Statics - TAM 210 & TAM 211

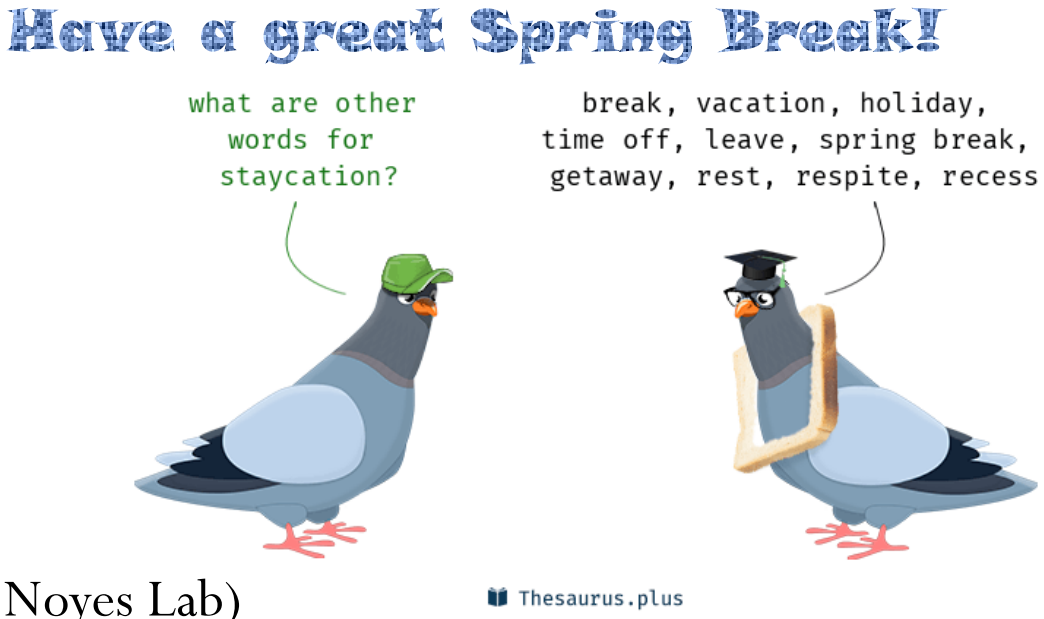
Lecture 25

March 16, 2018

Chap 8

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:
- Quiz 5 (3/14-16)
  - Sign up at CBTF
  - Up thru and including Lecture 22 (Shear Force & Bending Moment Diagrams), although review from Lectures 23-24 will be helpful.
- Monday (3/26)
  - Mastering Engineering Tutorial 11
- 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 (Monday 4/2, 7-9pm)
    - **Must make arrangements with Prof. H-W by Friday 3/16**
  - DRES accommodation exam. Make arrangements at DRES. Must tell Prof. H-W



Chapter 8: Friction

Goals and Objectives

- Introduce the concept of dry friction

- Analyze the equilibrium of rigid bodies subjected to this force

Friction

Friction is a force that resists the movement of two contacting surfaces that slide relative to one another. This force acts tangent to the surface at the points of contact and is directed so as to oppose the possible or existing motion between the surfaces.

Dry Friction (or Coulomb friction) occurs between the contacting surfaces of bodies when there is no lubricating fluid.

Figure: 08_COC
The effective design of each brake on this railroad wheel requires that it resist the frictional forces developed between it and the wheel. In this chapter we will study dry friction, and show how to analyze friction forces for various engineering applications.

Friction

In designing a brake system for a bicycle, car, or any other vehicle, it is important to understand the frictional forces involved.

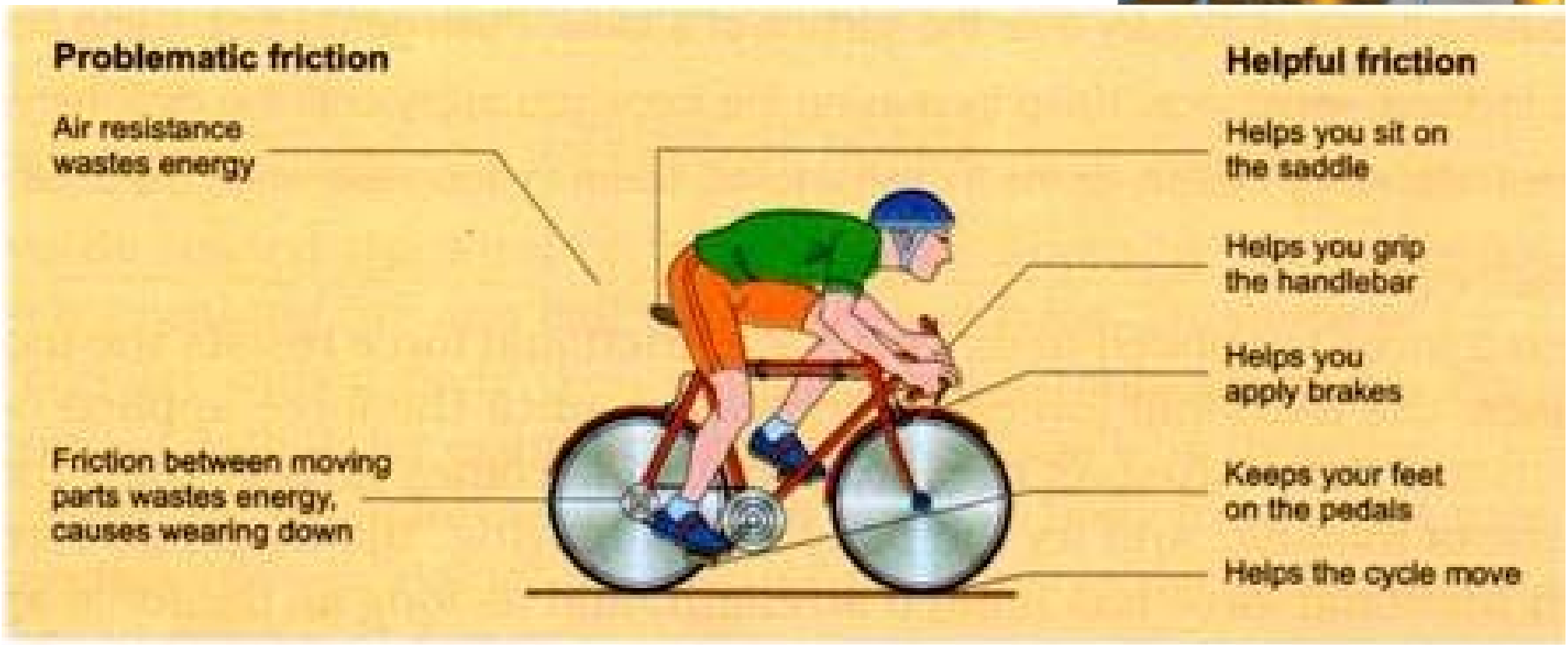
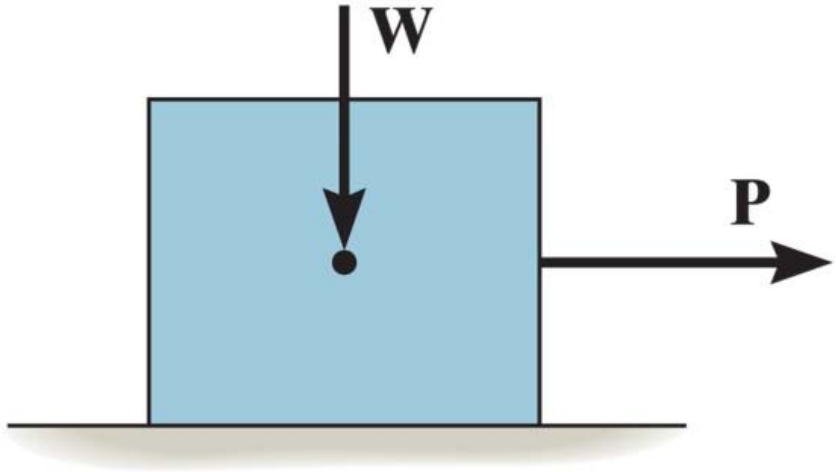


Fig. 8.6 How friction helps and creates problems when you cycle

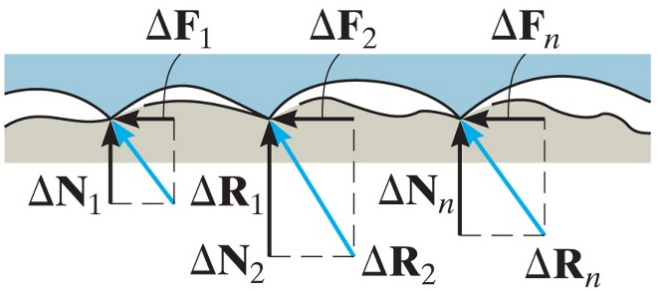
This is a good link to explain different types of forces:
http://www.yourarticlelibrary.com/science/4-important-types-of-force-explained-with-diagram/31675

Dry friction

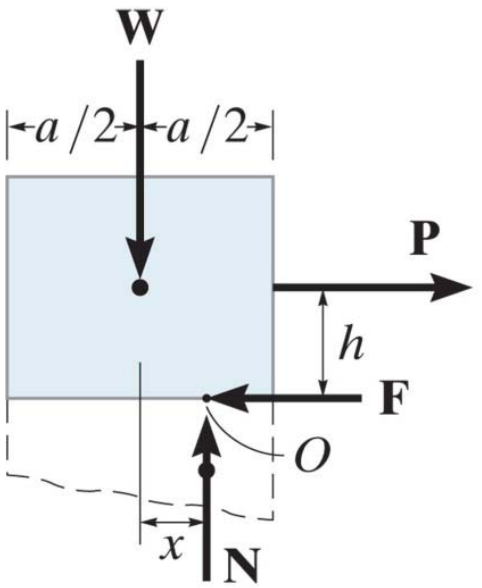
- Consider the effects of pulling horizontally a block of weight **W** which is resting on a **rough** surface.



- The floor exerts an uneven distribution of normal forces $\Delta \boldsymbol{N}_n$ and frictional forces $\Delta \boldsymbol{F}_n$ along the contacting surface.



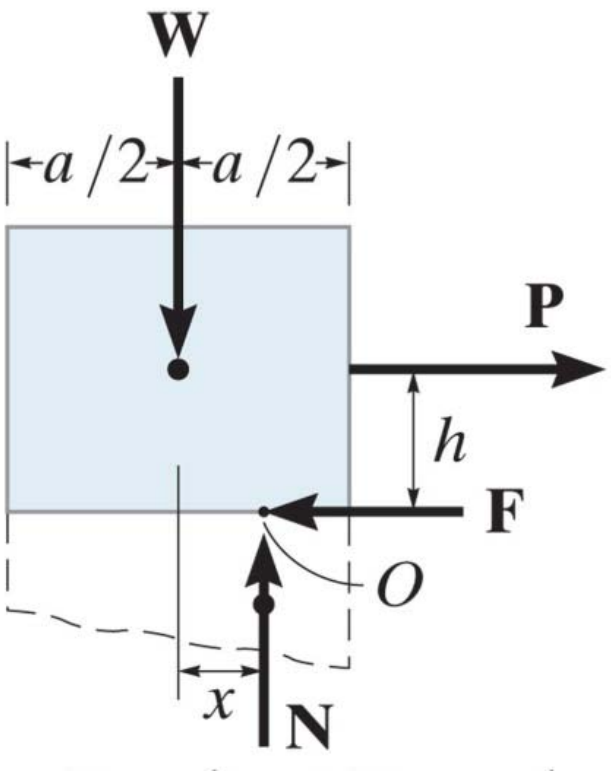
- These distributed loads can be represented by their equivalent resultant normal forces $\boldsymbol{N}$ and frictional forces $\boldsymbol{F}$



Dry friction

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

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

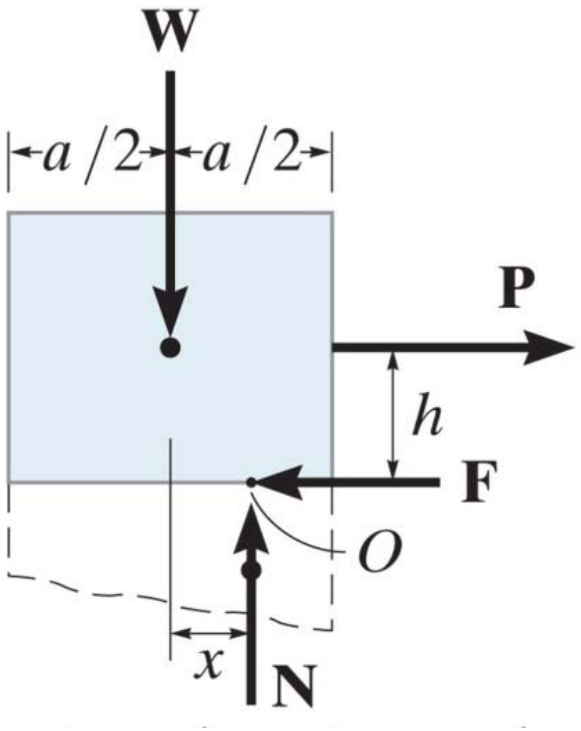


- **Impending motion**: the <u>maximum</u> force F_s before slipping begins is given by

$$F_s = \mu_s\, N$$

where μ_s is called the coefficient of static friction

1. $P = 0 \rightarrow$ no motion; no friction
2. $P < F_s \Rightarrow P < \mu_s W \rightarrow$ no motion; friction force $|F| = |P|$
3. $P = F_s = \mu_s W \rightarrow$ no motion, but on the point of sliding
4. $P > F_s \rightarrow$ box begins to slide, since $\sum F_x > 0$



When $P > F_s$, the frictional force is no longer a function of the coefficient of static friction, but instead it will drop to a smaller value F_k, i.e.,

$$F_k = \mu_k N$$

where μ_k is called the coefficient of kinetic friction, or dynamic friction. Typical values for μ_k are approximately 25% smaller than the ones for μ_s.

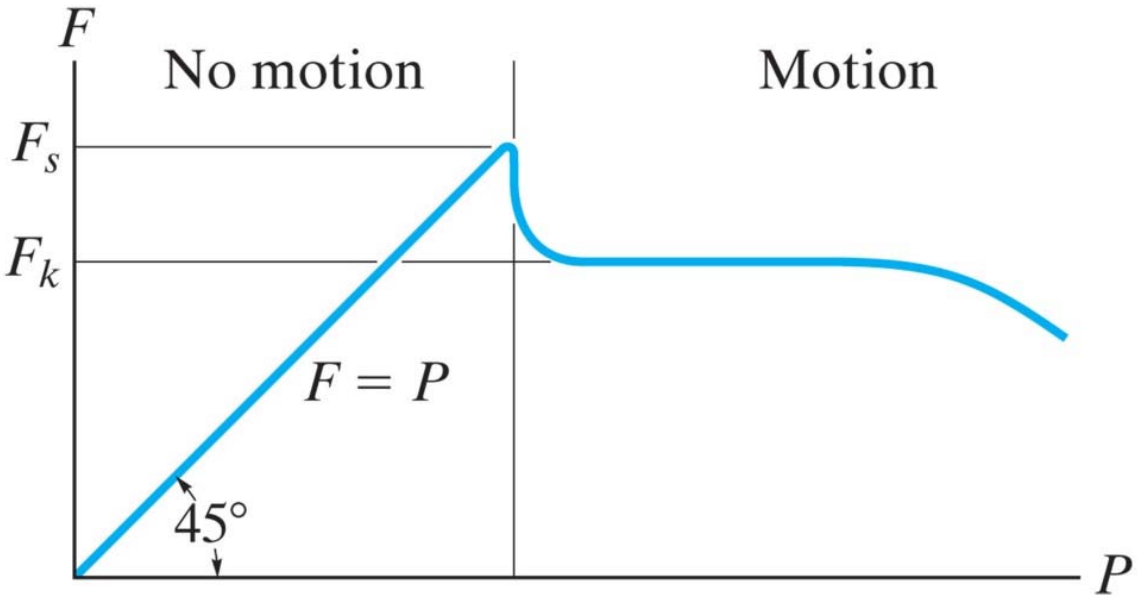
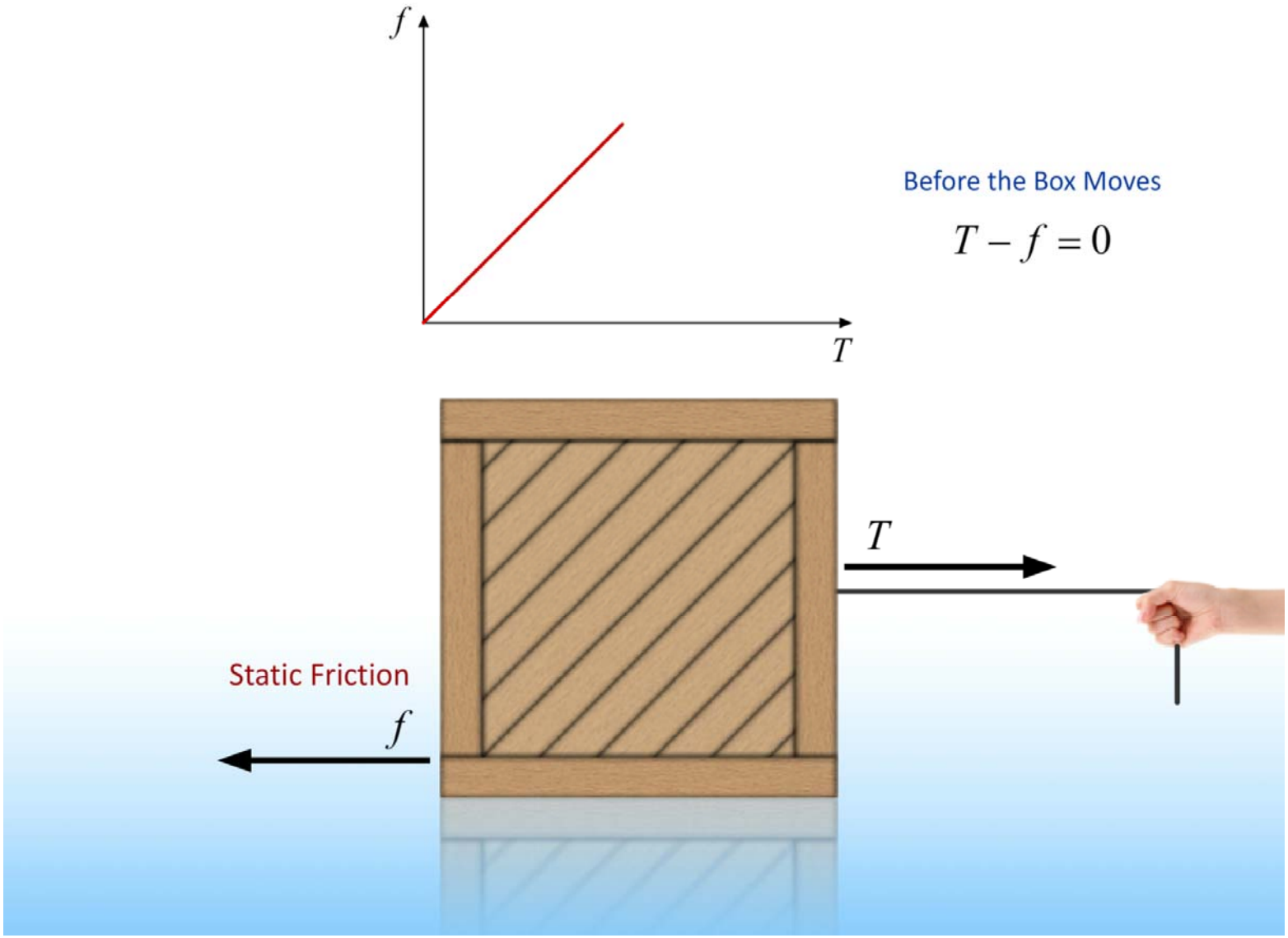
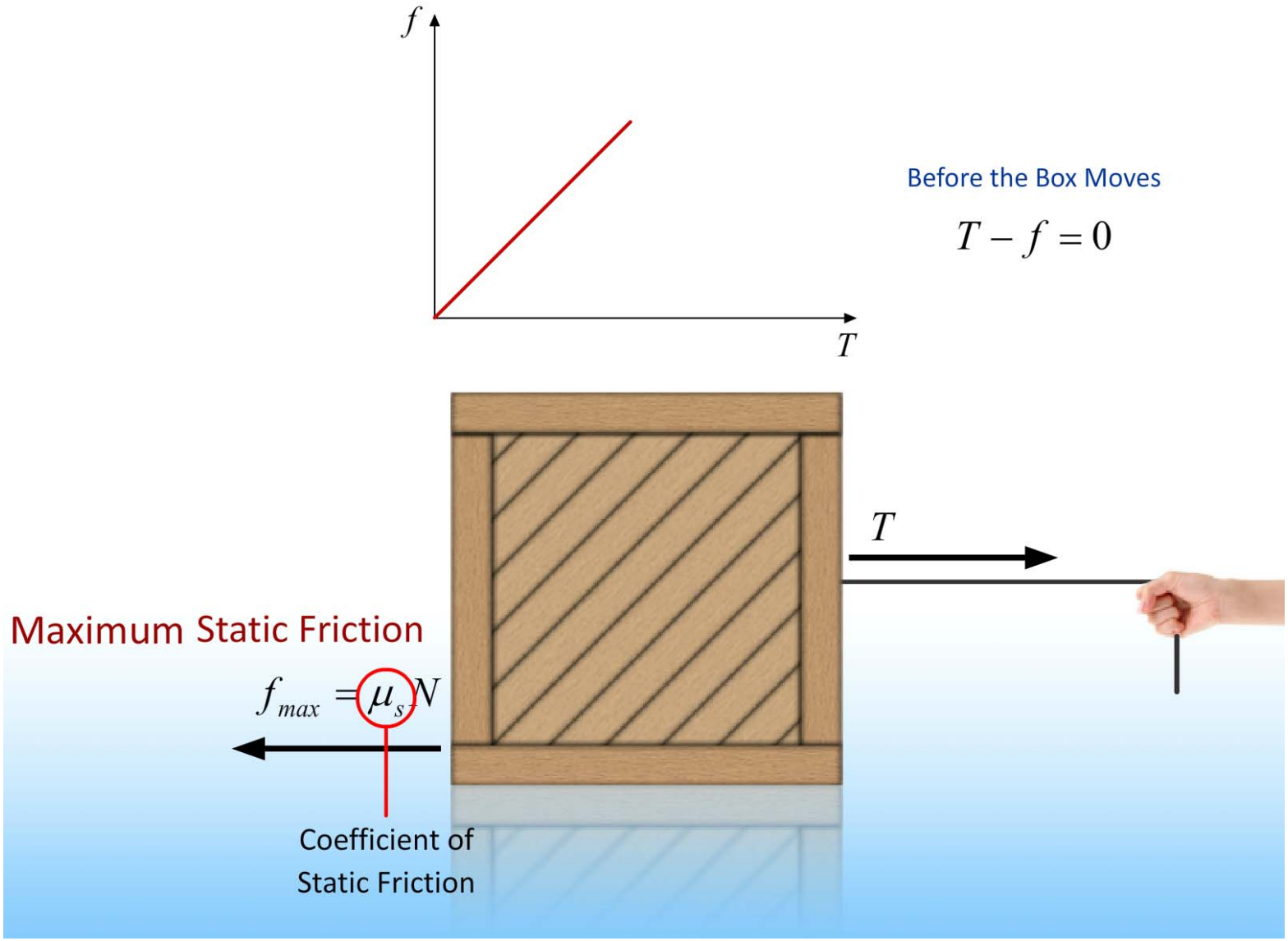


Table 8–1 Typical Values for μ_s

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



Physics 211: Flipitphysics.com



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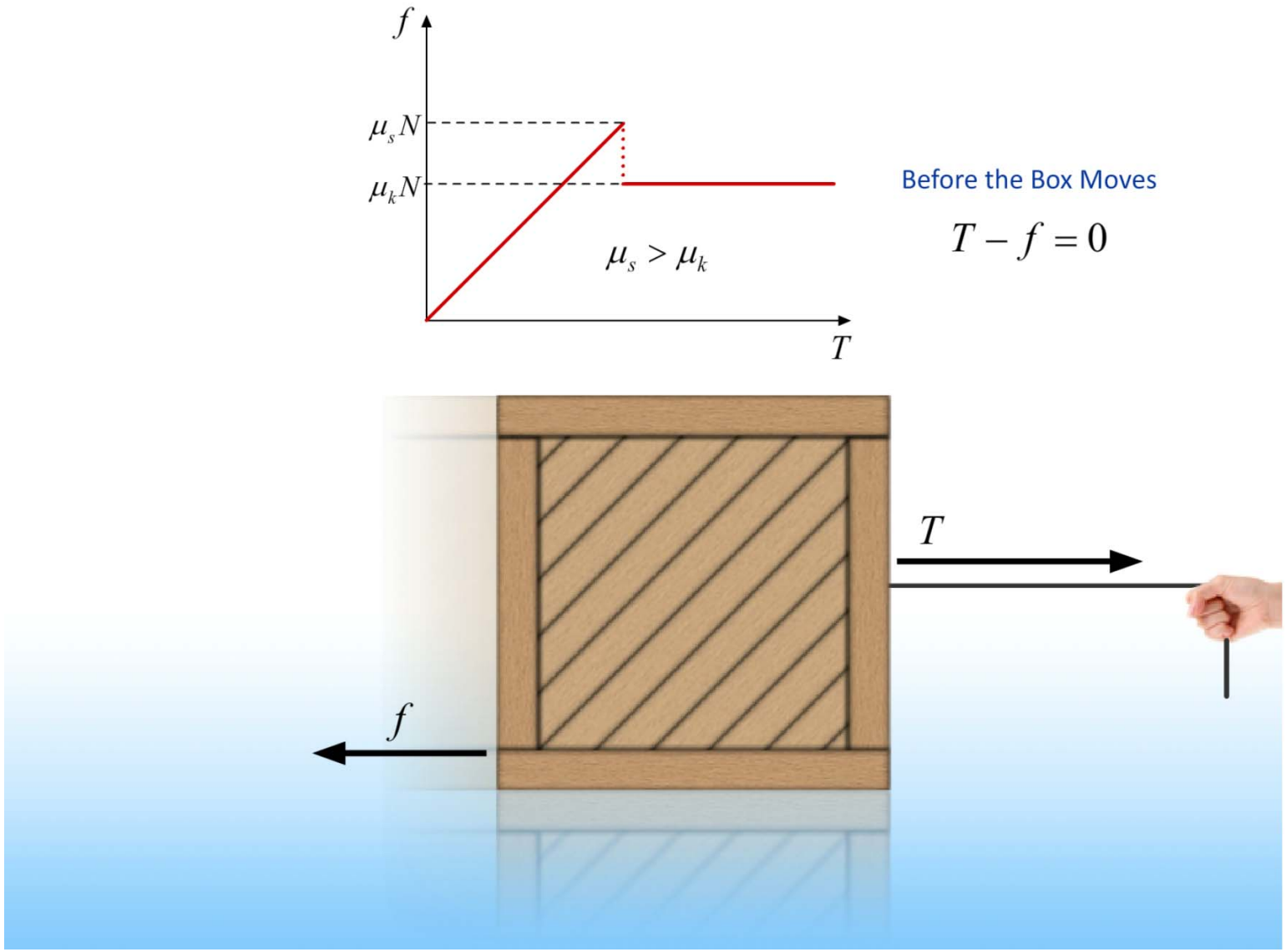
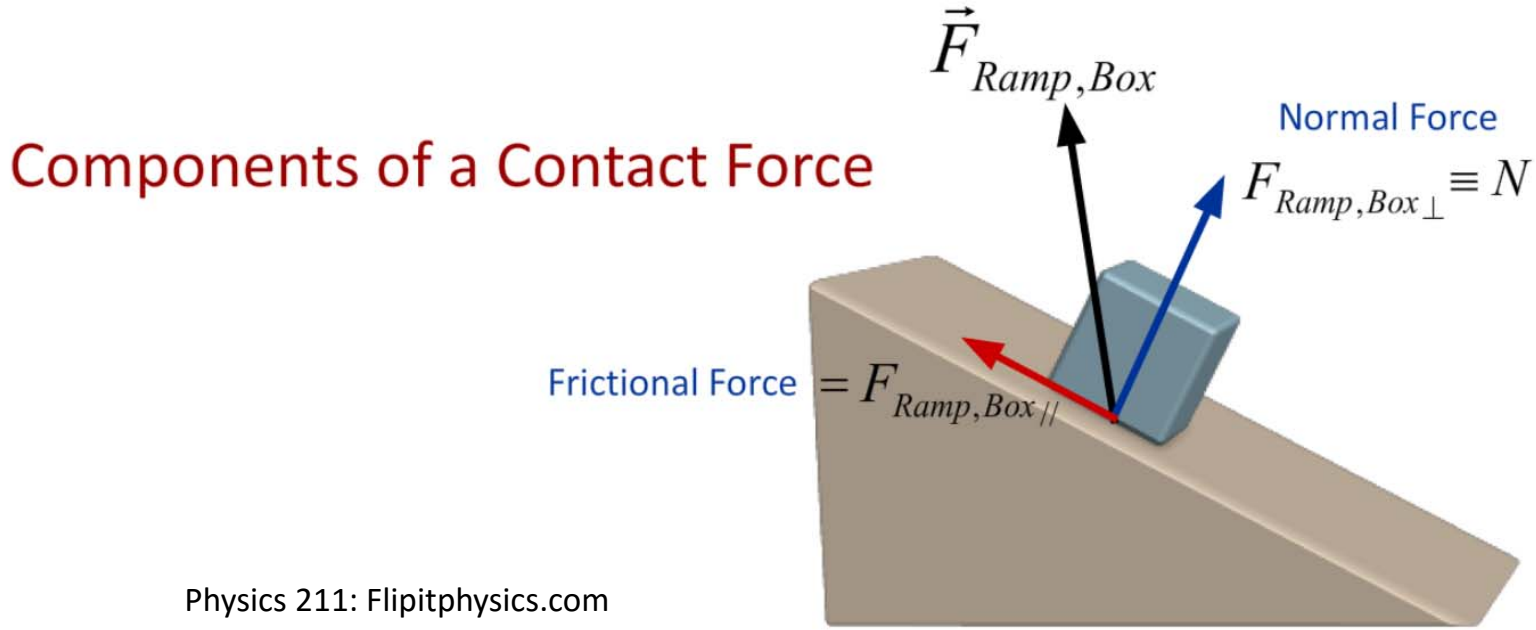


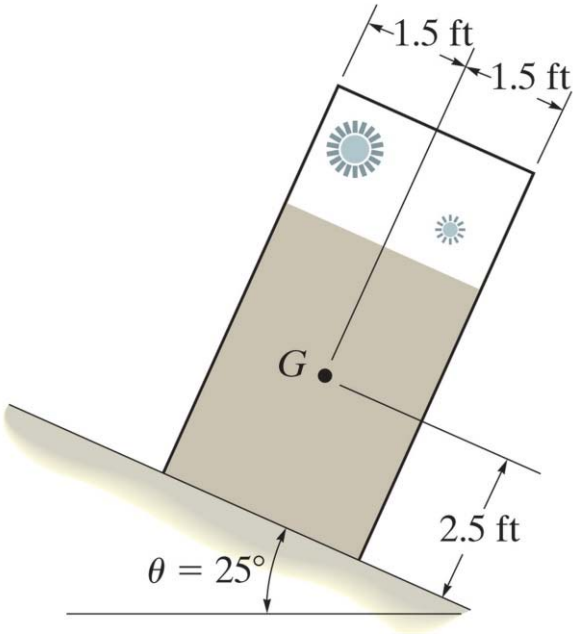
Physics 211: Flipitphysics.com

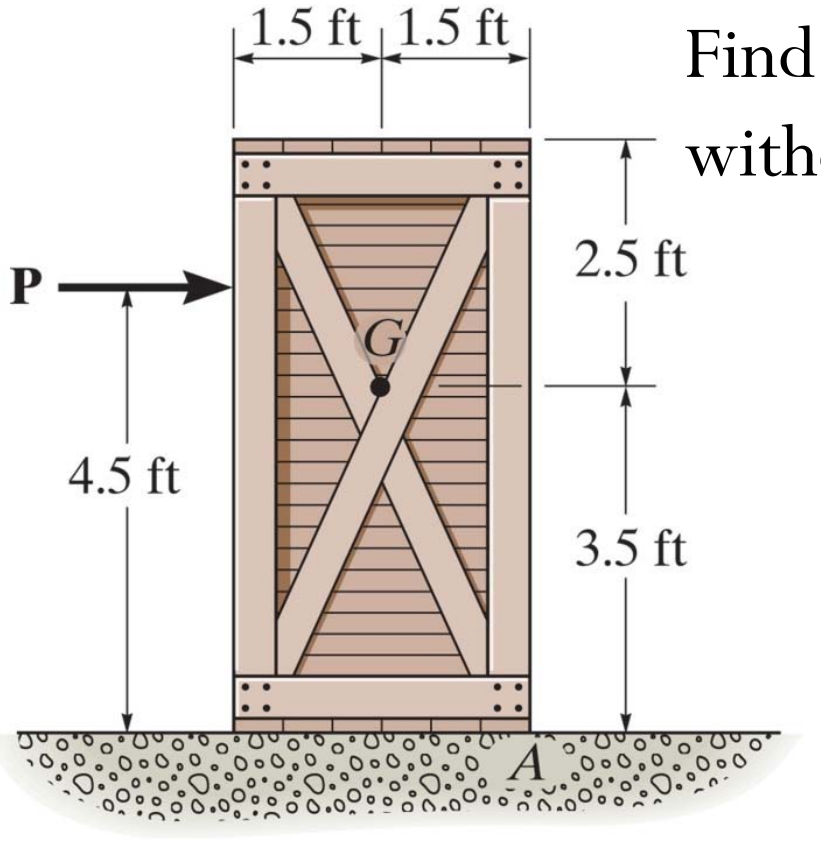
Summary: Dry friction

- Friction acts tangent to contacting surfaces and in a direction opposed to motion of one surface relative to another
- Coefficient of friction is the ratio of friction force F and normal force N
  - Static friction: $\mu_s \leq F_s/N$
  - Kinetic friction: $\mu_k = F_k/N$
- Maximum static frictional force occurs when motion is impending
- Kinetic friction is the tangent force between two bodies after motion begins. Less than static friction by about 25%.



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.





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