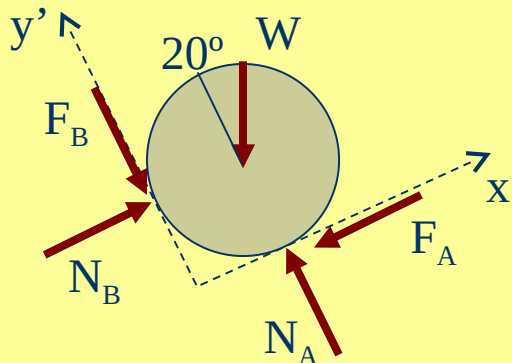
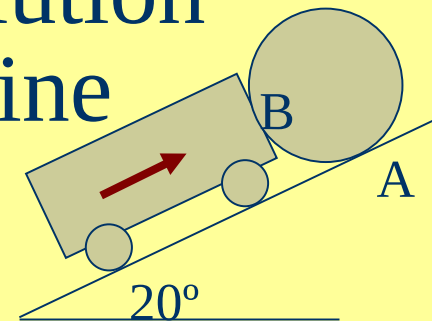
Find:

Force to push cyl up hill

Does it roll or slide?

Example Problem Solution

Introducing an Incline



$$\sum F_{x'} = 0$$

$$N_B - F_A = 981 \sin 20^\circ$$

$$\sum F_{y'} = 0$$

$$N_A - F_B = 981 \cos 20^\circ$$

$$\sum M_0 = 0$$

$$F_A = F_B$$

Assume Rolling

$$\mu_{kB} = 0.4$$

$$F_B = 0.4 N_B = F_A$$

$$N_B - F_A = 981 \sin 20^\circ$$

$$N_B = 559.2$$

$$N_A - F_B = 981 \cos 20^\circ$$

$$N_A = 1145.5$$

Check $F_A \leq \mu_{sA} N_A$

$$223.7 \leq 0.18 * 1145.5$$

Not Valid $223.7 \leq 206$

Try Sliding

$$\mu_{kA} = 0.15$$

$$F_A = 0.15 N_A = F_B$$

$$N_B = 498.2$$

$$N_A = 1084$$

$$F_B \leq \mu_{sB} N_B$$

$$162.7 \leq 0.45 * 498.2$$

$162.7 \leq 249.1$ **OK**

Guidelines for Solving Friction Problems

- ◆ Use equations of equilibrium first
 - $F \leq \mu N$
 - $F = \mu N$ only if motion impends, or occurs
- ◆ Use care in determining direction of F
 - Always opposes motion/impending motion
 - Opposite in 2 FBD of same point

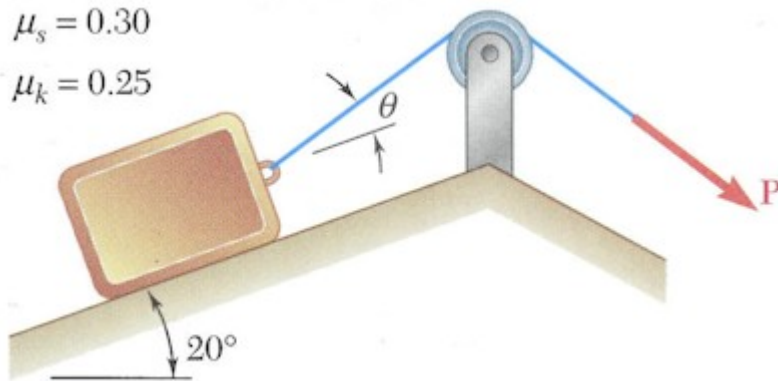
Guidelines for Solving Friction Problems

- ◆ For sliding blocks N may not align with W
 - Introduces Couple
 - This distance may be found by summing M
 - Can use to determine Slide vs. Tip
- ◆ With friction at multiple points need to examine motion at all points
 - Simultaneous - only if physical link
 - One slip vs. other not slip

Class Exercise Problems

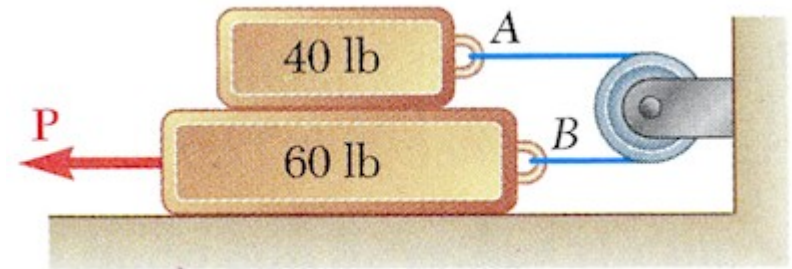
Problem 1

Find $P_{\min}$ & $P_{\max}$ for equilibrium

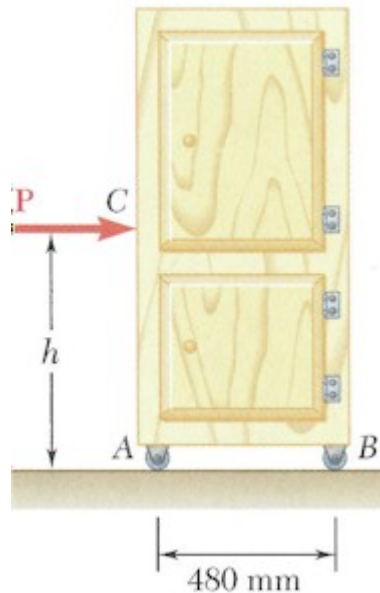


Problem 2

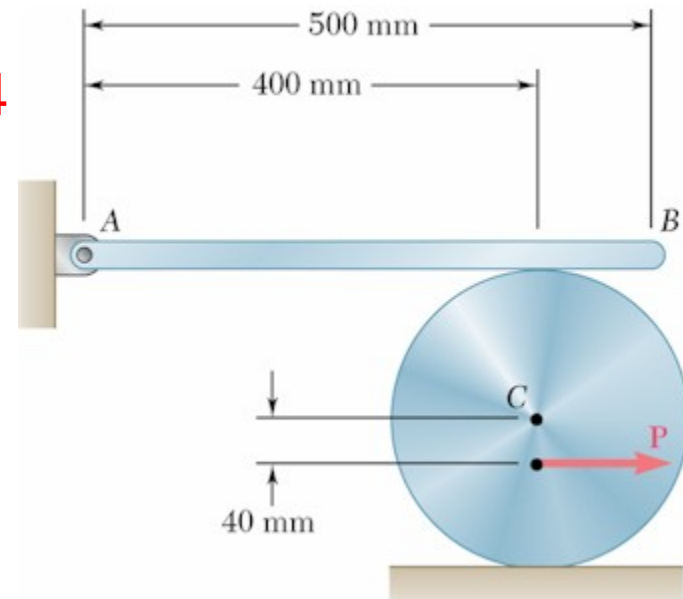
Find P for impending motion



Problem 3
Find largest h
w/o tipping



Problem 4
Find P for
impending
motion

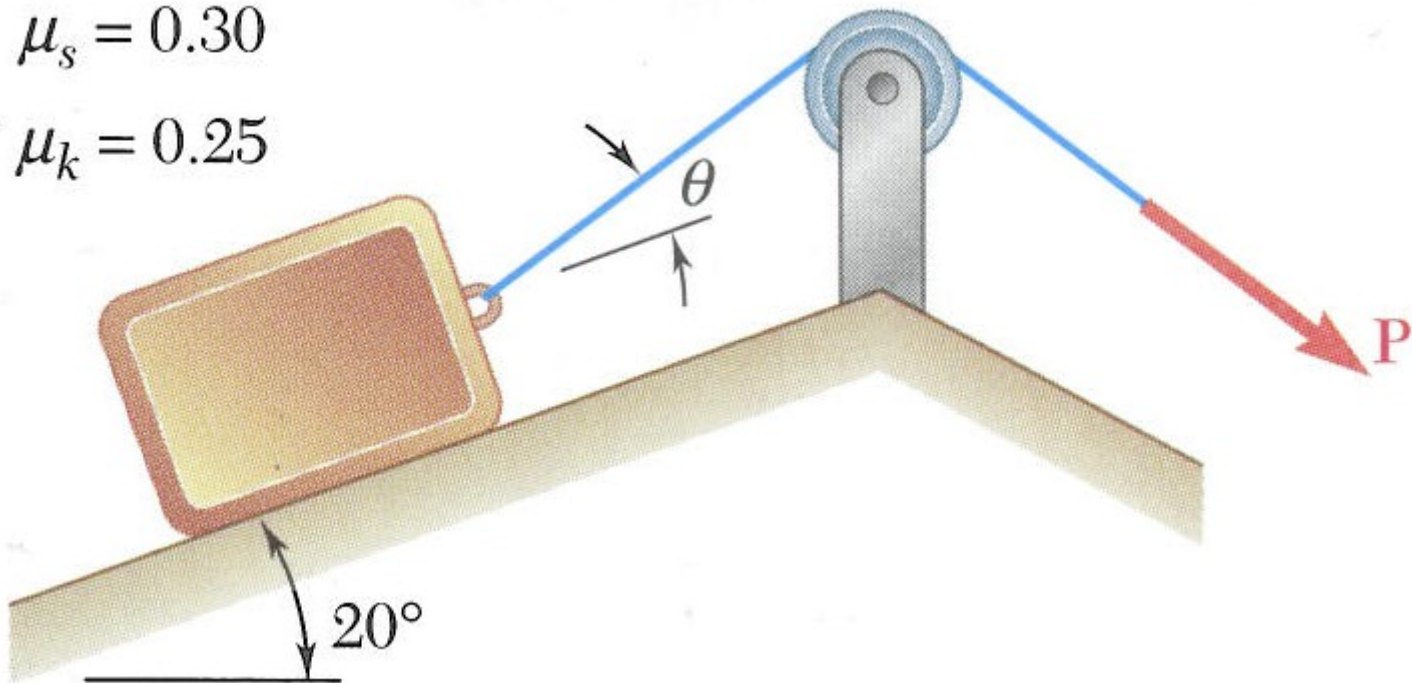


Problem 1

Given $\theta = 25^\circ$, find the range of values of P for which equilibrium is maintained

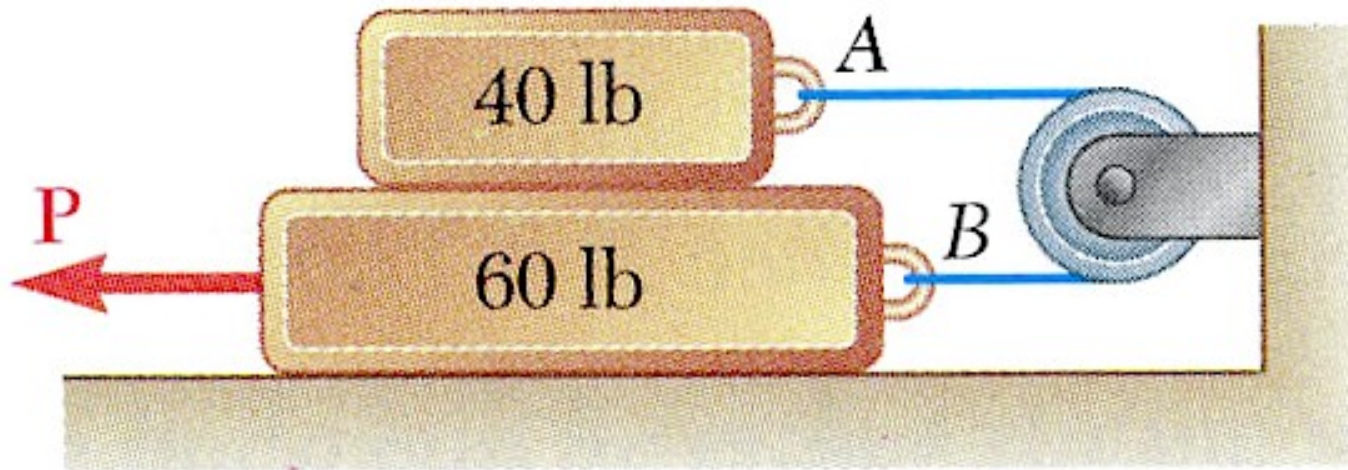
$$\mu_s = 0.30$$

$$\mu_k = 0.25$$



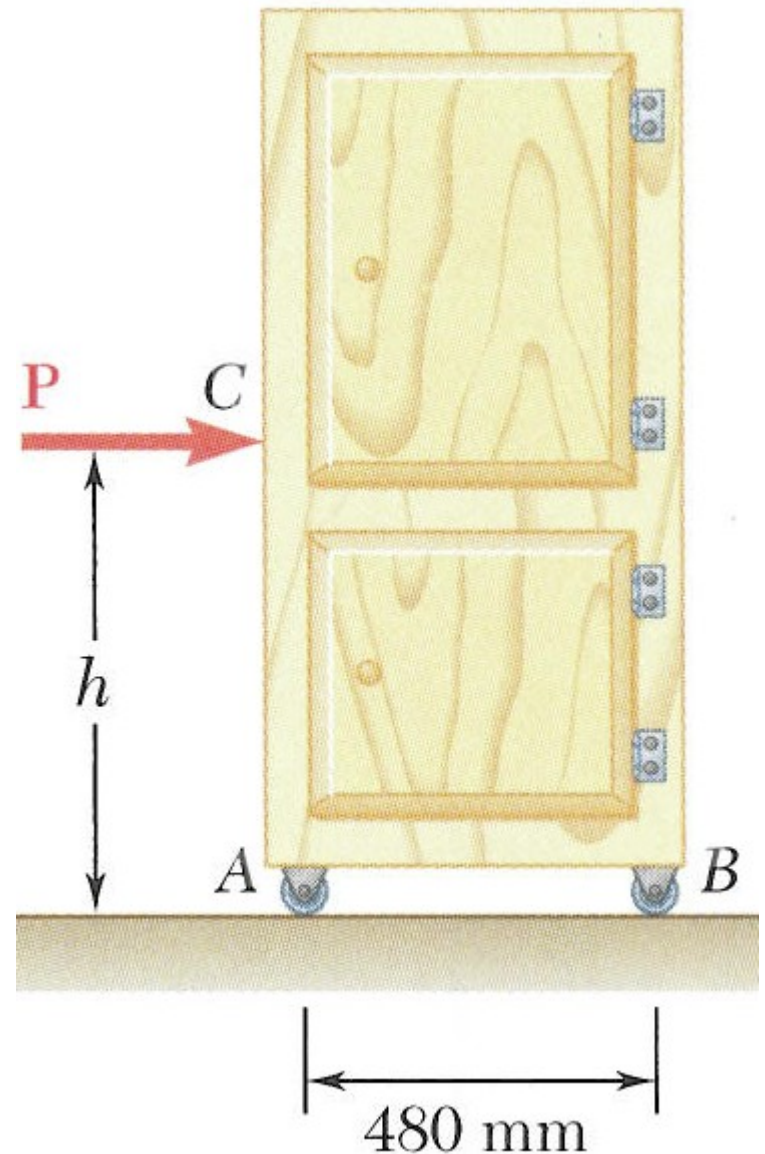
Problem 2

Given $\mu_s=0.40$ and $\mu_k=0.30$, find P for impending motion



Problem 3

Given $m=48$ kg,
 $\mu_s=0.30$, and
locked casters,
find largest h
without tipping
the cabinet



Problem 4

Given $\mu_s = 0.30$, $m_{\text{rod}} = 6 \text{ kg}$, $m_{\text{cyl}} = 18 \text{ kg}$,
 $d_{\text{cyl}} = 250 \text{ mm}$, find P for impending motion

