Lecture 26

Monday, October 30, 2017 12:40

To do …

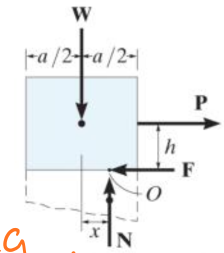
- **CBTF Quiz 5** – this week!
- Matlab session – Thurs Nov 2, 5-6 pm, location TBD
- WA2 has been regraded, thanks for the feedback
- Homework grade distribution
  - Online + written assignment = 18%

- 211 students **DO NOT TAKE** 210 final, or you will get a zero on 211 final

- HW 18 due **Wed**
- HW 19 due **Thurs**
- WA 3 due **Fri**

Dry friction: Static

1. $P = 0$ — no motion, (ΞM)
2. $P < f_s$ — no motion, $|f| = |P|$ (ΞM)
3. $P = f_s = \mu_s N$ — no motion, impending motion (ΞM)
4. $P > f_s$ — motion!



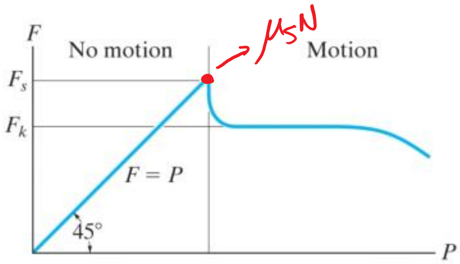
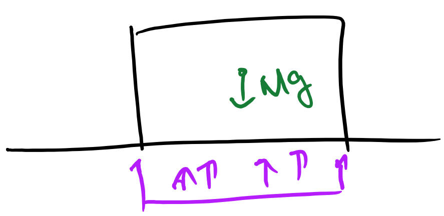
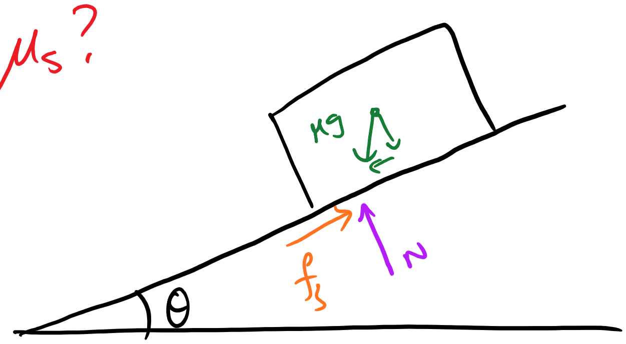


Table 8–1 Typical Values for μ_s	
Contact Materials	Coefficient of Static Friction (μ_s)
Metal on ice	0.03–0.05
Wood on wood	0.30–0.70
Leather on wood	0.20–0.50
Leather on metal	0.30–0.60
Aluminum on aluminum	1.10–1.70

Q: how do we determine μ_s?





$$\Sigma F_x: \; f_s - mg\sin\theta = 0$$

$$\Sigma F_y: \; N - mg\cos\theta = 0$$

take the ratio:

$$f_s \quad \frac{mg\sin\theta}{\quad} = \tan\theta$$

$$\frac{f_s}{N} = \frac{mg\sin\theta}{mg\cos\theta} = \tan\theta$$

At sliding: $f_s = \mu_s N$ $\therefore$

$$\frac{\mu_s N}{N} = \tan\theta$$

$$\boxed{\mu_s = \tan\theta_s.}$$

independent of mass, contact area!

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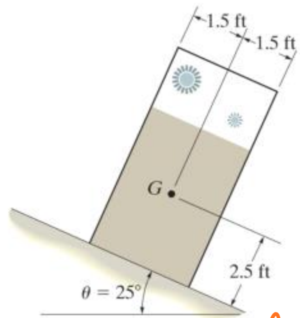
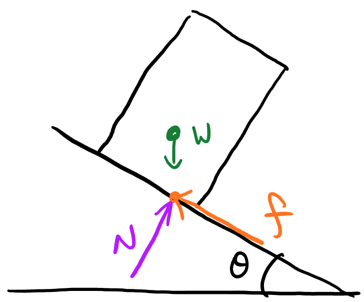
Wednesday, October 26, 2016 11:29

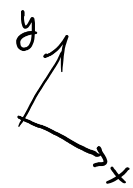
It is observed that when the bed of the dump truck is raised to an angle of $\theta = 25^o$ the vending machines will begin to slide off the bed. Determine the static coefficient of friction between a vending machine and the surface of the truck bed.



idealized model!

DRAW FBD:





Sum forces:

ΣF_x: $W\sin\theta - f = 0$

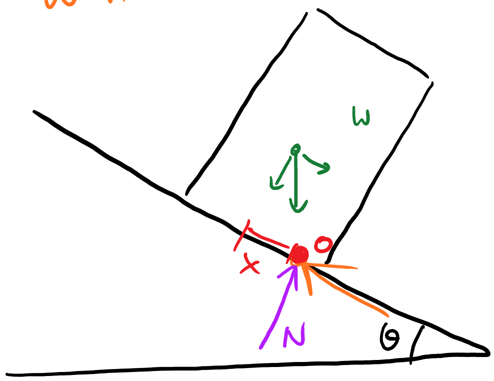
ΣF_y: $N - W\cos\theta = 0$

for sliding: $f_s = \mu_s N$ $\therefore$

$$\frac{f_s}{N} = \frac{W\sin\theta}{W\cos\theta}$$

$$\frac{\mu_s N}{N} = \tan\theta \quad \therefore \quad \mu_s = \tan\theta_s = 0.4666$$

will the machine tip?

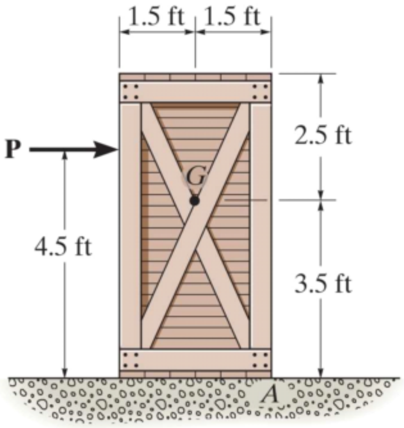


$$\Sigma M_O: \quad x W\cos\theta - y W\sin\theta = 0$$

$$x = \frac{y W \sin\theta}{W\cos\theta} = y\tan\theta$$

$$\underline{x} = (2.5\text{ ft})\tan(25°) = \underline{1.17\text{ ft}}$$

since $x = 1.17\text{ ft} < 1.5\text{ ft}$, indeed slipping occurs before tipping!



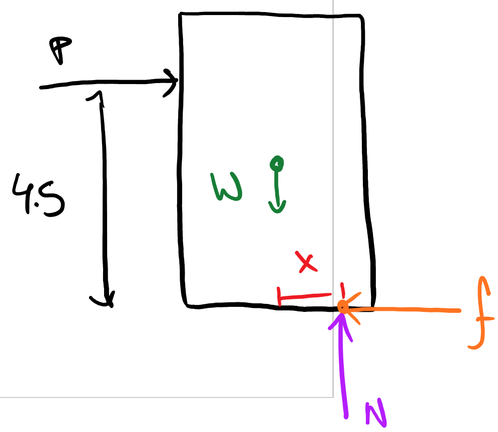
Find the maximum force P that can be applied without causing movement of the crate.

→ sliding (translation)
→ tipping (rotation)

Given: $w = 250\text{ lb}$

$\mu_s = 0.4$

DRAW the FBD



Q: How many unknowns?

4 unknowns!

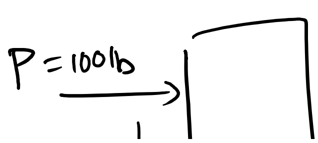
first assume slipping:

$\Sigma f_x: \quad P - f_s = 0 \quad \rightarrow \quad P = f_s = \mu_s N$

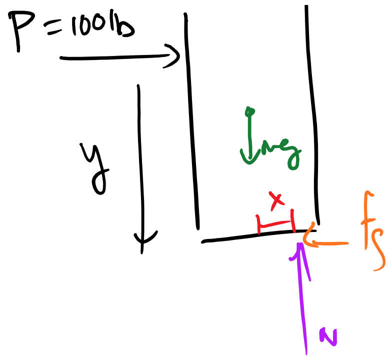
$\Sigma f_y: \quad N - W = 0 \quad\quad N = W$

So $P = \mu_s W = (0.4)(250\text{ lb}) = \underline{100\text{ lb}}$

Check to see if in rotational equilibrium:



$\Sigma M_o: \quad mgx - y(100) = 0$



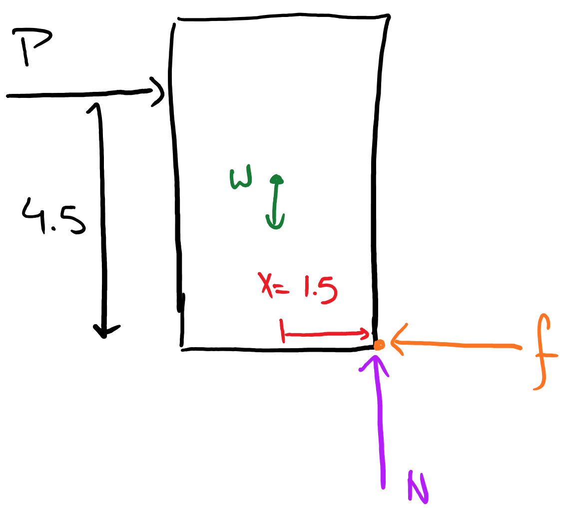
$\Sigma M_o: \quad mgx - y(100) = 0$

$$x = \frac{(4.5)(100)}{250} = \underline{1.8\ ft}$$

but $x = 1.8$ ft > 1.5 ft (half width of crate)

$\therefore$ no sliding, the box will tip first!

Consider tipping, Draw the FBD:



$\Sigma F_x: \quad P - f = 0$

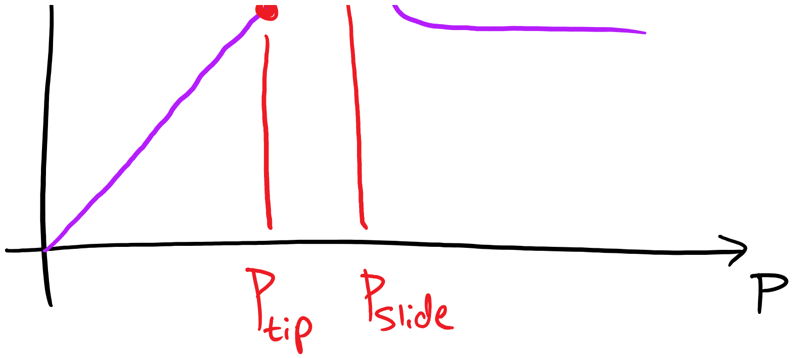
$\Sigma F_y: \quad N - W = 0$

$\Sigma M_o: \quad (1.5)W - (4.5)P = 0$

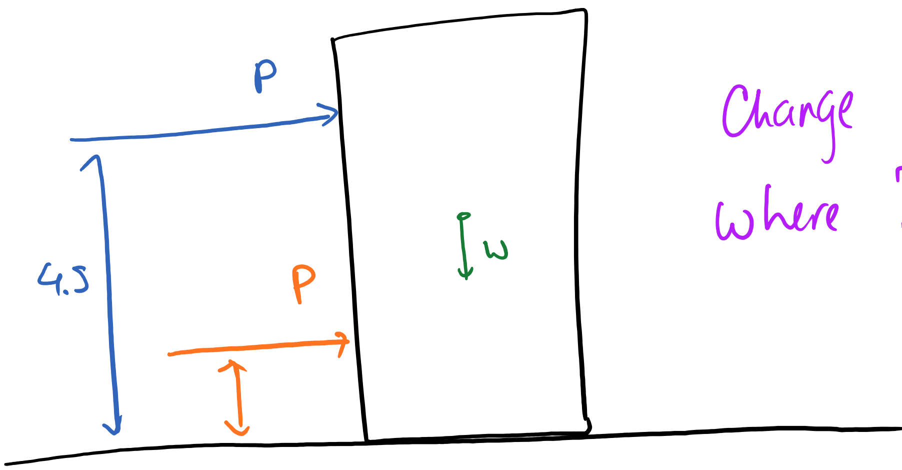
$$\underline{P} = \frac{(1.5)(250)}{4.5} = \underline{83.3\ lb}$$

$f = P = 83.3\ lb < f_s = 100\ lb$

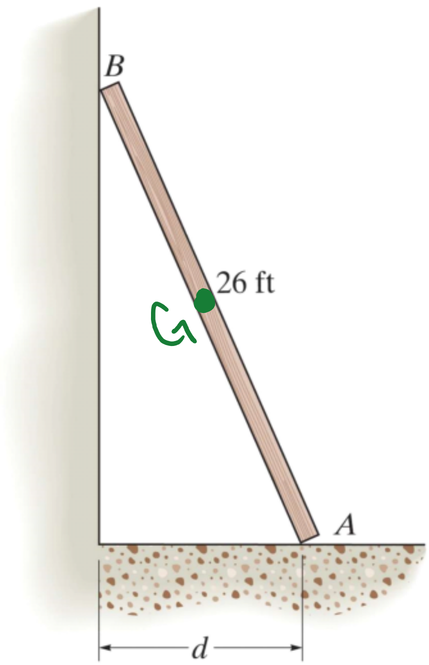
$\therefore$ tip before slide!



Q: What can we change to have $P_{slide} < P_{tip}$?



Change y position where P is applied!



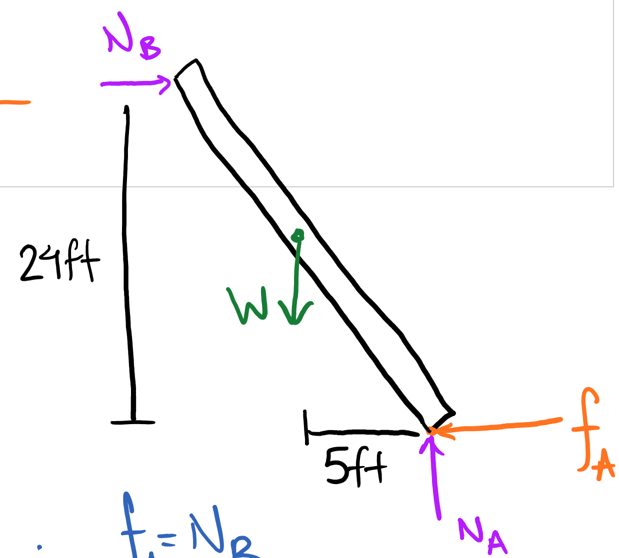
If it is placed against the smooth wall and on the rough floor in the position, d=10 ft, will it remain in this position when it is released?

Given:

$W = 30\ lb$

$\mu_s = 0.3$

The FBD



$\Sigma F_x = 0$

$N_B - f_A = 0 \quad \therefore \quad f_A = N_B$

$\Sigma F_y = 0$

$N_A - W = 0 \quad \therefore \quad N_A = W$

$\Sigma M_A = 0$

$$(5\text{ ft})(30\text{ lb}) - (24\text{ ft})N_B = 0$$

$$\therefore \quad N_B = 6.25\text{ lb}.$$

$$f_A = N_B = 6.25\text{ lb}$$

The maximum force at A such that it will remain in equilibrium is:

$$f_{max} = \mu_s N_A = \mu_s W = (0.3)(30\text{ lb})$$

$$f_{max} = 9\text{ lb}$$

Since $f_A < f_{max}$, the pole will remain stationary!