Statics - TAM 210 & TAM 211

Lecture 27

March 28, 2018

Chap 8.2

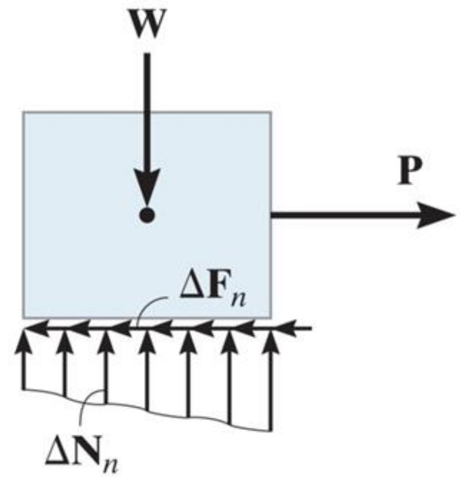
Announcements

- Concept Inventory: Ungraded assessment of course knowledge
  - Extra credit: Complete #1 or #2 for 0.5 out of 100 pt of final grade each, or both for 1.5 out of 100 pt of final grade
  - #2: Sign up at CBTF (4/2-4 M-Th)
  - 50 min appointment, should take < 30 min

- Upcoming deadlines:
- Thursday (3/29)
  - WA 4 due
- Monday (4/2)
  - PL HW 9/11
- Friday (3/30) – Review for exam
  - Last lecture for TAM 210 students
- Written exam
  - Comprehensive from start of course through today's material
  - Thursday 4/5, 7-9pm
  - TAM 210 students: 100 Material Science & Engineering Building (MSEB)
  - TAM 211 students: 100 Noyes Lab
  - Bring i-Card. No calculators
  - Conflict exam & DRES accommodation exam: Prof. H-W is not taking anymore requests

Chapter 8: Friction

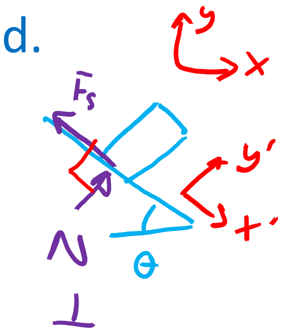
Dry Friction Problems



- 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.



- Procedure

A. Draw FBD for each body
   - Friction force points opposite direction of impending motion

Slip, $F_s = \mu_s N$

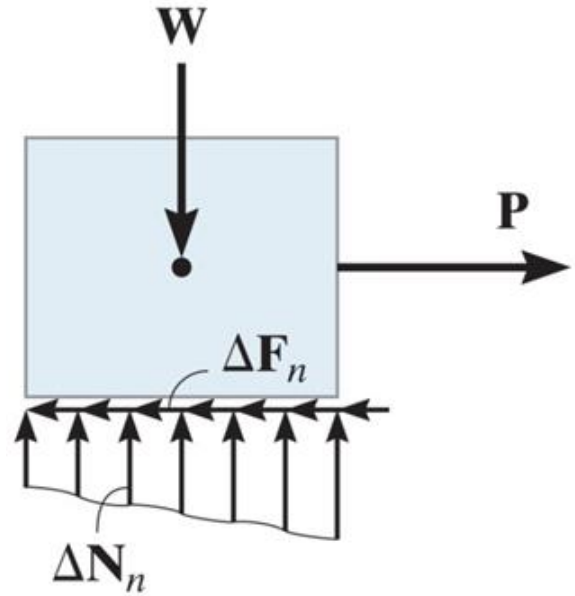
B. Determine # unknowns

ΣF_x ΣF_y ΣM_o → Tip

C. Apply eqns of equilibrium and necessary frictional eqns (or conditional eqns if tipping is possible)

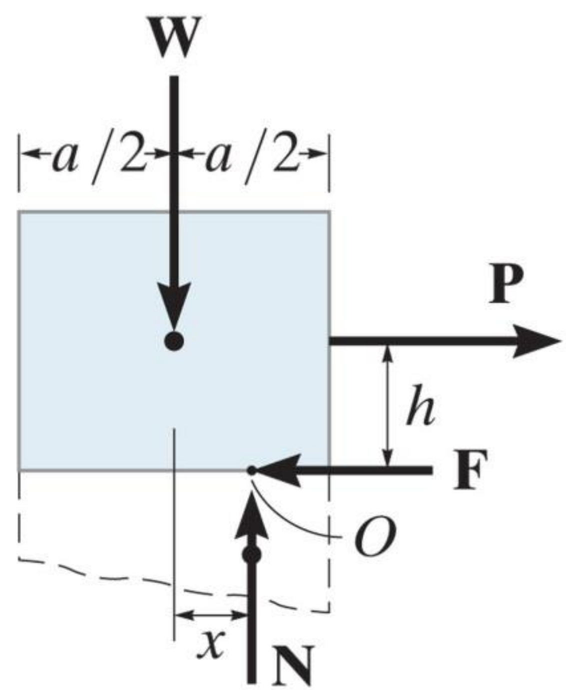
Recap: Dry friction

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

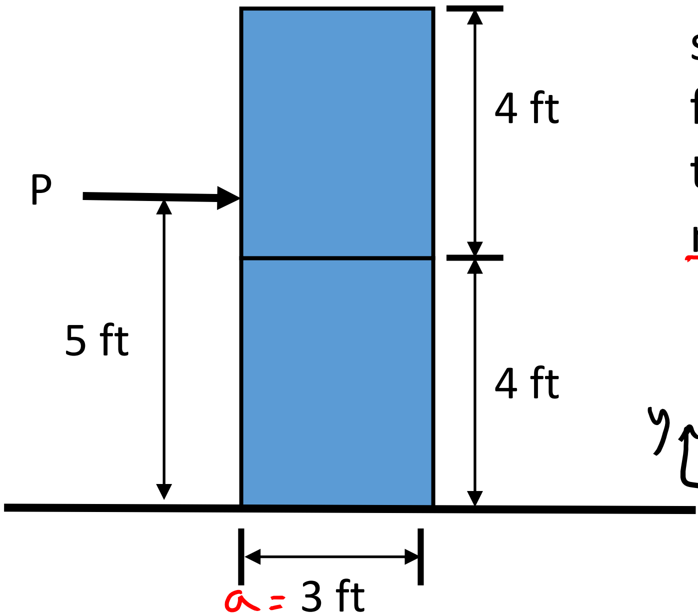


$$\sum M_O = -Ph + Wx = 0 \rightarrow x = \frac{P\,h}{W}$$

Compute value for x based on the applied loads:
If $x > a/2$, then these loads would cause tipping.
Otherwise $x < a/2$, will only slip



Two uniform boxes, each with weight 200 lb, are simply stacked as shown. If the coefficient of static friction between the boxes is $\mu_s = 0.8$ and between the box and the floor is $\mu_s = 0.5$, determine the minimum force P to cause motion.



How many possible motions?

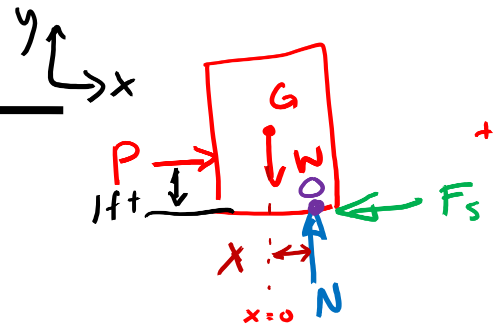
I) 1 slips

II) 1 tips

III) 1+2 slip

IV) 1+2 tip

Case I : 1 Slip



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

$\xrightarrow{+} \Sigma F_x: \; P - F_s = 0$

assume slipping $F_s = \mu_s N$

$P = \mu_s N = \mu_s W$

$P = (0.8)(200\,\text{lb})$

$\boxed{P_I = 160\,\text{lb}}$

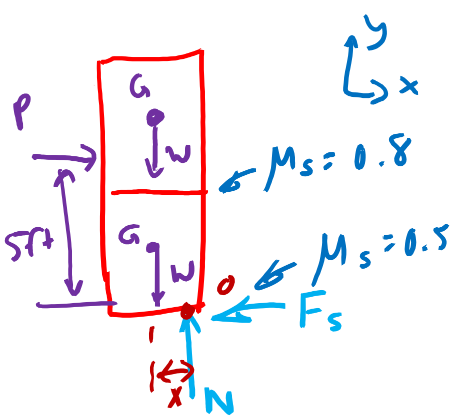
Case II : Assume 1 tips $\Rightarrow \therefore x = \frac{a}{2} = 1.5\,\text{ft}$

$+\circlearrowleft \Sigma M_o: \; W(1.5\,\text{ft}) - P(1\,\text{ft}) = 0$

$P = 1.5\,W = 1.5(200\,\text{lb})$

$\boxed{P_{II} = 300\,\text{lb}}$

case III : Assume 1+2 combo Slips



$+\uparrow \sum F_y: \; N - 2W = 0 \qquad N = 2W$

$\xrightarrow{+} F_x: \; P - F_s = 0 \quad , \; F_s = \mu_s N$

$P = \mu_s (2W) = (0.5)(2)(200\text{ lb})$

$$\boxed{P_{III} = 200\text{ lb}}$$

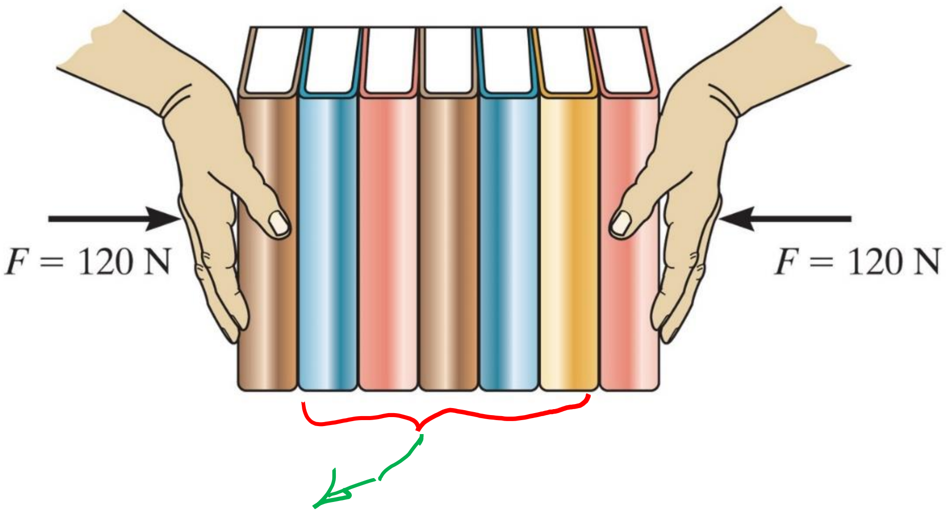
case IV : Assume 1+2 combo tip, $x = \frac{a}{2}$

$+\circlearrowleft \sum M_o: \; (2W)(1.5\text{ ft}) - P(5\text{ ft}) = 0$

$P = \frac{3}{5} W$

$$\boxed{P_{IV} = 120\text{ lb}}$$

Case IV will happen first since P_{IV} is minimum.



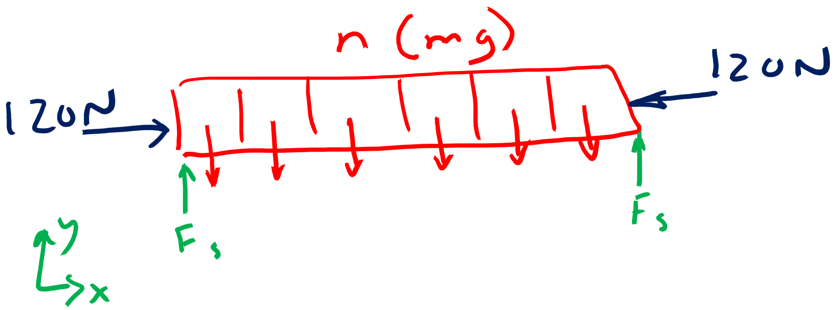
Determine the greatest number of books that can be supported in the stack.

Mass of each book: 0.95 kg

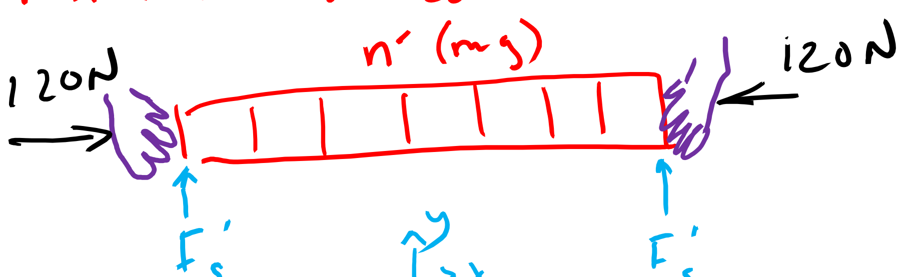
Coefficient friction hand-book: $(\mu_s)_h = 0.8$

Coefficient friction book-book: $(\mu_s)_b = 0.4$

FBD: Books only



FBD: Hands + Books



Slipping:

$\Sigma F_x: \; 120 - 120 = 0$

$\Sigma F_y: \; 2F_s - n(mg) = 0$

$F_s = (\mu_s)_b N$

$$n = \frac{2(0.4)(120\,N)}{(0.95\,kg)(9.81\,m/s^2)} = 10.3$$

$n = 10$ books held before slipping

$\Sigma F_y: \; 2F_s' - n'(mg) = 0$

$F_s' = (\mu_s)_h \; N$

$$n' = \frac{2(0.8)(120\,N)}{mg} = 20.6$$

Since $n < n'$, $10 < 20$

$\therefore N = n + 2 = \boxed{12 \text{ books}}$

outer books