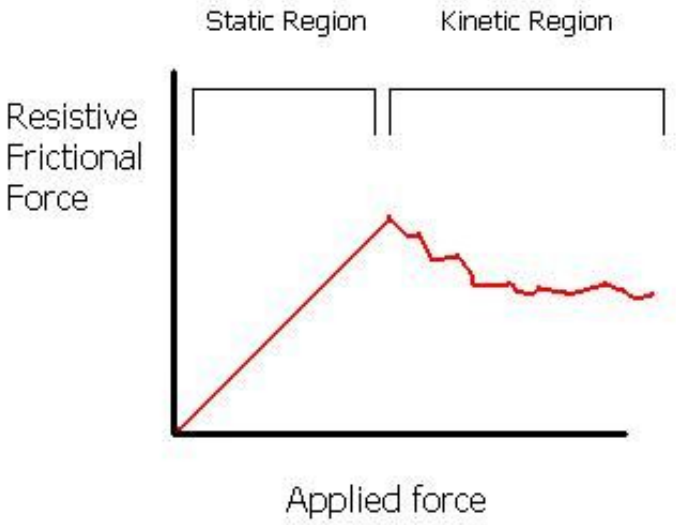
Friction & Inclined Planes

Honors Physics

TWO types of Friction

- Static – Friction that keeps an object at rest and prevents it from moving
- Kinetic – Friction that acts during motion



Force of Friction

- The Force of Friction is directly related to the Force Normal.
  - Mostly due to the fact that BOTH are surface forces

$$F_f \alpha F_N$$

$$\mu = \text{constant of proportionality}$$

$$\mu = \text{coefficient of friction}$$

$$F_{sf} = \mu_s F_N$$

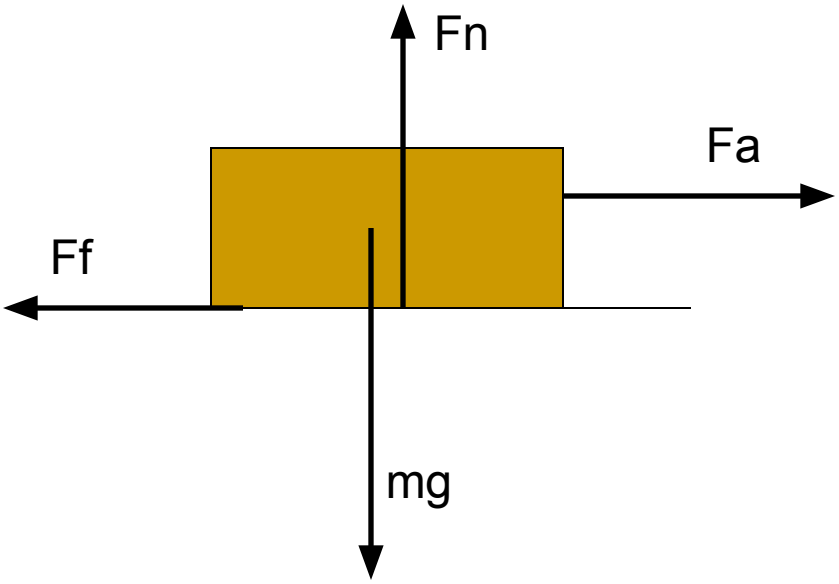
$$F_{kf} = \mu_k F_N$$

The coefficient of friction is a unitless constant that is specific to the material type and usually less than one.

Note: Friction ONLY depends on the MATERIALS sliding against each other, NOT on surface area.

Friction & N.F.L

If the coefficient of kinetic friction between a 35-kg crate and the floor is 0.30, what horizontal force is required to move the crate to the right at a constant speed across the floor?



$$F_a = F_f \qquad F_f = \mu_k F_N$$

$$F_a = \mu_k F_N$$

$$F_N = mg$$

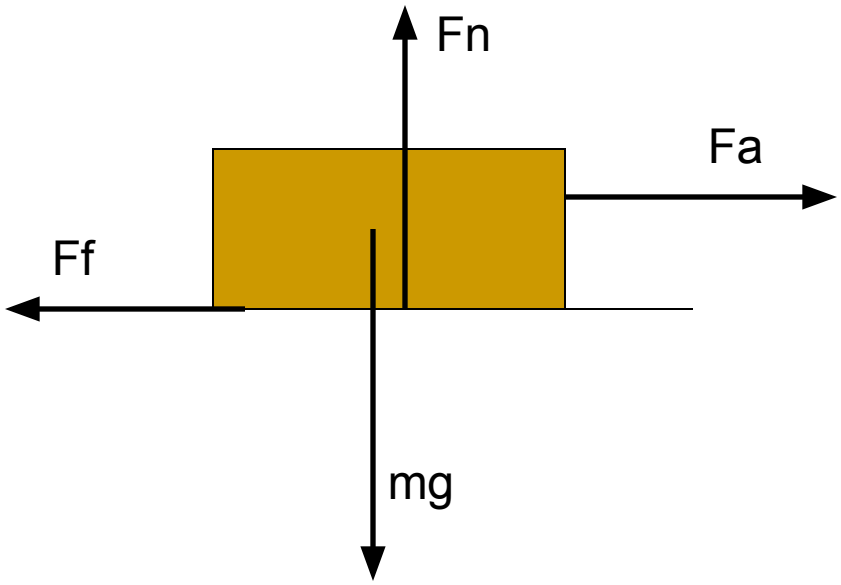
$$F_a = \mu_k mg$$

$$F_a = (0.30)(35)(9.8)$$

$$F_a = \quad \textbf{102.9 N}$$

Friction & N.S.L.

Suppose the <u>same</u> 35 kg crate was <u>not</u> moving at a constant speed, but rather accelerating at 0.70 m/s/s. Calculate the applied force. The coefficient of kinetic friction is still 0.30.



$$F_{NET} = ma$$

$$F_a - F_f = ma$$

$$F_a - \mu_k F_N = ma$$

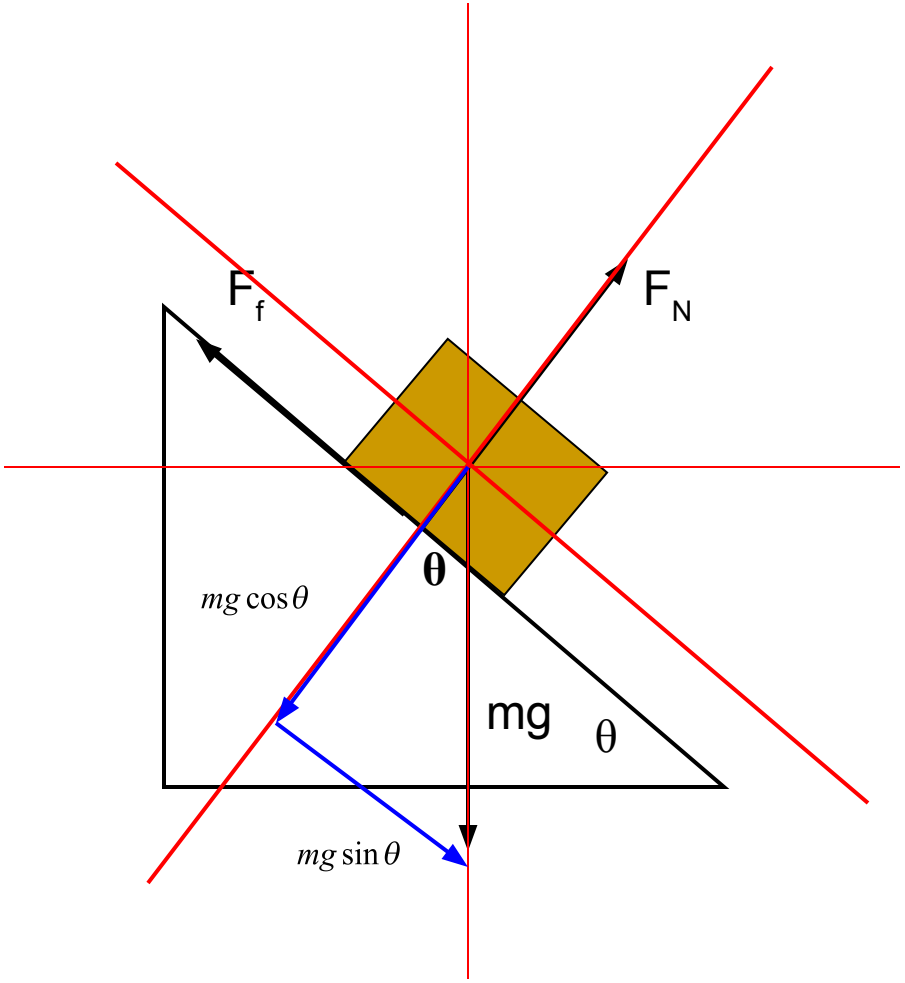
$$F_a - \mu_k mg = ma$$

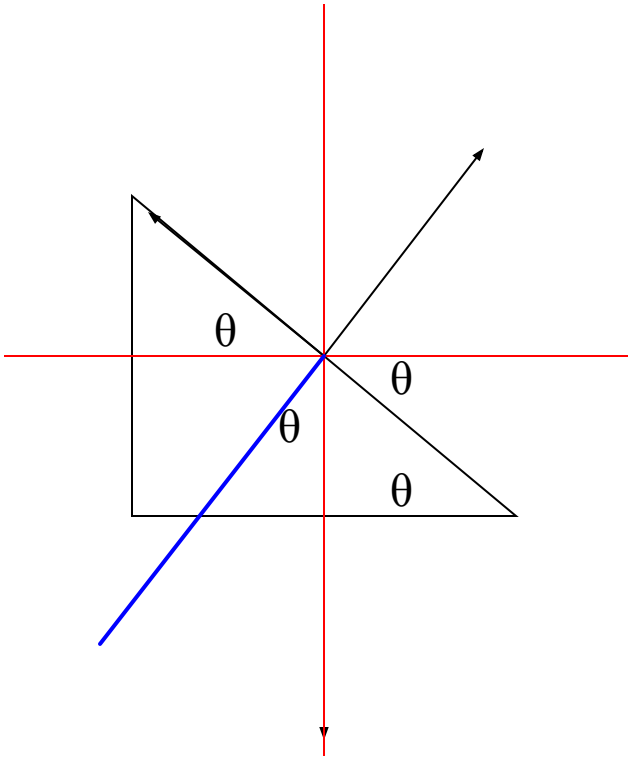
$$F_a = ma + \mu_k mg$$

$$F_a = (35)(0.70) + (0.30)(35)(9.8)$$

$$F_a = \textbf{127.4 N}$$

Inclines



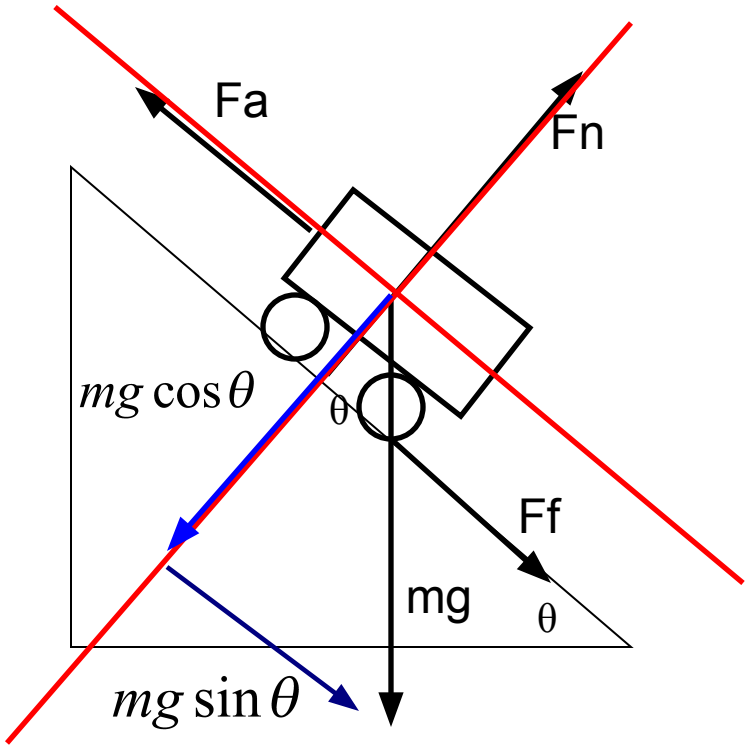


Tips

- Rotate Axis
- Break weight into components
- Write equations of motion or equilibrium
- Solve

Friction & Inclines

A person pushes a 30-kg shopping cart up a 10 degree incline with a force of 85 N. Calculate the coefficient of friction if the cart is pushed at a ***constant speed.***



$$F_a = F_f + mg\sin\theta \quad F_f = \mu_k F_N$$

$$F_a = \mu_k F_N + mg\sin\theta \quad F_N = mg\cos\theta$$

$$F_a = \mu_k mg\cos\theta + mg\sin\theta$$

$$F_a - mg\sin\theta = \mu_k mg\cos\theta$$

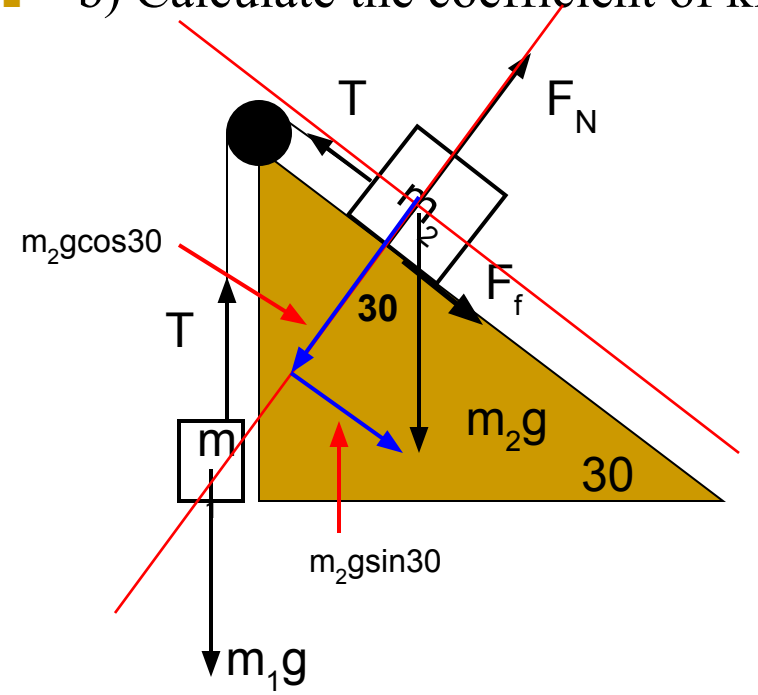
$$\mu_k = \frac{F_a - mg\sin\theta}{mg\cos\theta}$$

$$\mu_k = \frac{85 - (30)(9.8)(\sin 10)}{(30)(9.8)(\cos 10)} = \mathbf{0.117}$$

Example

A 5-kg block sits on a 30 degree incline. It is attached to string that is thread over a pulley mounted at the top of the incline. A 7.5-kg block hangs from the string.

- a) Calculate the tension in the string if the acceleration of the system is 1.2 m/s/s
- b) Calculate the coefficient of kinetic friction.



$$F_{NET} = ma$$

$$m_1 g - T = m_1 a$$

$$T - (F_f + m_2 g \sin\theta) = m_2 a$$

$$F_N = m_2 g \cos\theta$$

Example

$$F_{NET} = ma$$

$$m_1 g - T = m_1 a$$

$$m_1 g - m_1 a = T$$

$$(7.5)(9.8) - (7.5)(1.2) = T$$

$T =$ **64.5 N**

$$T - (F_f + m_2 g \sin\theta) = m_2 a$$

$$T - F_f - m_2 g \sin\theta = m_2 a$$

$$T - \mu_k F_N - m_2 g \sin\theta = m_2 a$$

$$T - m_2 a - m_2 g \sin\theta = \mu_k F_N$$

$$\frac{T - m_2 a - m_2 g \sin\theta}{F_N} = \mu_k \qquad F_N = m_2 g \cos\theta$$

$$\frac{T - m_2 a - m_2 g \sin\theta}{m_2 g \cos\theta} = \mu_k$$

$$\frac{64.5 - (5)(1.2) - (5)(9.8)(\sin 30)}{(5)(9.8)(\cos 30)} = \mu_k$$

$\mu_k =$ **0.80 N**