To do ...

- Quiz 5 in progress
  27. Having multiple attempts at each quiz problems allows me to locate and correct mistakes in my work

- HW 18 PL Today
- HW 19 ME Thurs
- WA 10 due Sun

- TAM 210 office hours
  - OCT 30, 31: 5-7 pm 112 Transportation bldg

- TAM 210 FINAL (Nov 1 – Nov 5)
Early feedback results – thank you!

13. I go to office hours for help

22. I use Matlab (or other software) for homework

23. The homework helps me understand course material

24. The homework prepares me for the quizzes
Chapter 8: Friction
Main goals and learning objectives

- Introduce the concept of dry friction
- Analyze the equilibrium of rigid bodies subjected to this force
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.
Dry friction

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

- Consider the effects of pulling horizontally (force $P$) a block of weight $W$ which is resting on a rough surface.

- The floor exerts an uneven distribution of normal forces $\Delta N_n$ and frictional forces $\Delta F_n$ along the contacting surface.

- These distributed loads can be represented by their equivalent resultant normal forces $N$ and frictional forces $F$.
Dry friction

**Table 8–1** Typical Values for $\mu_s$

<table>
<thead>
<tr>
<th>Contact Materials</th>
<th>Coefficient of Static Friction ($\mu_s$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Metal on ice</td>
<td>0.03–0.05</td>
</tr>
<tr>
<td>Wood on wood</td>
<td>0.30–0.70</td>
</tr>
<tr>
<td>Leather on wood</td>
<td>0.20–0.50</td>
</tr>
<tr>
<td>Leather on metal</td>
<td>0.30–0.60</td>
</tr>
<tr>
<td>Aluminum on aluminum</td>
<td>1.10–1.70</td>
</tr>
</tbody>
</table>
Dry friction
Dry friction

- Friction acts tangent to contacting surfaces and in a direction opposed to motion of one surface relative to another
- 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%.
- Coefficient of friction is the ratio

- Coefficient of friction is independent of normal force and area of contact
Find the maximum force $P$ that can be applied without causing movement of the crate.
It is observed that when the bed of the dump truck is raised to an angle of $\theta = 25^\circ$ 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.
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.