Printout

Monday, March 25, 2019 10:44 AM

Announcements

- TAM 210 – This is your last week of class ☹
- No class Wednesday (3/27)
  - Wednesday discussion sections will still meet
- Discussion next week is not required for TAM 210 students (but recommended)
- Exam next week is for <u>both</u> TAM 210 AND 211 students
- Quiz 4 retry review tonight (Monday, March 25, 6-8PM, DCL 520)

❑ Upcoming deadlines:

- Nothing this week! (Written Assignment 9 will be for practice only)

Next week:

- Last TAM 210 PrairieLearn homework (HW9/11) due Monday, April 1 (it's not a joke)

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Chapter 8: Friction

Objectives

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

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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.

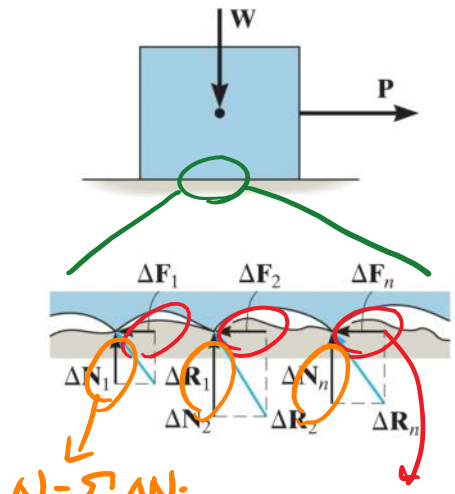
Dry Friction (or Coulomb friction) occurs between the contacting surfaces of bodies when there is no lubricating fluid.

(Not smooth)

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

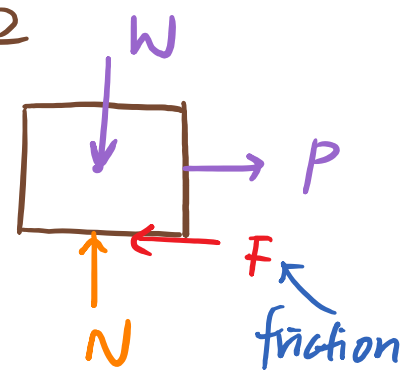
- Consider the effects of pulling horizontally (force **P**) a block of weight **W** which is resting on a **rough** surface.
- The floor exerts an uneven distribution of normal forces ΔN_n and frictional forces ΔF_n along the contacting surface.
- These distributed loads can be represented by their equivalent resultant normal forces N and frictional forces F



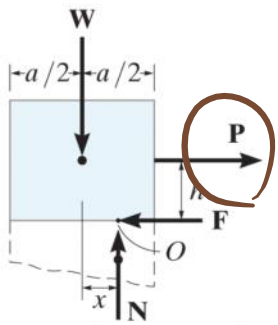
$N = \Sigma \Delta N_i$

$F = \Sigma \Delta F_i$

FBD



Dry friction



$F = \mu N$

F_s = maximum before motion

$\rightarrow F_s = \mu_s N$

F_k = kinetic friction

$\rightarrow F_k = \mu_k N$

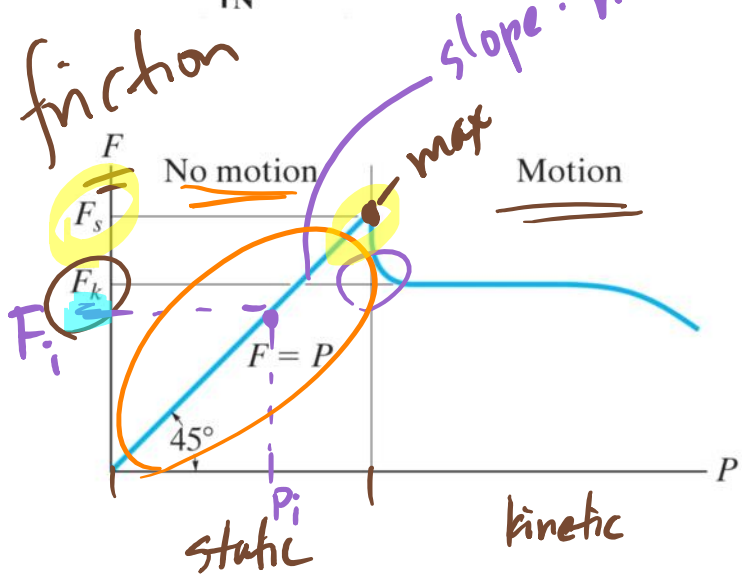


Table 8–1 Typical Values for μ_s	
Contact Materials	Coefficient of Static Friction (μ_s)
Metal on ice	0.03–0.05
Wood on wood	0.30–0.70
Leather on wood	0.20–0.50
Leather on metal	0.30–0.60
Aluminum on aluminum	1.10–1.70

Motion involving Friction

1.) $P < F_s$: $F = P$ (No motion)

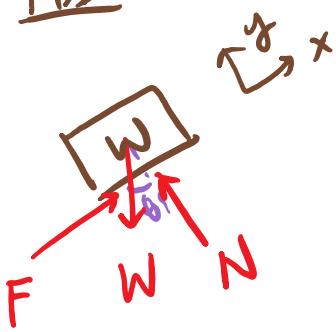
2.) $P = F_s$: $F = F_s$ (Pending motion)

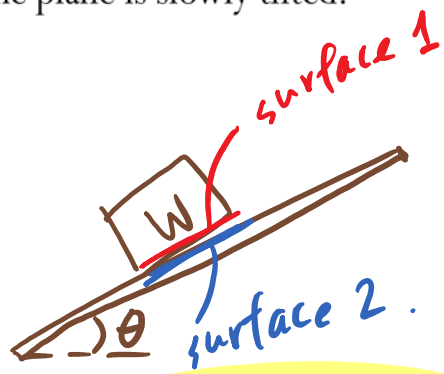
3) $P > F_s$: $F = F_k$ (in motion)

Determine μ_s Experimentally

A block with weight W is placed on an inclined plane. What will happen to the block when the plane is slowly tilted?

FBD





EoE

$$\Sigma F_x = F - W\sin\theta = 0$$
$$\Sigma F_y = N - W\cos\theta = 0$$

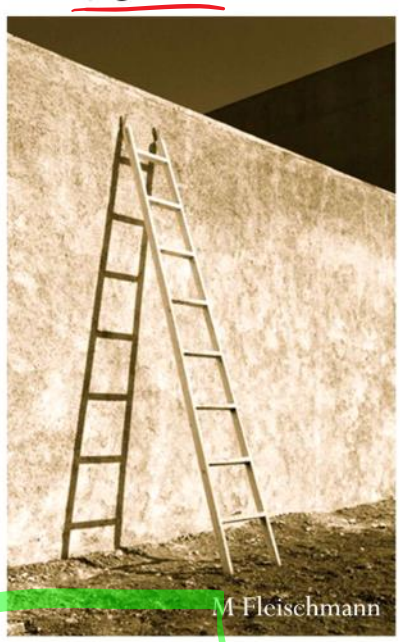
μ_s? $F_s = \mu_s N$ when F is at max.

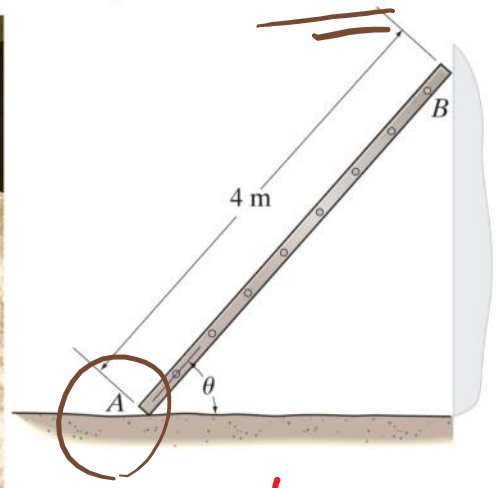
$$\mu_s N - W\sin\theta = 0$$
$$N - W\cos\theta = 0$$
at pending motion.

$$\longrightarrow \frac{\mu_s \cancel{N} = \cancel{W}\sin\theta}{\cancel{N} = \cancel{W}\cos\theta} \longrightarrow \mu_s = \underline{\tan\theta}$$

Example

A metal ladder with a mass of 10 kg is leaning against a smooth wall on an icy ground. Can it maintain equilibrium if $\theta = 30°$?

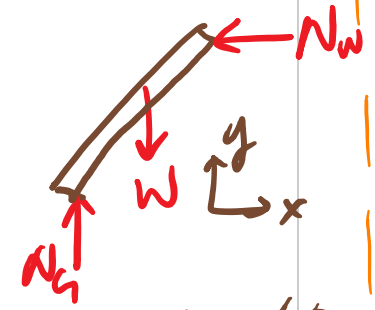




$\mu_s = 0.04$

If no friction,

FBD



$\Sigma F_x = N_w \neq 0$

$\rightarrow$ ~~equilibrium~~

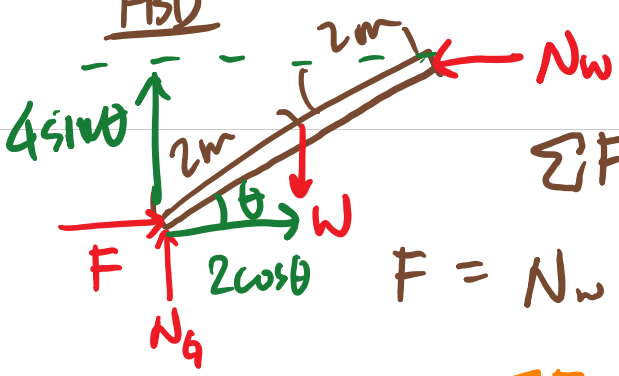
Friction

$F = N_w$?

$F = F_s$?

$F = F_k$?

FBD



$\Sigma F_x = F - N_w = 0$

$F = N_w$ for equilibrium

$\Sigma F_y = -W + N_G = 0$

$N_G = W$

$$\Sigma M_A = -W(2m)\cos\theta + N_w(4m)\sin\theta = 0$$

$$\rightarrow N_w = \frac{W\cos\theta}{2\sin\theta}$$

$$\cancel{W}\left(\frac{\cos\theta}{\ }\right) \overset{?}{\leq} \mu_s \cancel{W}$$

$$N_W = \frac{W\cos\theta}{2\sin\theta}$$

$$F_s = \underline{\mu_s N_G} = \mu_s W$$

$$\cancel{W}\left(\frac{\cos\theta}{2\sin\theta}\right) \boxed{>} \mu_s \cancel{W}$$

$$\frac{0.866}{2(0.5)} \qquad 0.04$$

$\therefore$ Since the normal force from the wall (N_W) is greater than maximum friction provided by the ground (F_s), the ladder <u>cannot</u> maintain equilibrium.