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 $F_{applied} = F_{f,kinetic}$

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, μ
- Table 4.1 on p.124 has several values

Coefficients of Friction

- The coefficient of static friction, μ_s, is the ratio of the maximum static friction force to the normal force.

$$\mu_s = \frac{F_{fs}}{F_N} \quad or \quad F_{fs} = \mu_s F_N$$

- The coefficient of kinetic friction, μ_k, is the ratio of the kinetic friction force to the normal force.

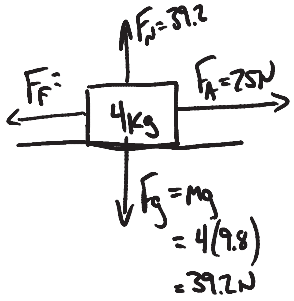
$$\mu_k = \frac{F_{fk}}{F_N} \quad or \quad F_{fk} = \mu_k F_N$$

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?

$\mu = \frac{F_F}{F_N}$

$= \frac{15}{39.2} = .383$



$F_{NET} = MA$

$= 4kg(2.5 m/s^2)$

$= 10N$

$F_{NET_x} = F_A - F_F$

$10 = 25 - F_F$

$F_F = 15N$

Sample Problem 2

- Jenny pulls her sister on a sled with a force of 124 N at an angle of 32^o. The combined mass of her sister and the sled is 46 kg. If they move at a <u>constant velocity</u>, what is the coefficient of friction between the sled and the snow? $F_{NET} = 0$

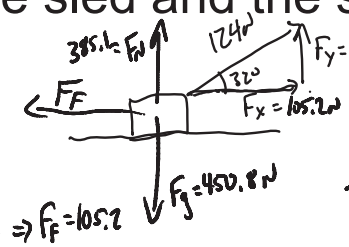
$F_N = F_g - F_y$

$= 450.8 - 65.7$

$= 385.1$

$F_{NET_x} = F_x - F_F$

$0 = 105.2 - F_F \Rightarrow F_F = 105.2$



$\mu = \frac{F_F}{F_N} = \frac{105.2}{385.1}$

$= .273$

$F_x = 124\cos 32°$

$= 105.2N$

$F_y = 124\cos 32°$

$= 65.7N$

Sample Problem 3

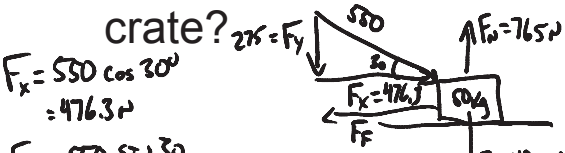
- A 50 kg wood crate is pushed across a wooden plank. A 550 N force is applied at an angle of 30^0 to the horizontal.
  - Will the crate move? YES
  - If it does, what is the acceleration of the crate?

$\mu_s = .58$

$\mu_k = .40$

$F_x = 550 \cos 30^0$
$= 476.3 N$

$F_y = 550 \sin 30$
$= 275 N$



$F_s = \mu F_N$
$= .58(765)$
$= 443.7 N$

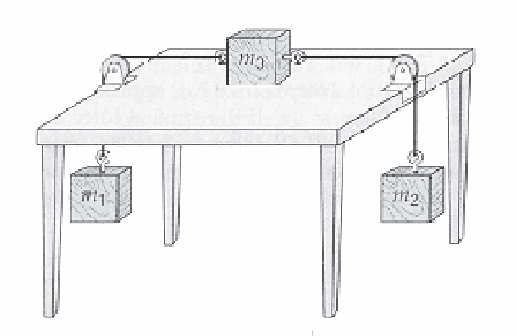
$F_N = F_g + F_y$
$= 490 + 275$
$= 765 N$

$F_k = .40(765)$
$= 306 N$

$F_{NET} = F_x - F_k$
$= 476.3 - 306$
$= 170.3$

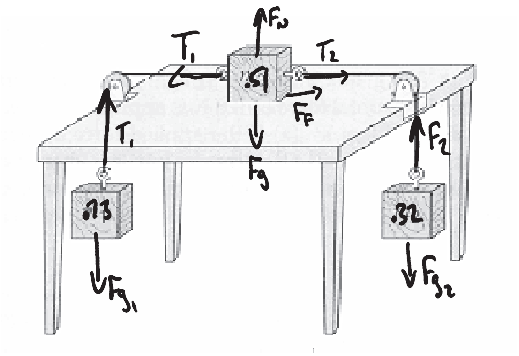
$F_{NET} = ma$
$170.3 = 50(a)$
$a = 3.41 m/s^2$

Sample Problem 4



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

Sample Problem 4



$\mu = .43$

$F_{net_{system}} = F_{g_1} - F_F - F_{g_2}$

$(m_1+m_2+m_3)a = m_1g - \mu m_3g - m_2g$

$(.73+.32+.51)a = (.73)(9.8) - (.43)(.51)(9.8) - (.32)(9.8)$

$1.56a = 1.87$

$a = 1.20\ m/s^2$