DeAnza College

Mechanics
Friction

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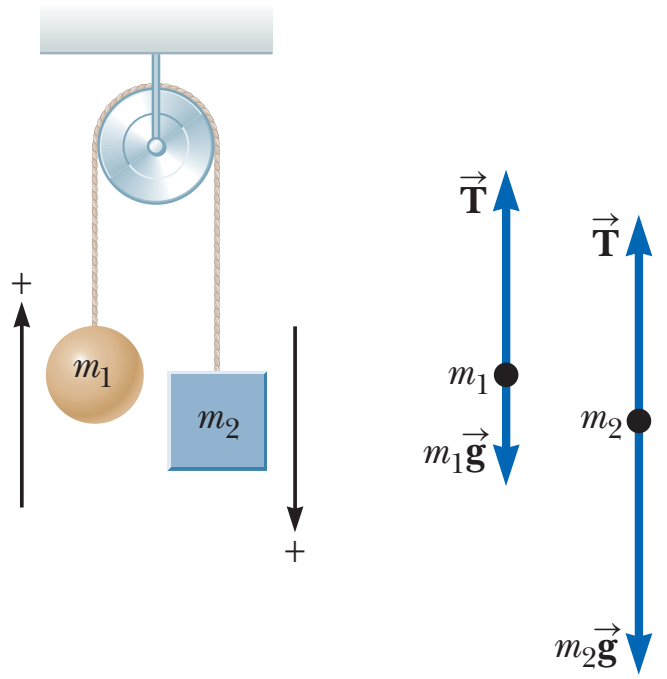
Last time

- Types of forces and new scenarios
  - contact forces
  - tension
  - pulleys

Overview

- finish Atwood machine
- friction

Recap: Pulleys and the Atwood Machine



We can consider the motion for each mass separately. In the y-directions:

$$F_{\text{net},1,y} = T - m_1 g = m_1 a \qquad \text{(up positive)} \qquad (1)$$

$$F_{\text{net},2,y} = m_2 g - T = m_2 a \qquad \text{(down positive)} \qquad (2)$$

Be careful about the signs! Both masses must accelerate together - one up, one down.

Recap: Pulleys and the Atwood Machine

Finding acceleration and tension in the rope:

$$F_{\text{net},1,y} = T - m_1 g = m_1 a \tag{1}$$

$$F_{\text{net},2,y} = m_2 g - T = m_2 a \tag{2}$$

Take eq (1) + eq (2):

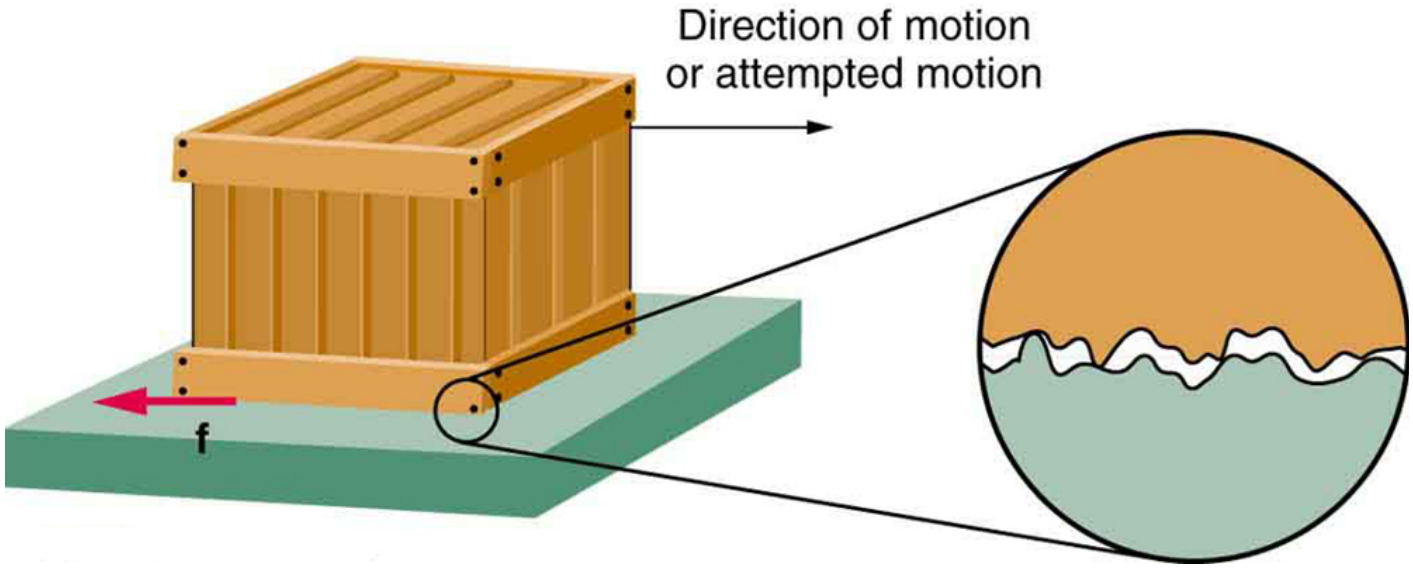
$$\begin{aligned} m_2 g - m_1 g &= m_1 a + m_2 a \\ a &= \frac{(m_2 - m_1) g}{m_1 + m_2} \end{aligned}$$

$$T = \frac{2 m_1 m_2 g}{m_1 + m_2}$$

Question

You push on a heavy crate and moves it across the floor. However, even as you push it does not accelerate and if you stop pushing, the box stops moving. Why?

Some Types of Forces: Friction



Friction is a force that opposes motion.

Tiny defects in the surface of the floor and the crate catch on one another as the crate is pushed.

[1] Figure from boundless.com

Friction

friction

The force caused by small-scale roughness of surfaces or even electrostatic attractions between surfaces. It resists motion.

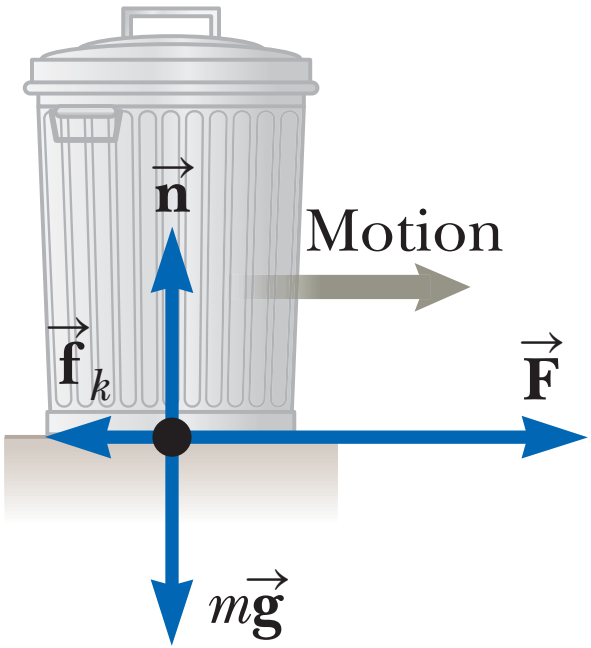
There are actually two types of friction:

- kinetic (moving across surface)
- static (stationary on surface)

Friction

Kinetic Friction

Kinetic friction is a resistive force that dissipates energy.



kinetic friction $\propto$ normal force

$$f_k = \mu_k n$$

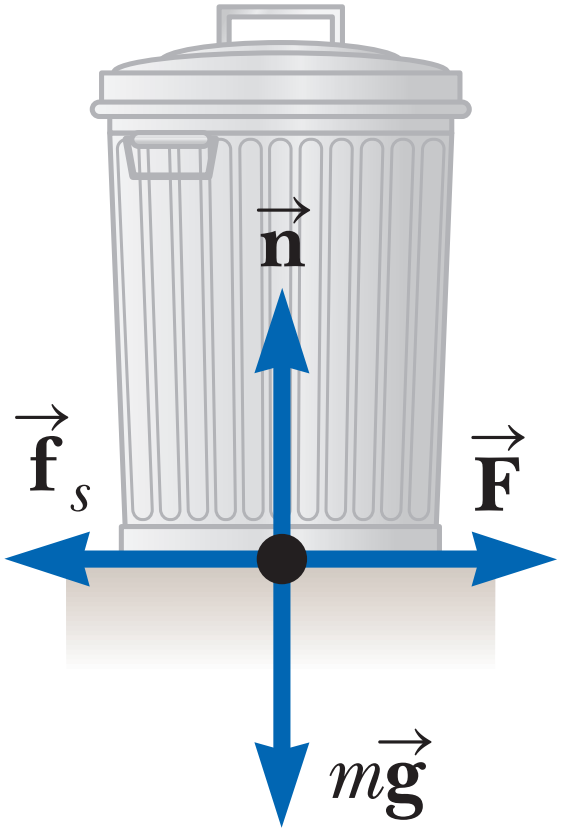
μ_k is the coefficient of **kinetic** friction

The kinetic friction force always acts to oppose motion of the surfaces relative to each other. That means the kinetic friction $\mathbf{f}_k$ always points opposite to the velocity vector.

Friction

Static Friction

Static friction acts when there is some component of a force on an object parallel to the surface it rests on, but the object does not move relative to the surface.



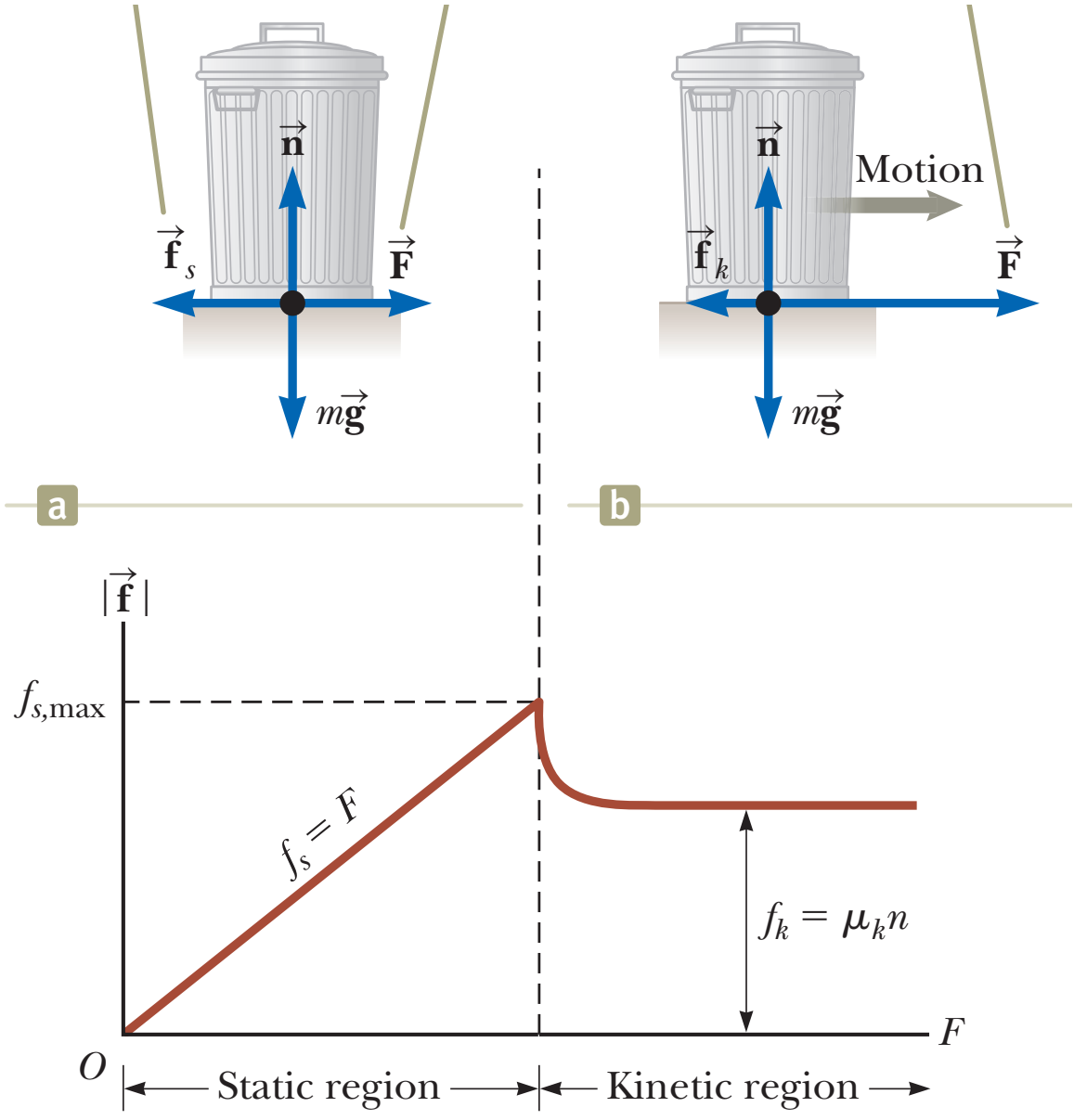
max. static friction $\propto$ normal force

$$f_s \leqslant \mu_s n$$

μ_s is the coefficient of **static** friction

$$f_{s,\text{max}} = \mu_s n$$

Friction


n
f s
F
mg
a
n
Motion
f k
F
mg
b
|f|
fs,max
fs = F
fk = μkn
F
O
Static region
Kinetic region

Friction Example

For waxed wood on wet snow $\mu_s = 0.14$ and $\mu_k = 0.10$. You pull on a sled of mass 10 kg that is at rest initially. How much force do you need to apply to get the sled moving? If you continue to apply that force, what will the magnitude of sled's acceleration be once it is moving?

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To get the sled moving $F_{app} \geqslant f_s$

$$\begin{aligned} f_s &= \mu_s n \\ &= (0.14)(10\text{ kg})g \\ &= 13.72\text{ N} = 14\text{ N} \quad (2\text{ sig figs}) \end{aligned}$$

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$$\begin{aligned} F_{app} - f_k &= 13.72 - \mu_k n \\ &= 13.72 - (0.1)(10\text{ kg})g \\ &= 3.92\text{ N} \quad \Rightarrow a = \frac{3.92\text{ N}}{10\text{ kg}} = 0.39\text{ ms}^{-2} \end{aligned}$$

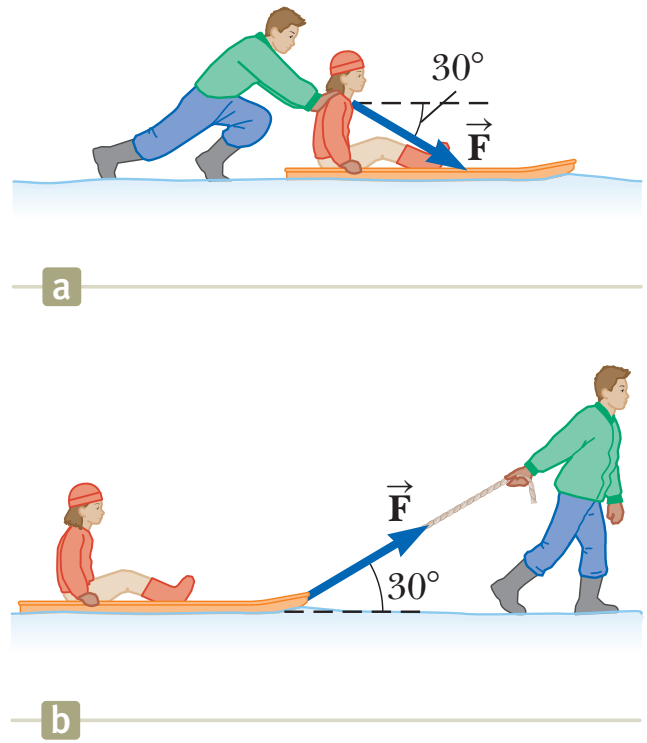
Friction Question

Quick Quiz 5.7.[1] You are playing with your daughter in the snow. She sits on a sled and asks you to slide her across a flat, horizontal field. You have a choice of:

(A) pushing her from behind by applying a force downward on her shoulders at 30° below the horizontal or

(B) attaching a rope to the front of the sled and pulling with a force at 30° above the horizontal.

Which would be easier for you and why?



[2]Serway & Jewett, page 132.

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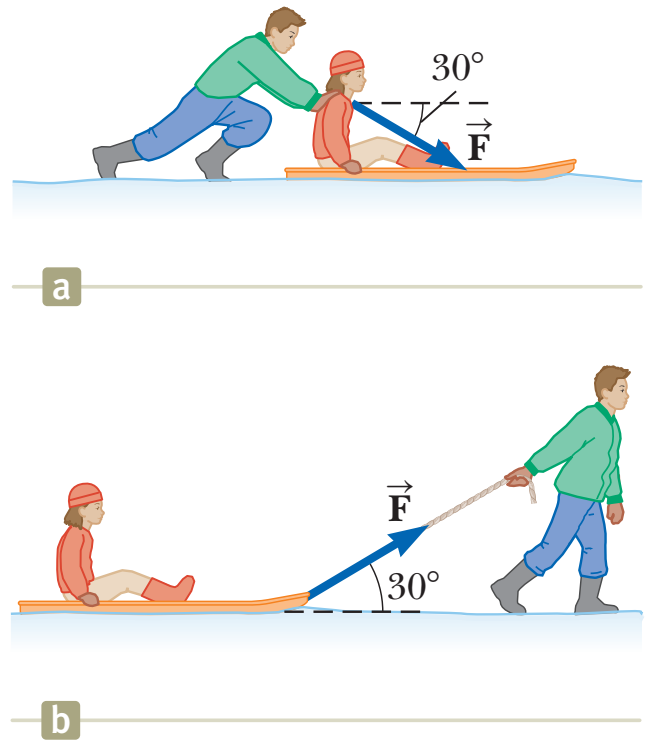

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Friction Example

60. W A woman at an airport is towing her 20.0-kg suitcase at constant speed by pulling on a strap at an angle θ above the horizontal (Fig. P5.60). She pulls on the strap with a 35.0-N force, and the friction force on the suitcase is 20.0 N. (a) Draw a free-body diagram of the suitcase. (b) What angle does the strap make with the horizontal? (c) What is the magnitude of the normal force that the ground exerts on the suitcase?

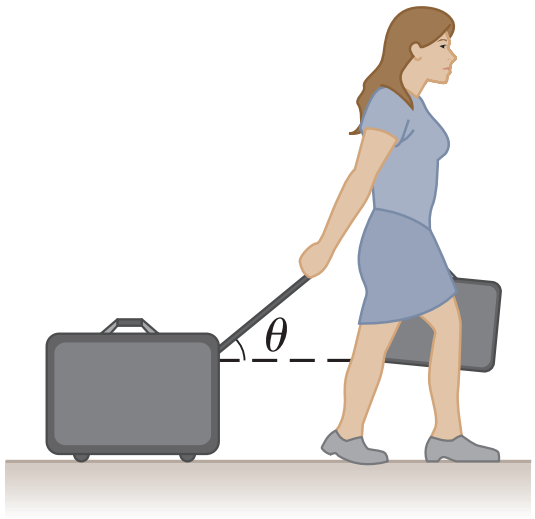

Figure P5.60

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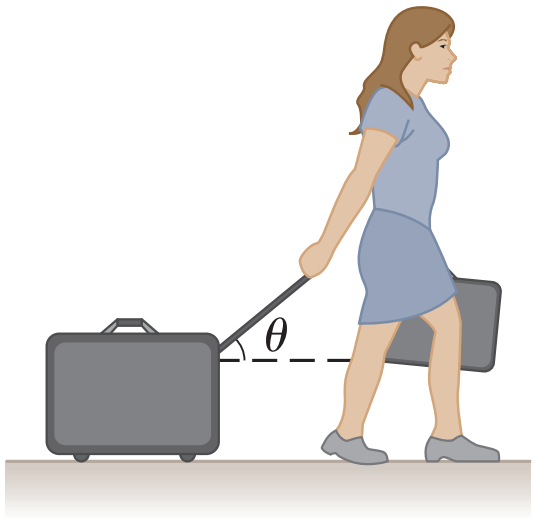

Figure P5.60

Answers:

b) $\theta = 55.2°$

c) $n = 167$ N

Summary

- finish Atwood machine
- friction

Homework

- Ch 6 Ques: 1, 3; Probs: 1, 5, 7, 9, 17, 27, 29