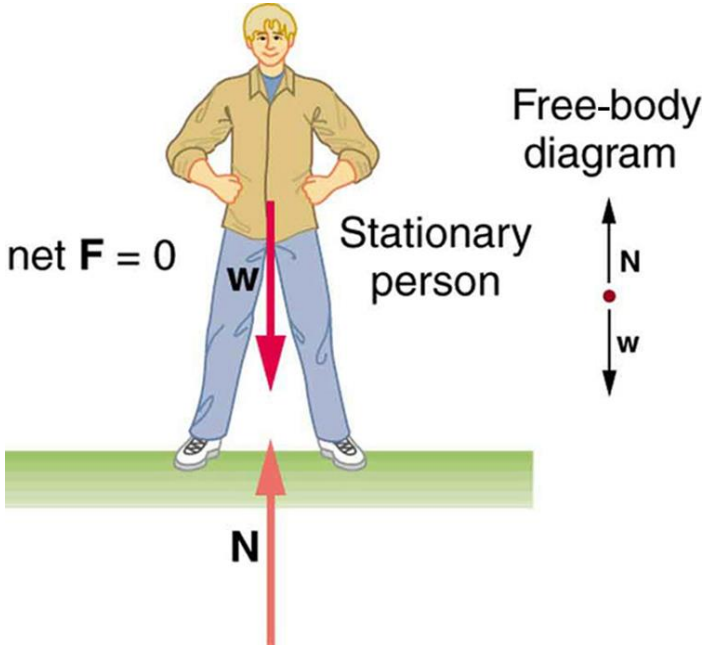
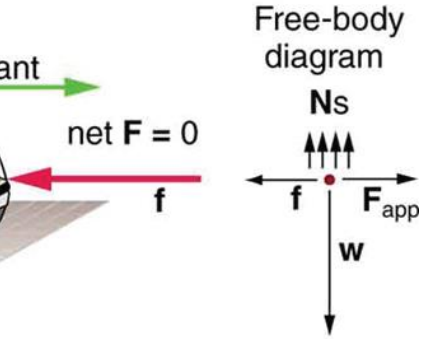
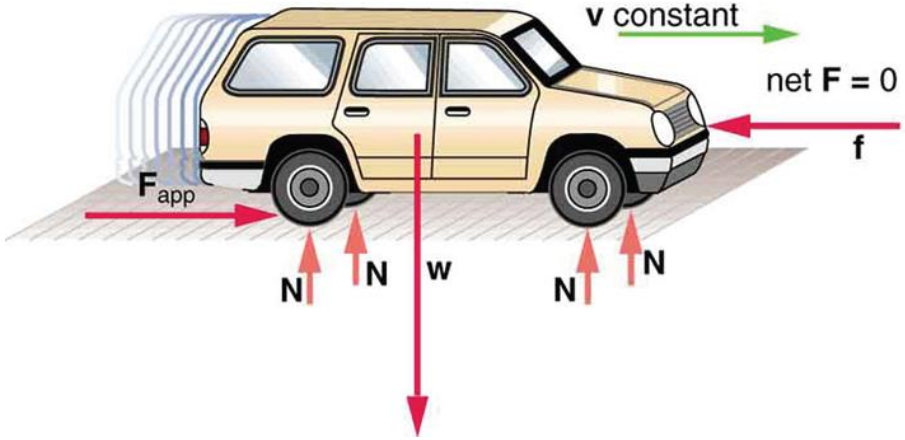
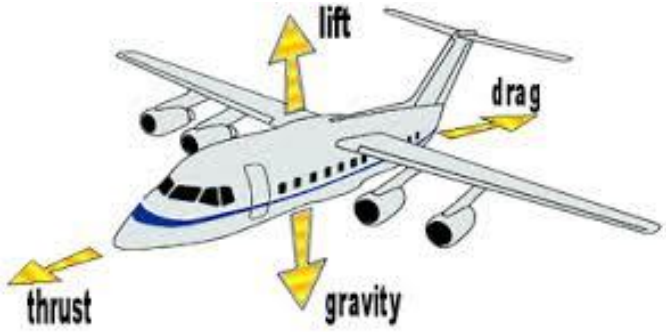
Laws of motion



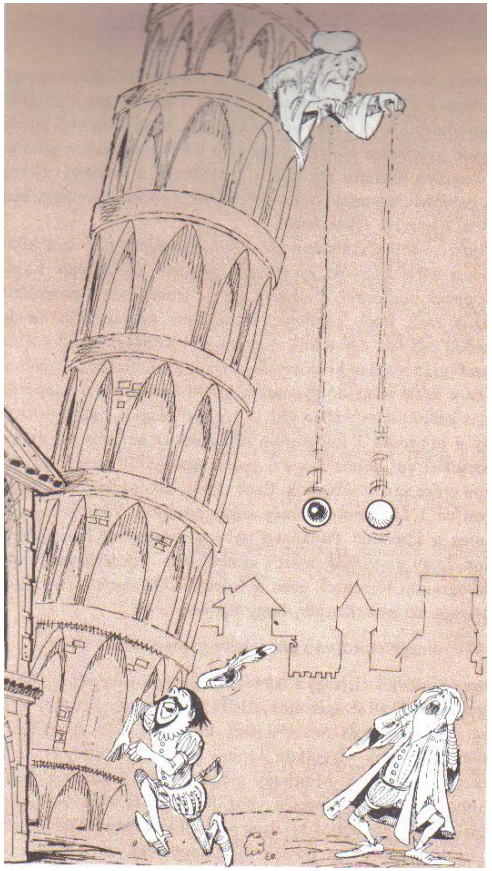


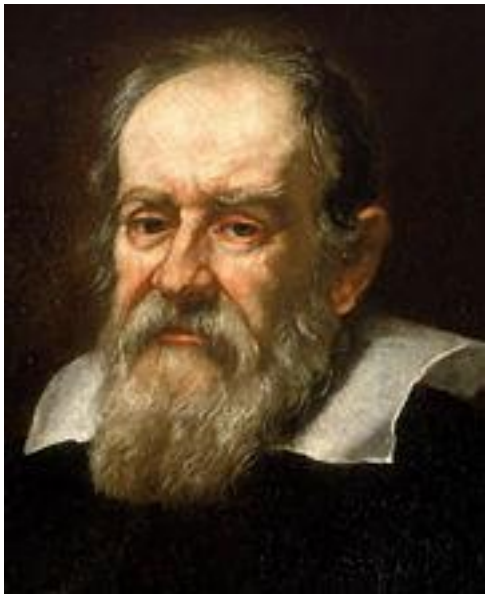




Laws of motion & forces

Aristoteles → Galilei → Newton





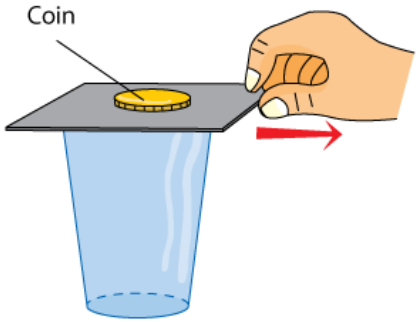
Galileo Galilei
(1564 – 1642)

Sir Isaac Newton
(1642. – 1727.)

Def.: Linear momentum: $\vec{p} = m\vec{v}$ $\left[\text{kg}\frac{\text{m}}{\text{s}} = \text{Ns} \right]$

Newton's laws: (point mass, inertial frame of reference)

1. The law of inertia



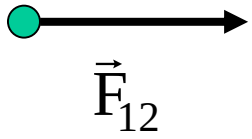
If $\vec{F}_{net} = 0 \Rightarrow \vec{a} = 0$ ("No force, no acc.")

2. $\vec{F} = m \cdot \vec{a}$ ➡ $\vec{F} = m\cdot\vec{a} = m\frac{\Delta\vec{v}}{\Delta t} = \frac{\Delta\vec{p}}{\Delta t}$ $\left[\text{kg}\frac{\text{m}}{\text{s}^2} = \text{N} \right]$

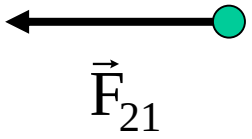
Def.: Impulse: $\vec{I} = \vec{F}\Delta t = \vec{p}(t_2) - \vec{p}(t_1) = \Delta\vec{p}$

$\vec{F}_{ave}$

3. The law of action - reaction

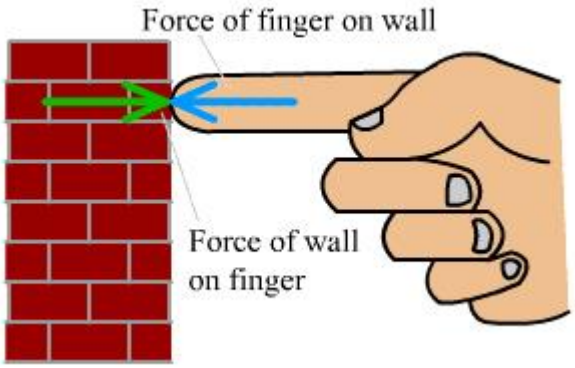


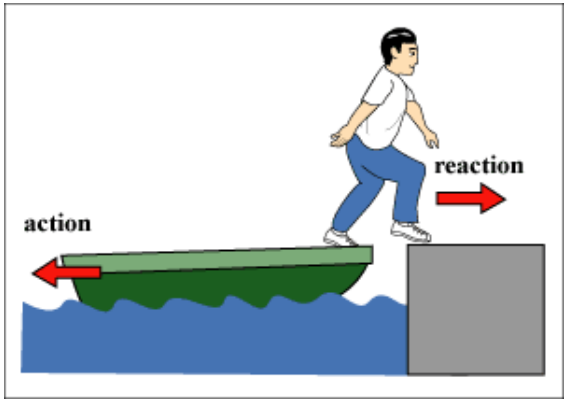
$\vec{F}_{12}$

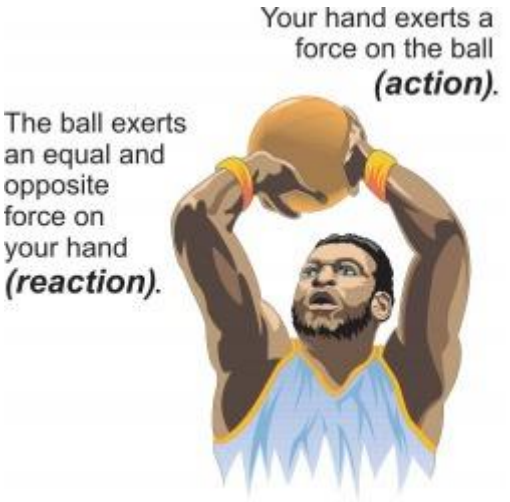


$\vec{F}_{21}$

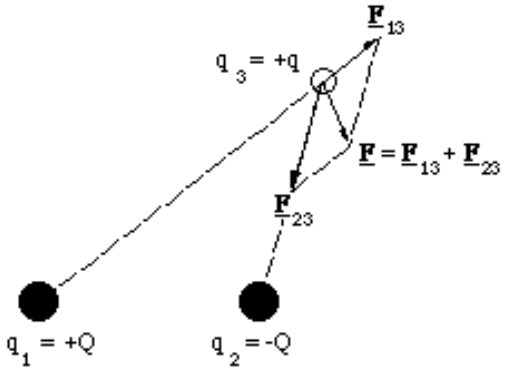
$$\vec{F}_{12} = -\vec{F}_{21}$$







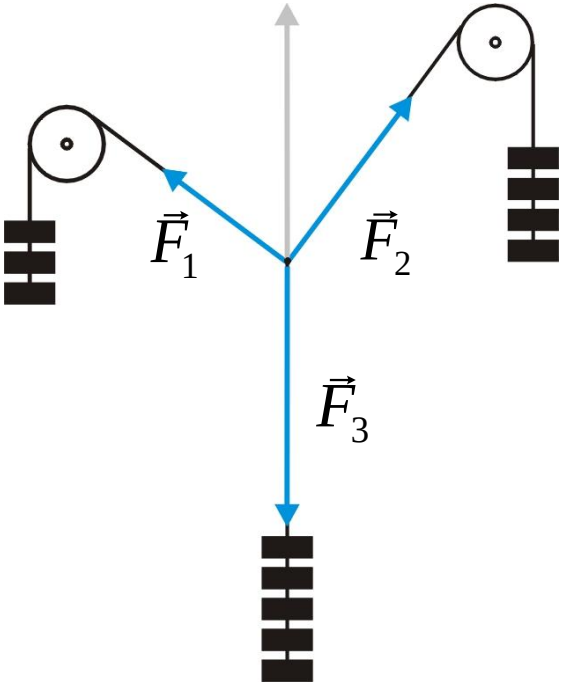
4. Superposition theorem: $\vec{F}_{net} = \sum_i \vec{F}_i$



$$\Sigma \vec{F} = m\Sigma \vec{a}$$

$$\sum_i \vec{F}_i = 0$$

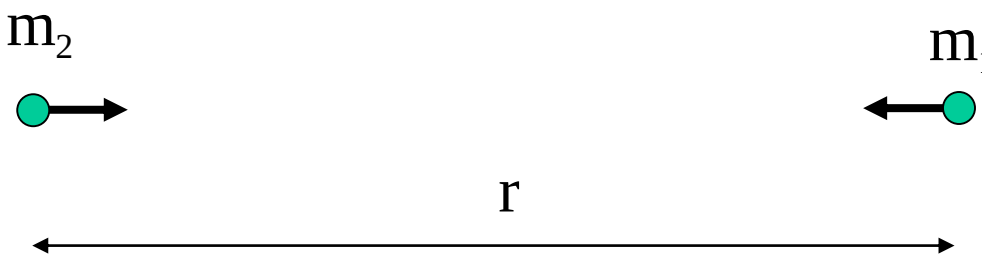
Equilibrium



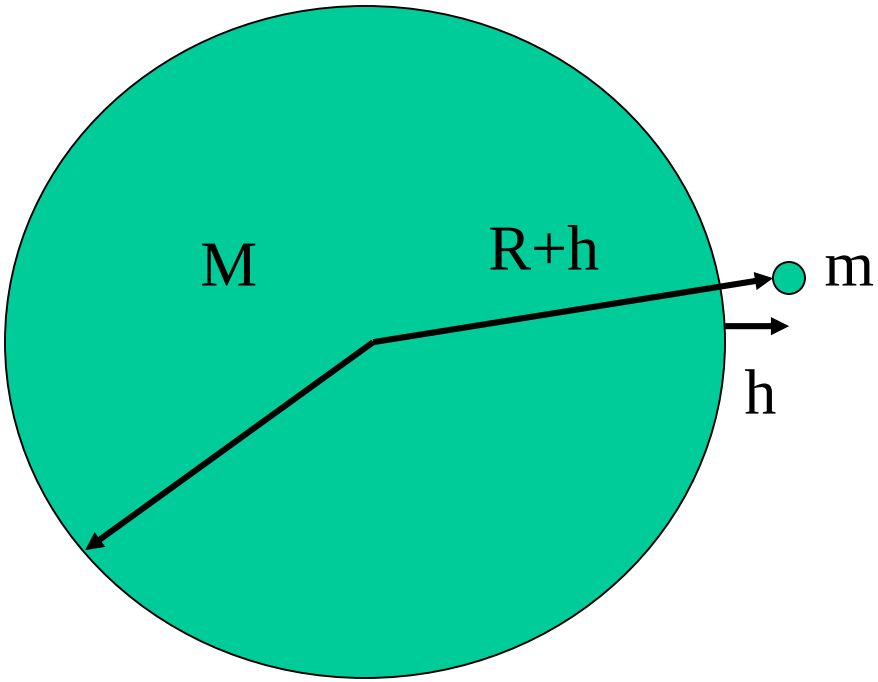
Force

$G = 6{,}67 \cdot 10^{-11}\ Nm^2/kg^2$

1. Weight, the force of gravity



$$F_{gr.} = G\frac{m_1 m_2}{r^2}$$

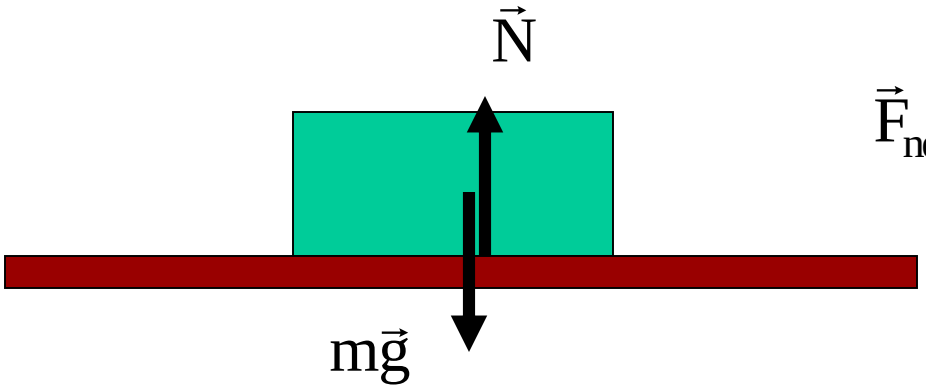


$$h << R$$

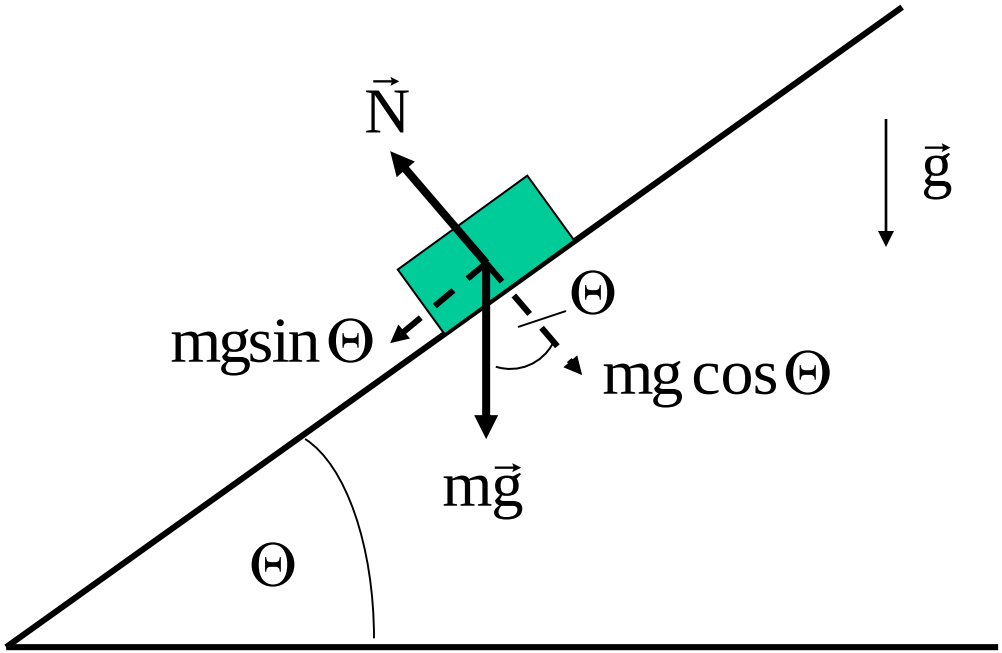
$$F_{gr.} = G\frac{mM}{(R+h)^2} \approx G\frac{mM}{R^2}$$

$$F_{gr.} = G\frac{Mm}{R^2} = mg \Rightarrow g = G\frac{M}{R^2}$$

2. Normal force

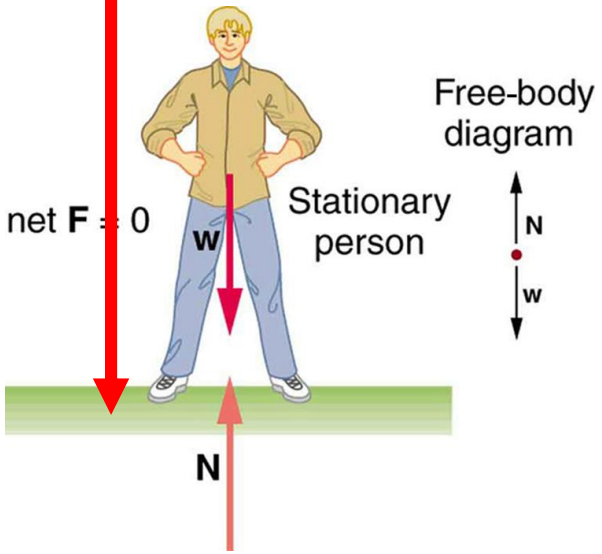


$$\vec{F}_{net} = m\vec{g} + \vec{N} = 0 \Rightarrow N = mg$$



$$N = mg\cos\Theta$$

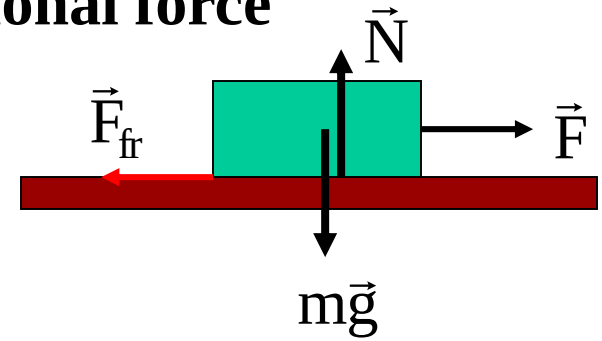
$$\left|\vec{N} + m\vec{g}\right| = mg \cdot \sin\Theta$$



$$m = \frac{\left|\vec{N}\right|}{g}$$

$$weight = \left|\vec{F}_{gr.}\right| = \left|\vec{N}\right|$$

3. Frictional force



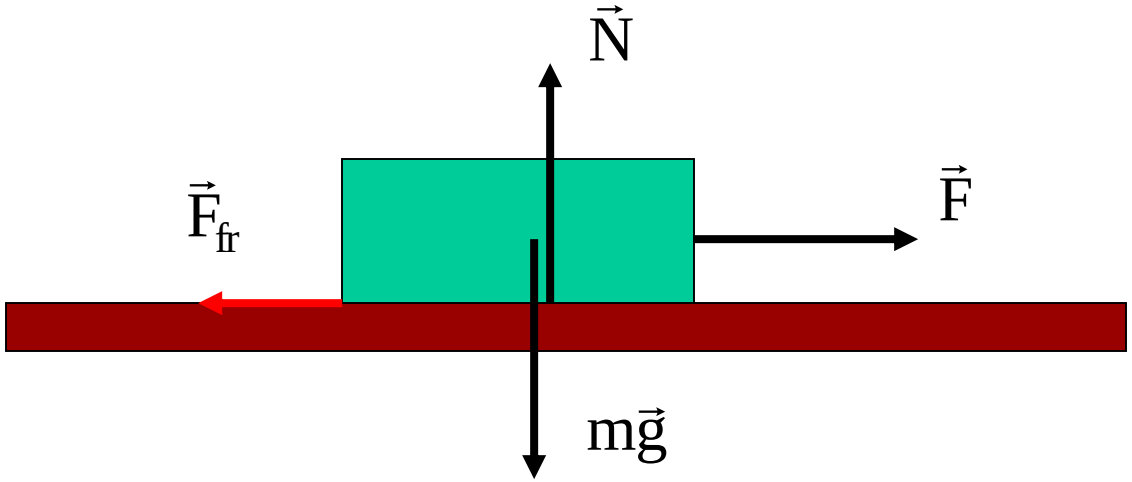
Static friction

(Object is at rest, $F_{net}=0 \Rightarrow a=0$)

$$F_{fr} \leq \mu_o N$$

Coefficient of static friction: μ_o

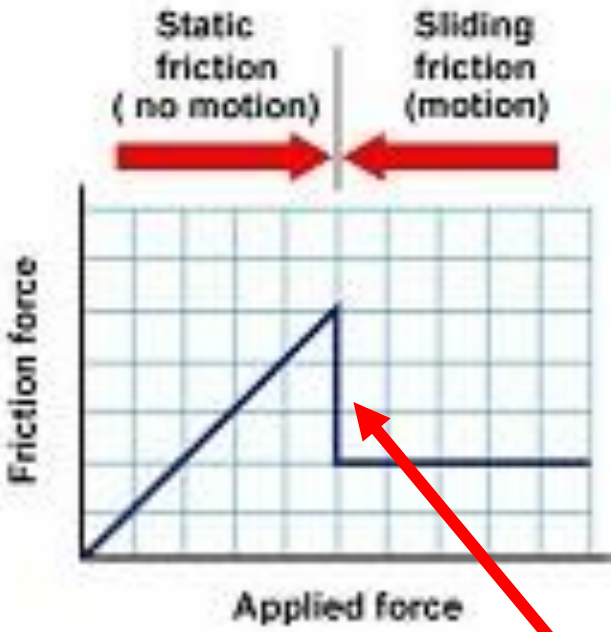
Coefficient of static friction: μ_o The object is sliding

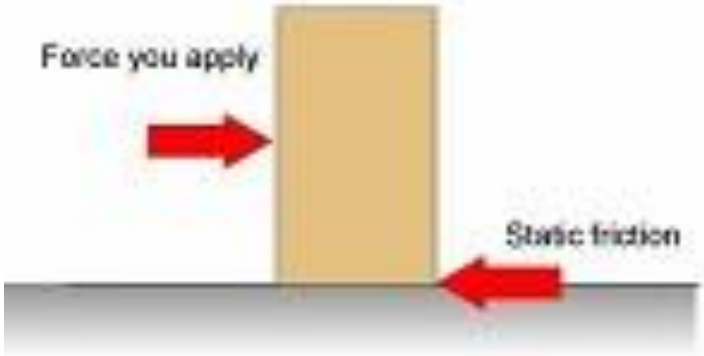


$$F_{fr} = \mu_k N$$

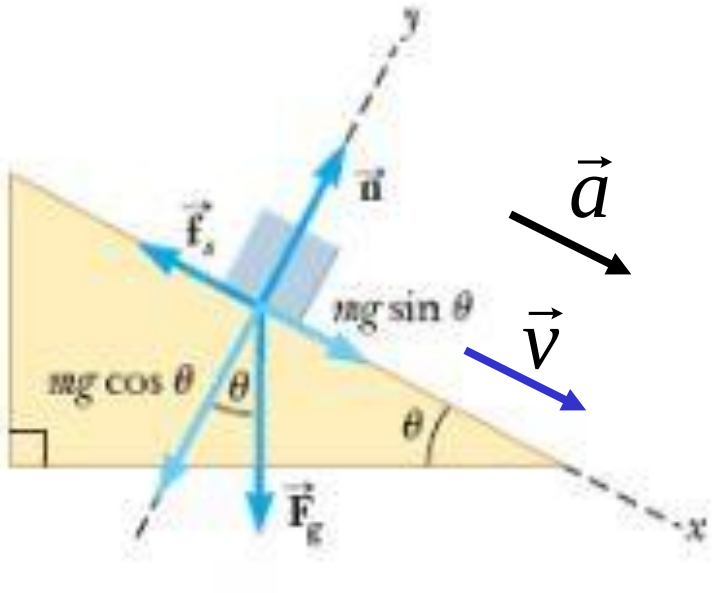
$$\mu_k \leq \mu_o$$

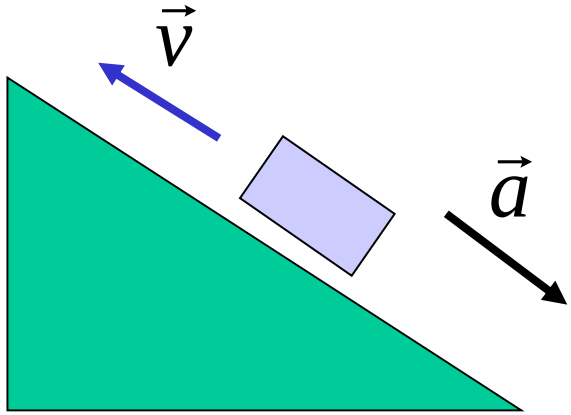
Friction Forces





$\mu_k \leq \mu_o$

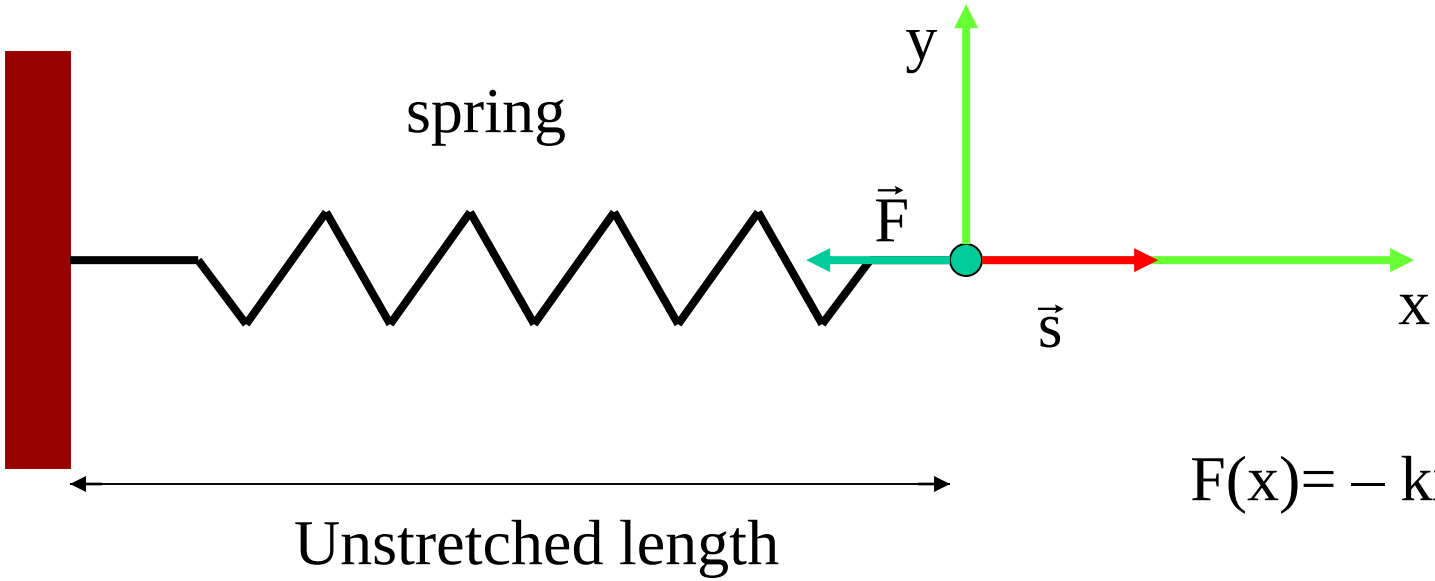

y
$\vec{n}$
$\vec{f}_s$
$\vec{a}$
$mg \sin\theta$
$\vec{v}$
$mg \cos\theta$
θ
θ
$\vec{F}_g$
x


$\vec{v}$
$\vec{a}$

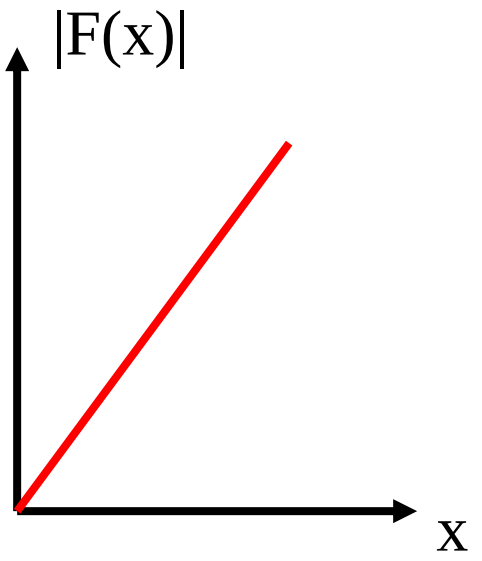
$\vec{a} = ?$

$\vec{a}' = ?$

4. Spring force

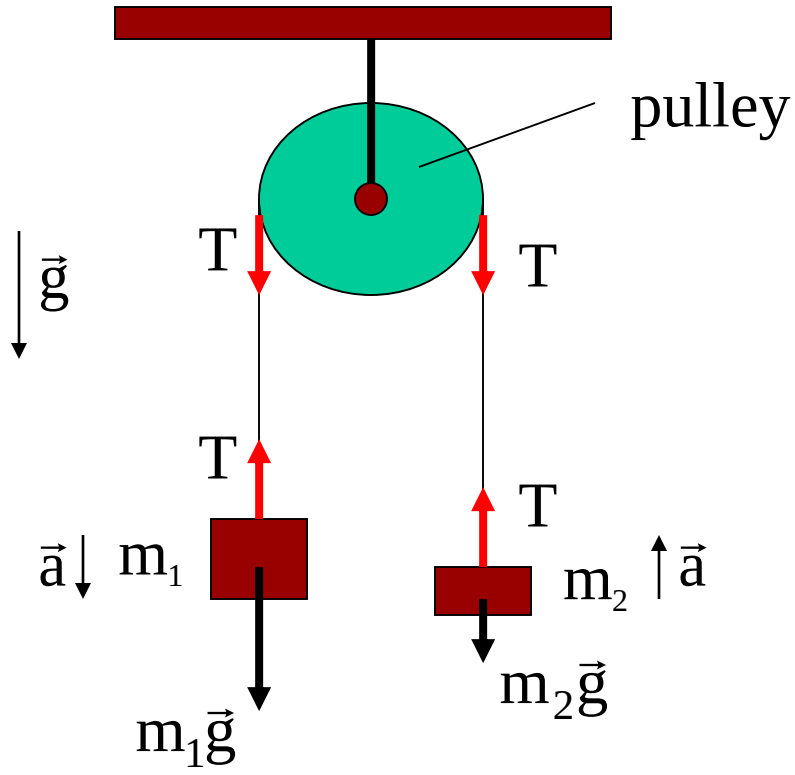


$$F(x) = -kx$$



Spring constant: k $\left[\frac{N}{m}\right]$

5. **Tension** (in the string)



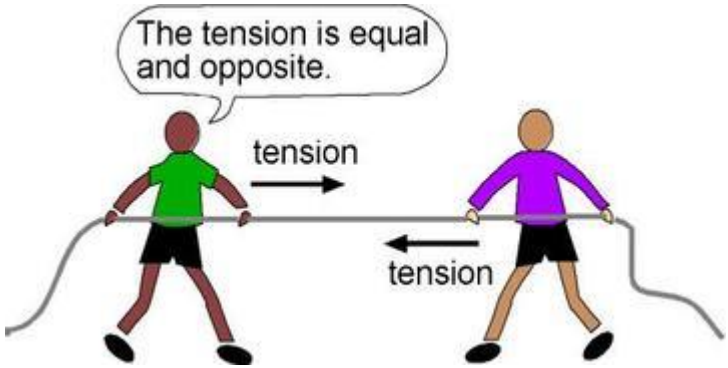
m_1g , m_2g : weight

T : tension

T = ? a = ?

I. $m_1g - T = m_1a$

II. $T - m_2g = m_2a$



$$a = \frac{m_1g - m_2g}{m_1 + m_2}$$

$$T = \frac{2m_1m_2}{m_1 + m_2}g$$