Exam next Tuesday evening

Today: Newton's Laws and Forces (Ch. 5+6)

Force - an interaction

It's a vector quantity

Newton's Laws:

<u>1st Law:</u> Every object continues to move at a constant velocity if no force acts on it.

2nd Law:

The acceleration of an object is directly proportional to the net force acting on it and inversely proportional to its mass.

$$\Rightarrow \vec{a} = \frac{\vec{F}_{net}}{m}$$

OR $\vec{F}_{net} = m\vec{a}$

mass is a resistance to change
~ inertia

$$\sum \vec{F} = \vec{F}_{net}$$

$F_{net,x} = \sum F_x$ and $\sum F_{net,y} = \sum F_y$

$F_{net,x} = ma_x$, $F_{net,y} = ma_y$

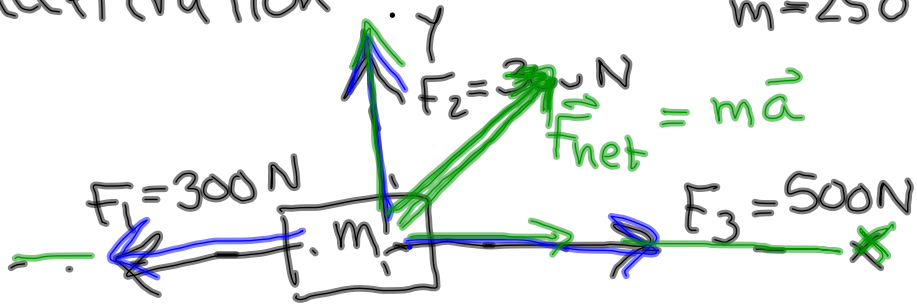
$$\underbrace{[F]}_{\text{units}} = [m][a] = kg \cdot \frac{m}{s^2} \equiv N$$

"Newton"

Example:

An object (top view) has the following forces acting on it. What is its acceleration?

$m = 250\ kg$



$$\vec{F}_{net} = \vec{F}_1 + \vec{F}_2 + \vec{F}_3$$

$$F_{net,x} = F_{1x} + F_{2x} + F_{3x}$$
$$= -300\ N + 0 + 500N = 200N$$

$$F_{net,y} = F_{1y} + F_{2y} + F_{3y}$$
$$= 0 + 300\ N + 0 = 300\ N$$

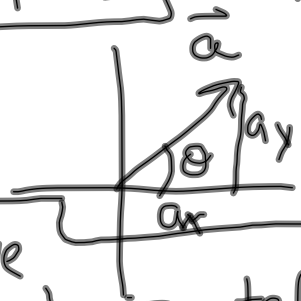
$$a_x = \frac{F_{net,x}}{m} = \frac{200N}{250kg} = 0.8\ \frac{m}{s^2}$$

$$a_y = \frac{F_{net,y}}{m} = \frac{300N}{250\ kg} = 1.2\ m/s^2$$

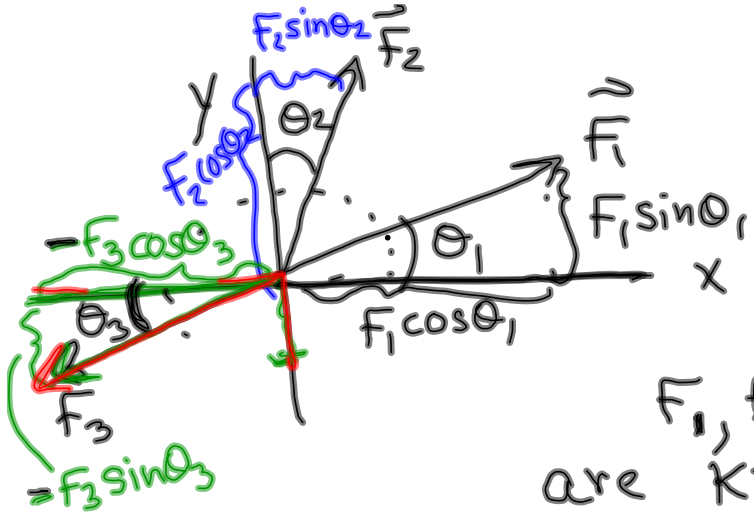
$$a = \sqrt{a_x^2 + a_y^2} = \boxed{1.44\ m/s^2}$$

$\vec{F}_{net} = m\vec{a}$

$$\theta = \tan^{-1}\left(\frac{a_y}{a_x}\right) = \tan^{-1}\left(\frac{1.2}{0.8}\right)$$



$$= \boxed{56^\circ \text{ above the horizontal}}$$



$F_1, F_2, \theta_1, \theta_2, \theta_3$ are known

The object is at <u>rest</u>.

Find F_3

$\Rightarrow \vec{a} = 0$

$\sum F_x = m a_x = 0$ $\qquad$ $a_x = a_y = 0$

$\sum F_y = m a_y = 0$

$\sum F_x = F_{1x} + F_{2x} + F_{3x} = 0$

mag.

$= F_1 \cos\theta_1 + F_2 \sin\theta_2 - F_3 \cos\theta_3 = 0$

$F_3 \cos\theta_3 = F_1 \cos\theta_1 + F_2 \sin\theta_2$

$$\boxed{F_3 = \frac{F_1 \cos\theta_1 + F_2 \sin\theta_2}{\cos\theta_3}}$$

$\sum F_y = F_{1y} + F_{2y} + F_{3y} = 0$

mag

$F_1 \sin\theta_1 + F_2 \cos\theta_2 - F_3 \sin\theta_3 = 0$

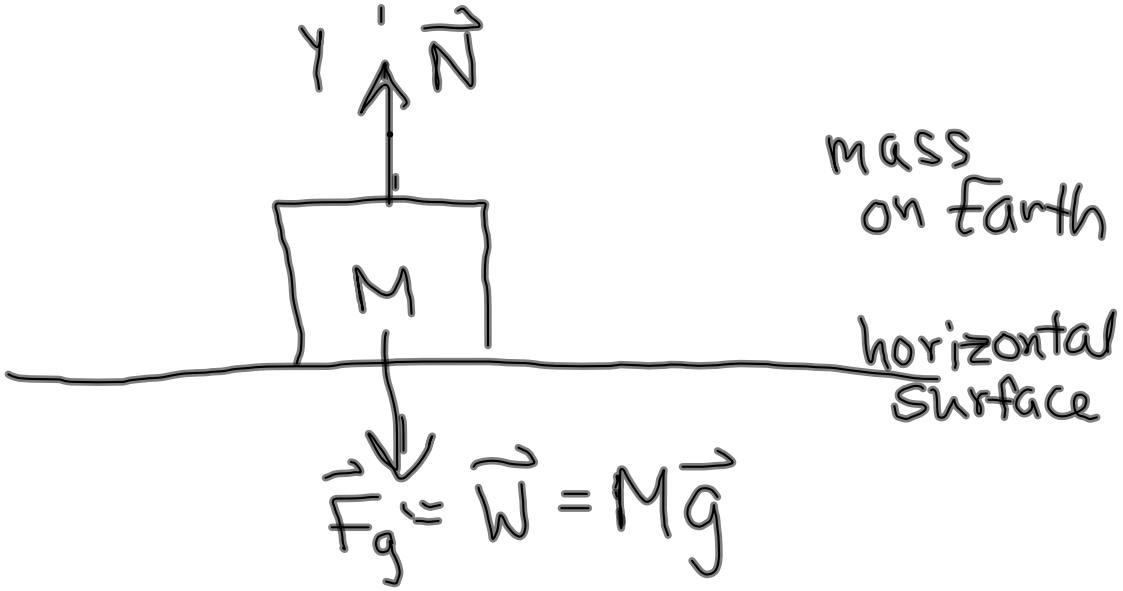
$$\boxed{F_3 = \frac{F_1 \sin\theta_1 + F_2 \cos\theta_2}{\sin\theta_3}}$$

Types of Forces

Fundamental Forces

1. Gravitational Force $\vec{F}_G = \vec{W} = m\vec{g}$
2. Weak Nuclear Force } "Electroweak"
3. Electromagnetic Force
4. Strong Nuclear Force

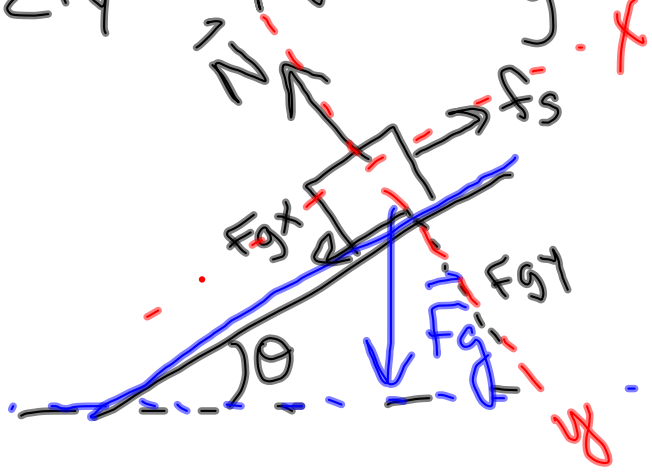
- Normal force $\vec{N}$
- Tension $\vec{T}$
- friction force (Kinetic vs. Static)
  $\vec{f}_{fric}$



$$F_{net,y} = ma_y = 0$$

$$\sum F_y = +N - F_g = N - Mg = 0$$

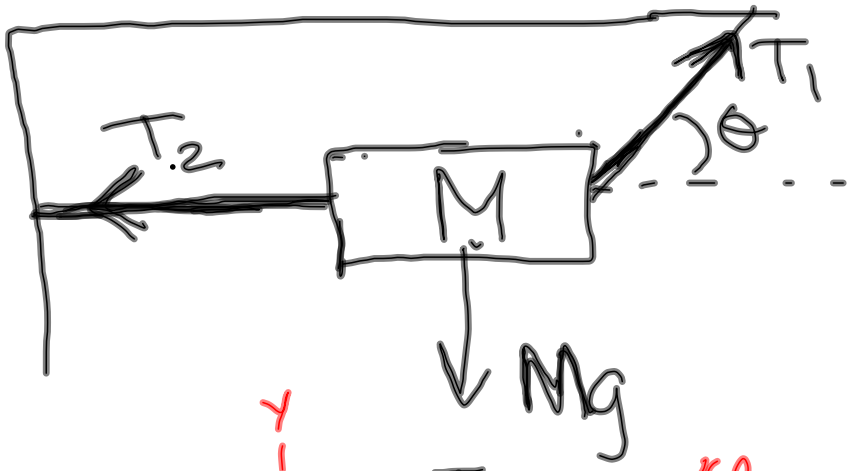
$$N = Mg$$

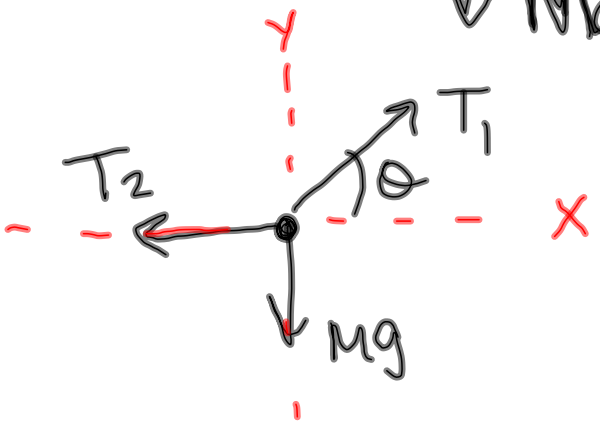


normal force is always "normal" or perpendicular to the surface

$$N - F_{g,y} = 0 \Rightarrow N = F_{g,y} = Mg\cos\theta$$

Tension: (from past exam)





"free-body diagram"

$\vec{a}_{net} = 0$ $\qquad a_x = 0, \; a_y = 0$

$\sum F_x = ma_x = 0$ <u>and</u> $\sum F_y = ma_y = 0$

$\sum F_x = T_1 \cos\theta - T_2 = 0$

$\sum F_y = T_1 \sin\theta - mg = 0$

$\hookrightarrow \boxed{T_1 = \frac{mg}{\sin\theta}}$

Plug back into x-comp eq:

$\left(\frac{mg}{\sin\theta}\right)\cos\theta - T_2 = 0$

$\Rightarrow \boxed{T_2 = mg\cot\theta}$