Statics - TAM 210 & TAM 211

Lecture 26

March 26, 2018

Chap 8.2

Announcements

- Check your grades in Compass2g Gradebook
  - **Report missing or incorrect grades within 2 weeks. Do not report grading errors after final grades are posted, as these will not be changed!**

- Upcoming deadlines:

- Thursday (3/29)
  - WA 4 due
- Monday (4/2)
  - PL HW 9/11
- Friday (3/30)
  - Last lecture for TAM 210 students
- Written exam (Thursday 4/5, 7-9pm in 1 Noyes Lab)
  - Conflict exam & DRES accommodation exam: Prof. H-W is not taking anymore requests

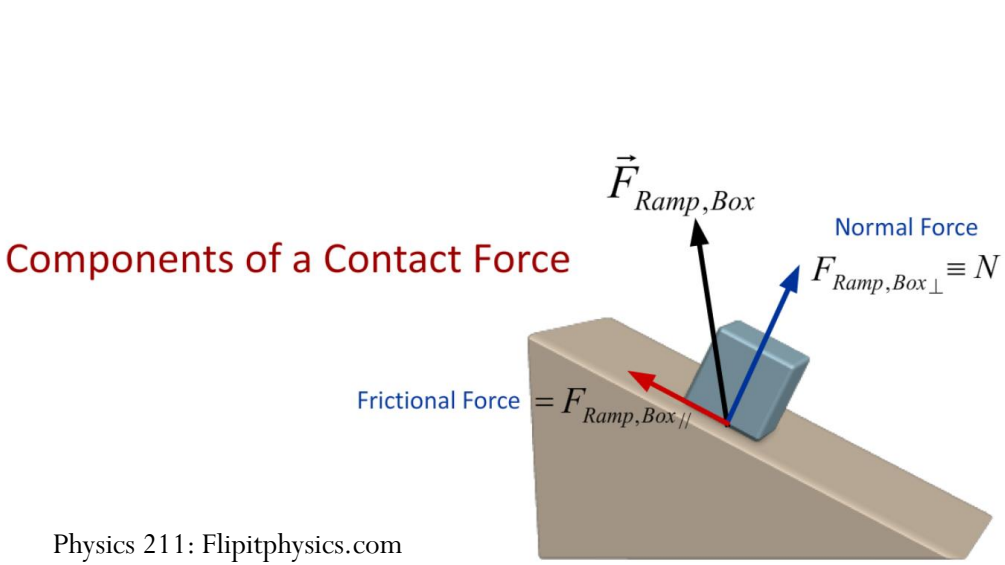
Chapter 8: Friction

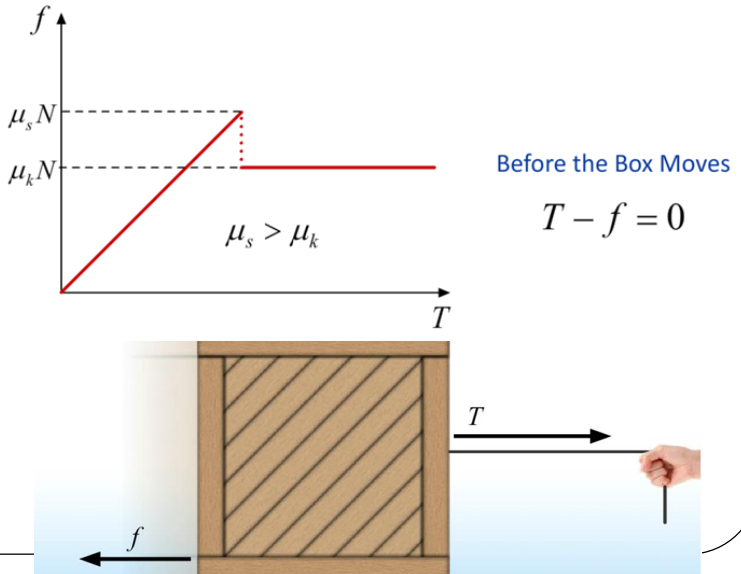
Goals and Objectives

- Sections 8.1-8.2
- Introduce the concept of dry friction
- Analyze the equilibrium of rigid bodies subjected to this force

Recap: Dry friction

- Friction acts tangent to contacting surfaces and in a direction <u>opposed</u> to motion of one surface relative to another
- Friction force F is related to the coefficient of friction and normal force N
  - Static friction (no motion): $F_s \leq \mu_s N$
  - Kinetic friction (moving): $F_k = \mu_k N$
- Magnitude of coefficient of friction depends on the two contacting materials
- <u>Maximum</u> static frictional force occurs when motion is impending



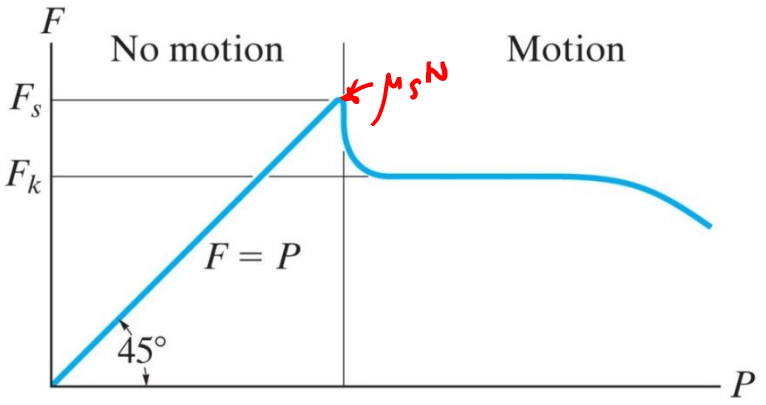


Recap: Dry friction

- **Impending slipping motion**: the maximum force F_s before slipping begins is given by

$$F_s = \mu_s N$$

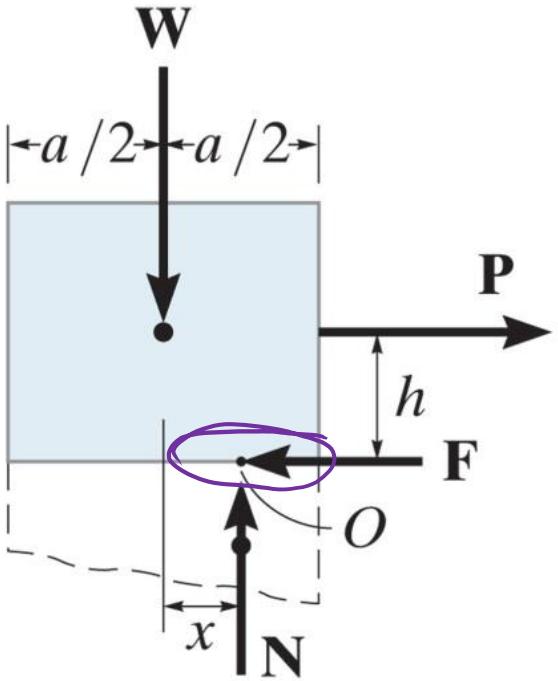
Slipping starts when P just exceeds $\mu_s N$



- **Tipping condition**: to avoid tipping of the block, the following equilibrium should be satisfied:

$$\sum M_O = -Ph + Wx = 0 \rightarrow x = \frac{P\,h}{W}$$

Tipping occurs if $x > a/2$, otherwise will only slip



Dry Friction Problems

- 3 types of static problems with dry friction

1. No apparent impending motion
2. Impending motion at all points of contact
3. Impending motion at some points of contact

Note that all of these cases are for IMPENDING motion (since static case).

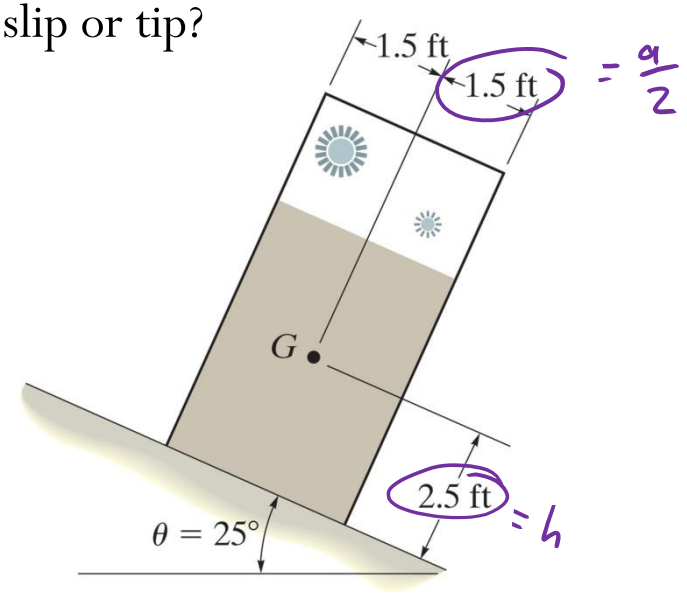
Therefore in tipping problems, the entire bottom surface is still in contact with ground. Thus we assume that $\vec{N}$ is not at the edge. (see previous slide.)

- Procedure

A. Draw FBD for each body
   - Friction force points opposite direction of impending motion
B. Determine # unknowns
C. Apply eqns of equilibrium and necessary frictional eqns (or conditional eqns if tipping is possible)

$\Sigma F_x \quad \Sigma F_y \quad \Sigma M_o$

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. Will it slip or tip?

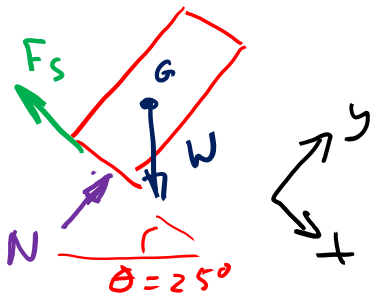


Find: μ_s ; slip or Tip?

Assume look @ slipping first

$F_s = \mu_s N \rightarrow \mu_s = \frac{F_s}{N}$

FBD:



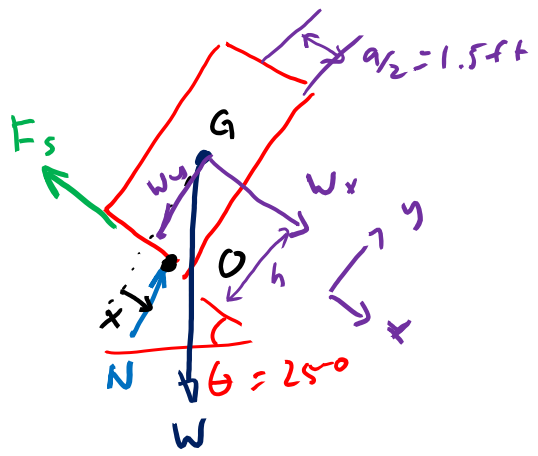
$\mu_s = \frac{W \sin\theta}{W \cos\theta} = \tan\theta \quad , \theta = 25°$

$\therefore \boxed{\mu_s = 0.466}$

$\rightarrow \Sigma F_x : W \sin\theta - F_s = 0 \rightarrow f_s = W \sin\theta$

$+\uparrow \Sigma F_y : N - W\cos\theta = 0 \rightarrow N = W\cos\theta$

Will it tip?



$+\circlearrowleft \Sigma M_o$: $x(W\cos\theta) - h(W\sin\theta) = 0$

$$x = \frac{h(W\sin\theta)}{W\cos\theta} = h\tan\theta$$

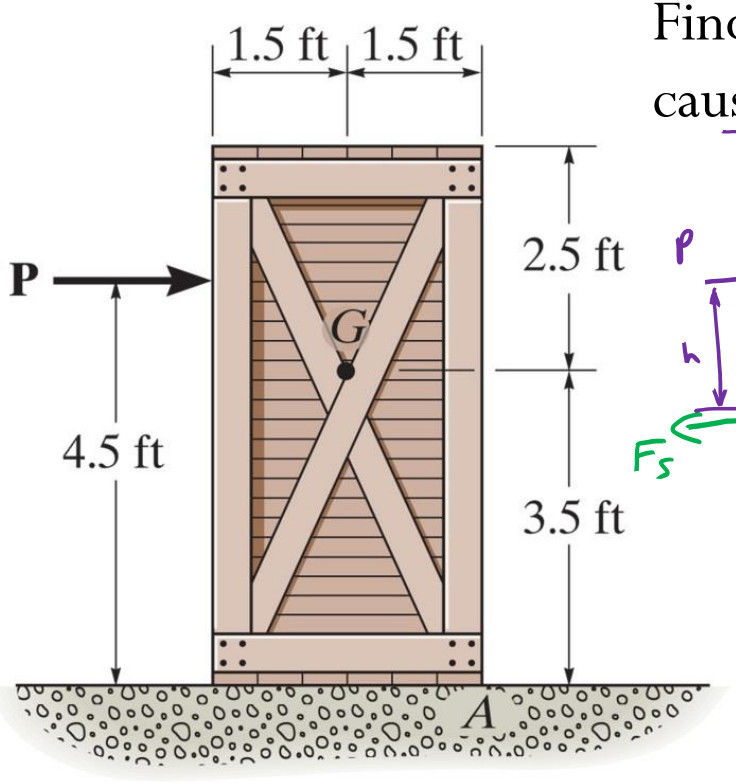
$x = (2.5ft)\tan(25°)$

$x = 1.17ft$

Tip or slip?

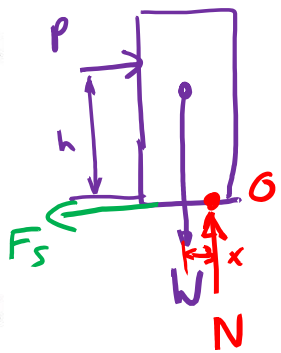
$x = 1.17ft < a/2 = 1.5ft$

$\therefore$ Slip first



Find the maximum force P that can be applied without causing movement of the crate. Given: $\mu_s = 0.4$, W=250lb

↳ Slip or Tip?



y
↑
→ x

UNKNOWNS: P, F_s, N, x

EOE:

$+\uparrow \Sigma F_y: N - W = 0 \rightarrow N = W$

$+\rightarrow \Sigma F_x: P - F_s = 0 \rightarrow$ assume slipping first

$F_s = \mu_s N$

$\therefore P = \mu_s N = \mu_s W = (0.4)(250\,lb) = 100\,lb$

$\boxed{P = 100\,lb}$

will it tip?

$+\circlearrowleft \Sigma M_O: Wx - hP = 0$

$x = \frac{hP}{W} = \frac{(4.5\,ft)(100\,lb)}{250\,lb} = 1.8\,ft$

$x = 1.8\,ft > \frac{a}{2} = 1.5\,ft$

$\therefore$ will tip first

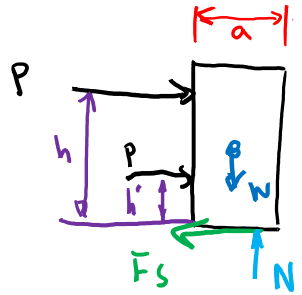
Solve for P for tipping:

$\Sigma M_o : \rightarrow P = \frac{xW}{h} = \frac{(1.5\text{ft})(250\text{lb})}{4.5\text{ft}}$

$\boxed{P = 83.3\text{lb}}$ ✕ max Force to start first movement, which turns out to be tipping (not slipping)

How to get slipping instead of tipping?

→ Apply P at lower location on crate ⇒ reduce value of h



$x = \frac{Ph}{W}$, x↓ when h↓

for slipping, want $x < \frac{a}{2}$