Lecture 25

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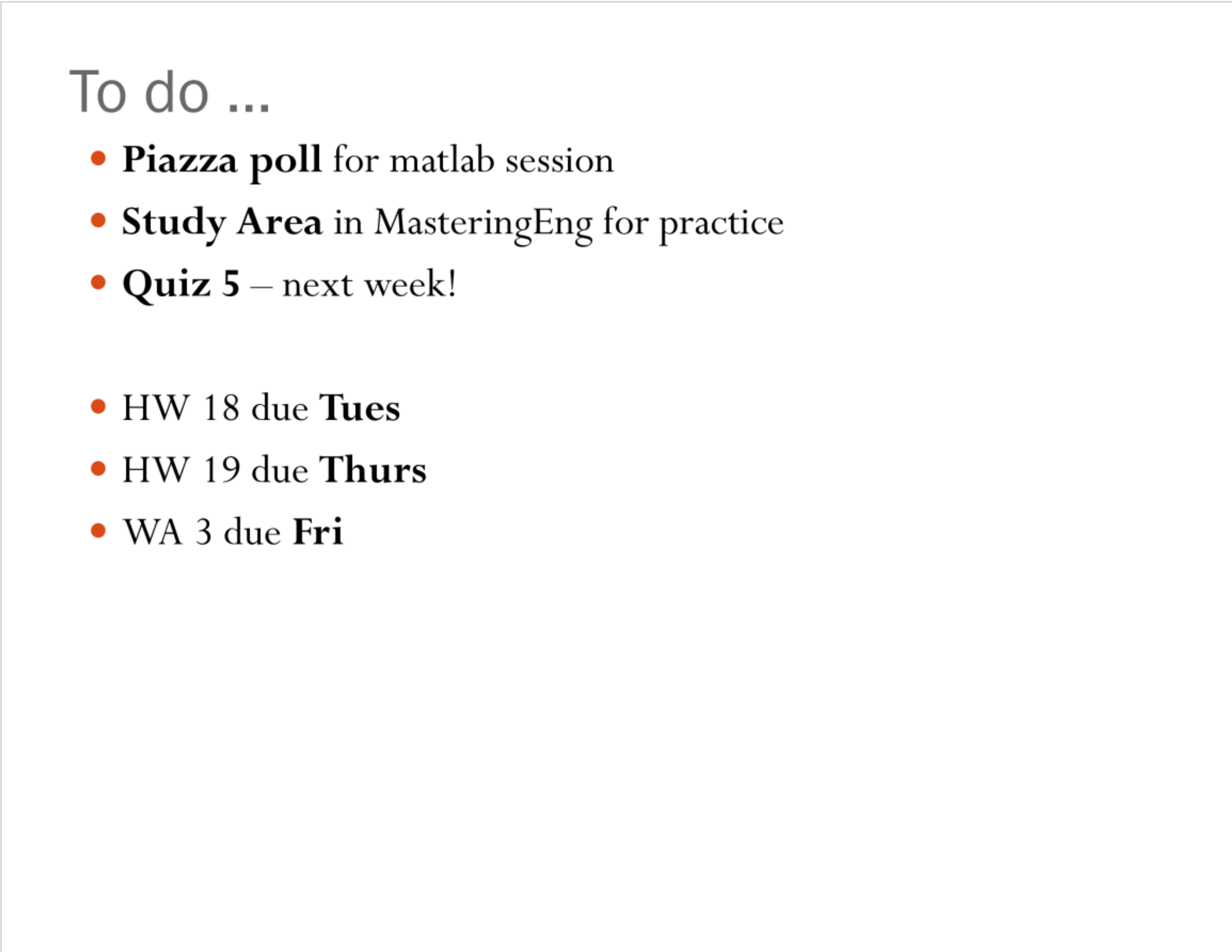

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Chapter 8: Friction

Main goals and learning objectives

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

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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.

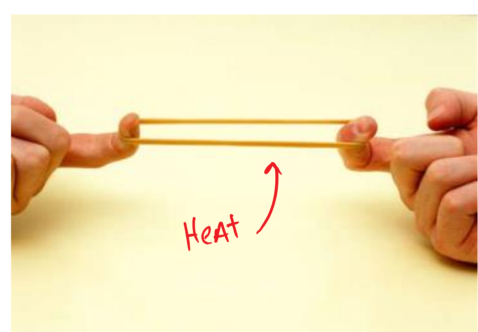
Dry Friction (or Coulomb friction) occurs between the contacting surfaces of bodies when there is no lubricating fluid.

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.

Dry
Fluid (viscosity)
Lubricated
Skin (Drag)
Internal (deformation)

bearing
Atmospheric Entry
Rubber band

Heat




P ZERO

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Dry friction

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

good AND bAD!

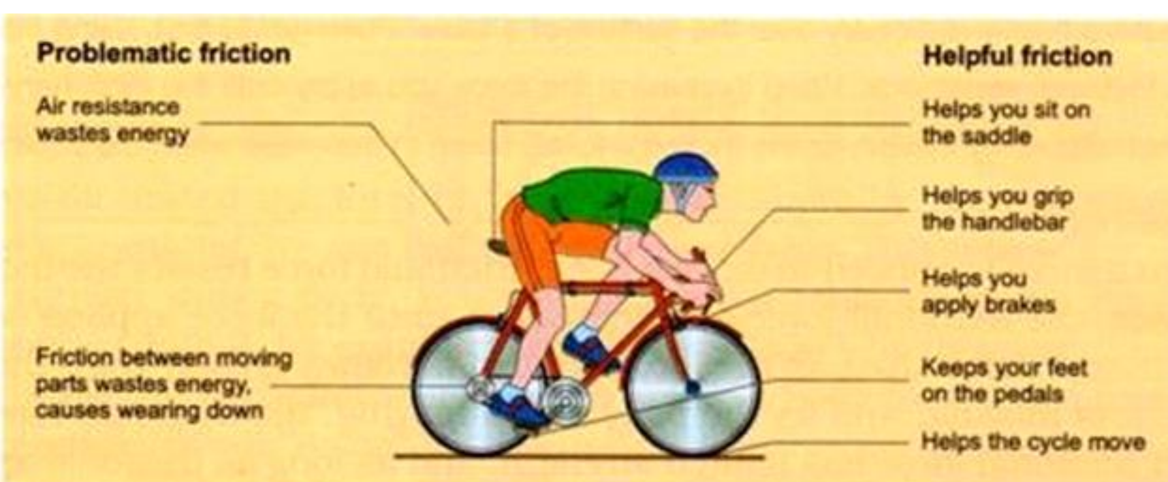
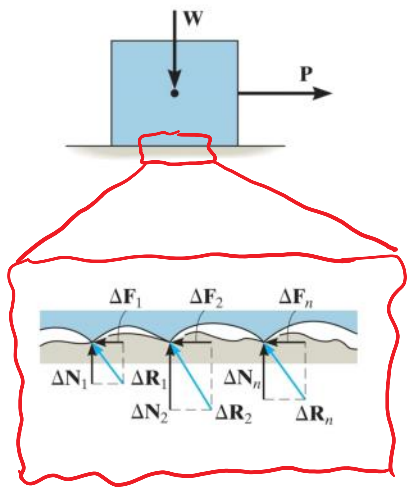
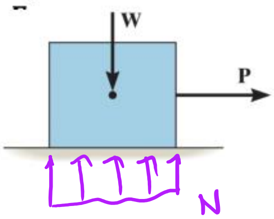


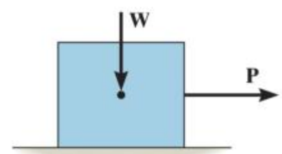
Fig. 8.6 How friction helps and creates problems when you cycle

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 ΔN_n and frictional forces ΔF_n along the contacting surface.
- These distributed loads can be represented by their equivalent resultant normal forces N and frictional forces







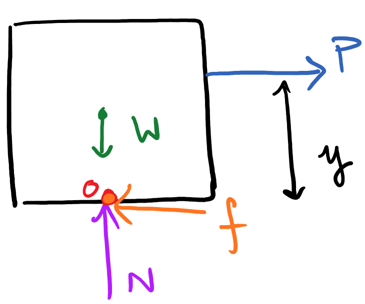
* think about interactions at the surface, small scale

* Friction acts tangent to surface

* Normal force acts perpendicular

Q: where should you put N?

Assume N under W. Is the rigid body in equilibrium?



Sum forces & moments:

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

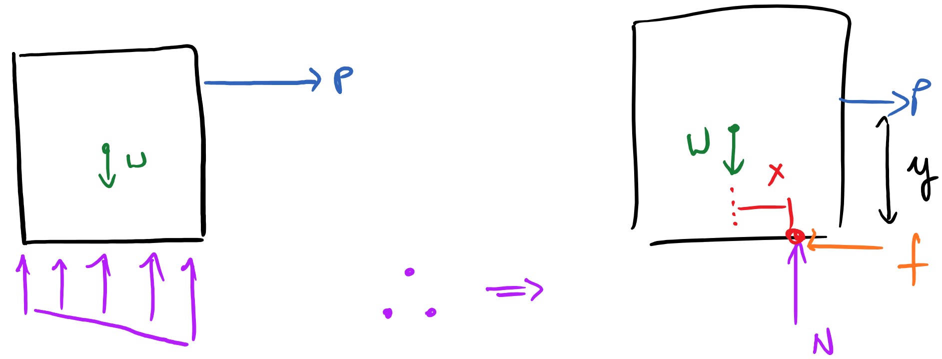
$\Sigma F_y: \quad N - W = 0$

$\Sigma M_O: \quad -yP = 0 \quad \therefore P = 0$??

w, f, N → no moments about O

∴ the location of N is incorrect.

lets redraw using the following:



Sum forces and moments:

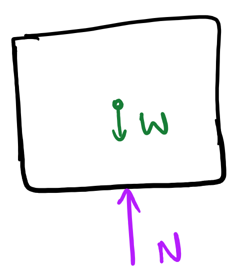
$\Sigma F_x: \; P - f = 0 \longrightarrow P = f$

$\Sigma F_y: \; N - W = 0 \longrightarrow N = W$

$\Sigma M_o: \; xW - yP = 0 \quad \therefore \quad \boxed{x = \frac{yP}{W}}$

from this equation we get:

$x = 0$ if and only if $P = 0$



if $P \neq 0$ then $x \neq 0$,

$x = y \cdot P \cdot \frac{1}{W}$

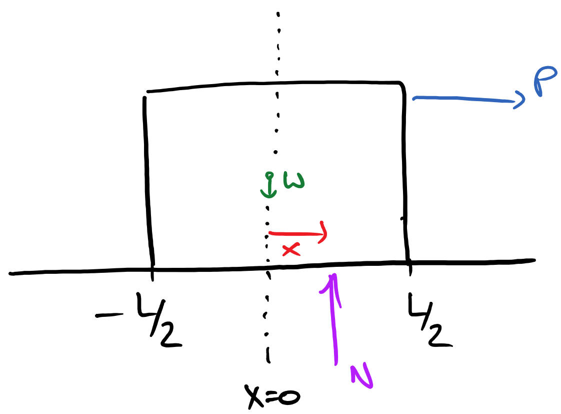
if $W \uparrow$ then $x \downarrow$

if $P \uparrow$ then $x \uparrow$

if $y \uparrow$ then $x \uparrow$

Q: CAN x be Any value?

NO! – the normal force must act below object, between contacting surfaces!

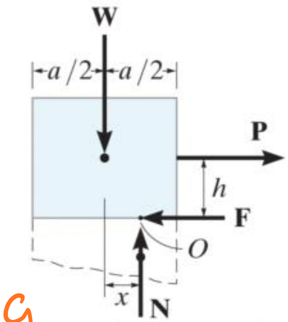


$0 < x < L/2 \rightarrow$ sliding

$x = L/2 \rightarrow$ tipping

Dry friction: Static

1. $P = 0$ – no motion, ($\equiv M$)
2. $P < f_s$ – no motion, $|F| = |P|$ ($\equiv M$)
3. $P = f_s = \mu_s N$ – no motion, impending motion ($\equiv M$)
4. $P > f_s$ – motion!



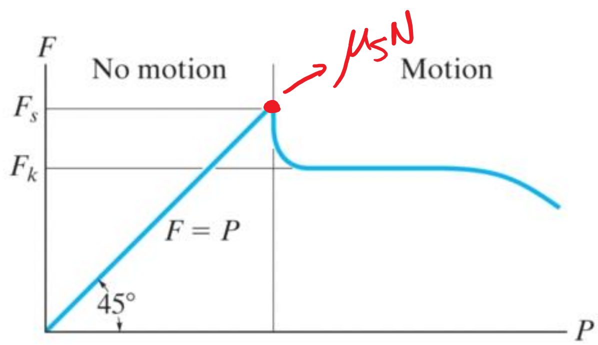


Table 8–1 Typical Values for μ_s

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