# Friction

## Friction

- Friction is the force that opposes applied forces.
- Caused by the interaction between the two surfaces in contact
- Two types
  - Static friction
  - Kinetic friction

# Static Friction

- Frictional force that keeps the object from beginning to move.
- Always matches the applied force until the applied force is large enough to move the object. ($F_{applied} = F_{f,static}$)
- When the applied force is as great as it can be without moving the object, the force of static friction is at a maximum, $F_{f,max\ static}$. ($F_{applied} = F_{f,max\ static}$)

# Kinetic Friction

- The frictional force that opposes the motion of a moving object.
- The force of kinetic friction, $F_{f,kinetic}$, is less than the $F_{f,max\ static}$
- $F_{net} = F_{applied} - F_{f,kinetic}$
- When an object is moving at a constant velocity, the net force is zero, then $F_{applied} = F_{f,kinetic}$

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# What Affects Friction?

- The surfaces themselves (Rubber on Ice vs Rubber on concrete)
- The normal force
- The relationship between surfaces and the normal force is expressed by the coefficient of friction, $\mu$
- Table 4.1 on p.124 has several values

# Coefficients of Friction

- The coefficient of static friction, $\mu_s$, is the ratio of the maximum static friction force to the normal force.

$$\mu_s = \frac{F_{f\,s}}{F_N} \quad or \quad F_{f\,s} = \mu_s F_N$$

- The coefficient of kinetic friction, $\mu_k$, is the ratio of the kinetic friction force to the normal force.

$$\mu_k = \frac{F_{f\,k}}{F_N} \quad or \quad F_{f\,k} = \mu_k F_N$$

# Sample Problem 1

- A force of 25 N is applied to a 4-kg box to move it across the floor with an acceleration of 2.5 m/s$^2$. What is the coefficient of friction between the box and the floor?
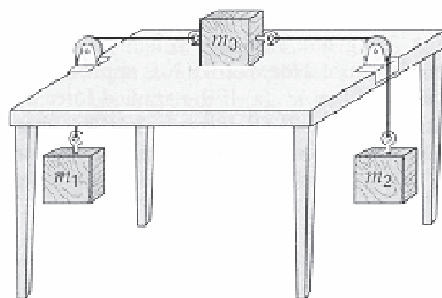
# Sample Problem 2

- Jenny pulls her sister on a sled with a force of 124 N at an angle of 32$^\circ$. The combined mass of her sister and the sled is 46 kg. If they move at a constant velocity, what is the coefficient of friction between the sled and the snow?

# Sample Problem 3

- A 50 kg wood crate is pushed across a wooden plank. A 550 N force is applied at an angle of $30^0$ to the horizontal.
  - Will the crate move?
  - If it does, what is the acceleration of the crate?

# Sample Problem 4



- $\mu_k$ between $m_3$ and table is 0.43.
- $m_1 = 0.73$kg, $m_2 = 0.32$kg, $m_3 = 0.51$kg
- Find the acceleration of the system.

# Sample Problem 4