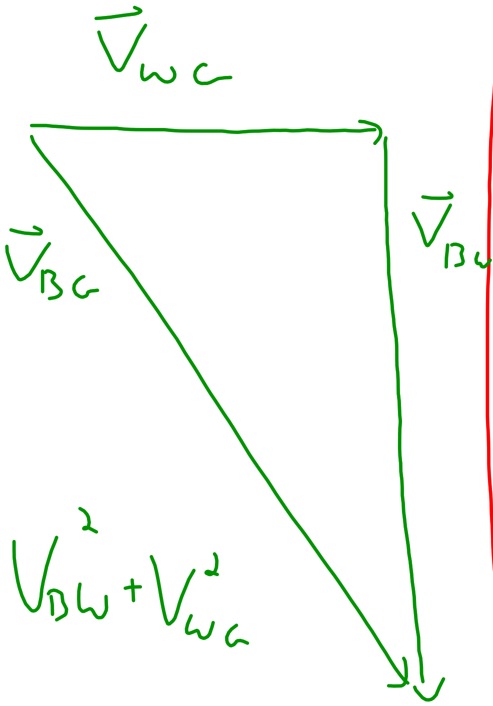
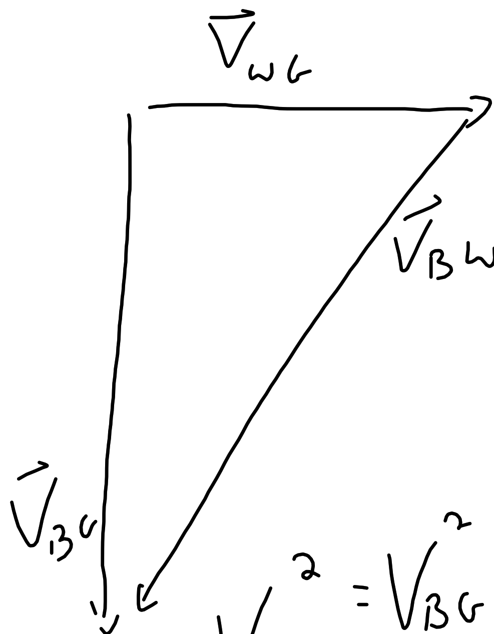
$$\vec{V}_{BG} = \vec{V}_{BW} + \vec{V}_{WG}$$



$$V_{BG}^2 = V_{BW}^2 + V_{WG}^2$$



$$V_{BW}^2 = V_{BG}^2 + V_{WG}^2$$

Forces

- Review of Newtons Laws

1st Law

- Law of Inertia
- Objects at rest tend to stay at rest, objects in motion tend to stay in motion, unless acted upon by an external force.

2nd Law

- $\boxed{F = ma}$ $\frac{\Delta p}{\Delta t}$
- The force an object experiences is proportional to its acceleration and mass.

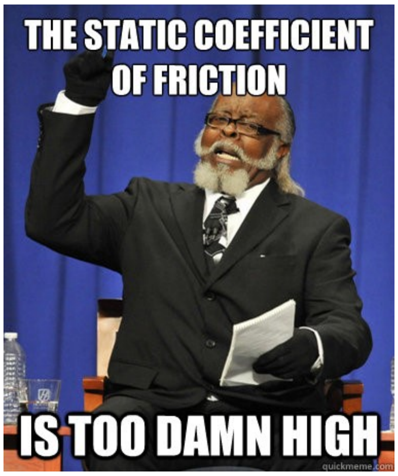
3rd Law

- For every action there is an equal and opposite reaction.
- All forces in the universe exist in pairs.

Forces

- Review of Common forces

μ "mu"



Friction

μ_k kinetic

μ_s static

- $\boxed{F_f = \mu F_N}$
- Can have Static or Kinetic (Sliding) friction - different coefficients for both
- Max static always bigger than kinetic
- Always opposite direction of motion
- Only present if moving or trying to move

Gravity

$\vec{g} = |\vec{g}|$ down

- $\boxed{F_g = mg}$
- Always towards the ground
- g = 9.81 m/s^2 ← magnitude
- Always present no matter the type of motion

Me: He died of natural causes

Cop: You pushed him off the roof

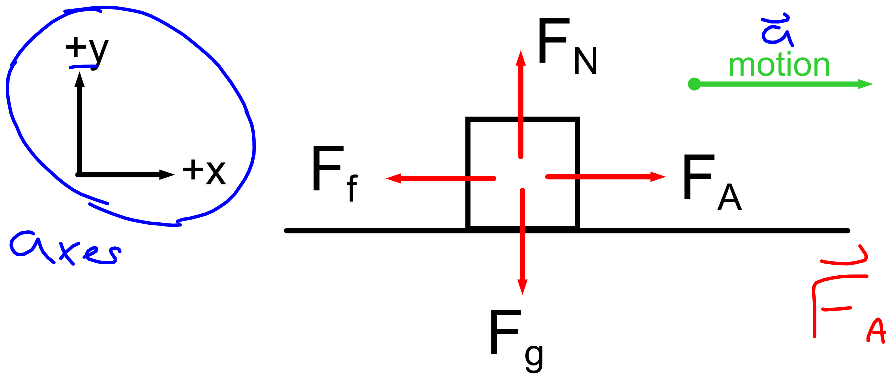
Me:

Normal

- A reaction force from object being in contact with a surface
- Direction always perpendicular to the surface
- Size various depending on the situation

Forces in 2 Dimensions

Typical scenario: Object on flat surface, all forces act at right angles to the object. Motion along surface.



$\vec{F}_A + \vec{F}_F$

$$F_{Net,x} = \sum F_x = +F_A - F_f$$

$$F_{Net,x} = ma_x$$

$$\therefore \boxed{ma_x = F_A - F_f}$$

takes dir. into account

$$F_{Net,y} = \sum F_y = +F_N - F_g$$

mag

$g = +9.81$

$$F_{Net,y} = ma_y = 0N$$

$$\therefore F_N - F_g = 0N$$

$$\therefore F_N = F_g$$

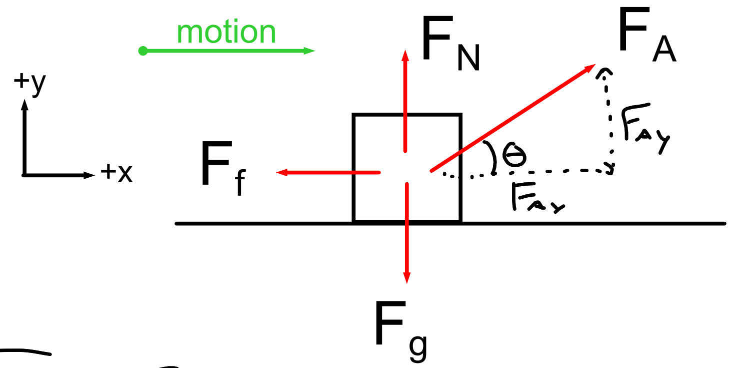
$|\vec{F}_N| = |\vec{F}_g|$

$\vec{F}_N = -\vec{F}_g$

While these two equations are for separate directions, using $F_f = \mu F_N$ helps find a way to combine them.

Forces in 2 Dimensions

What if the applied force was at an angle up?
What changes?



$$F_{Net,x} = \Sigma F_x = F_{Ax} - F_f$$

$$\boxed{ma_x = F_{Ax} - F_f}$$

$$F_{Net,y} = \Sigma F_y = F_N + F_{Ay} - F_g$$

$$ma_y = 0\text{ N}$$

$$\therefore F_N + F_{Ay} - F_g = 0$$

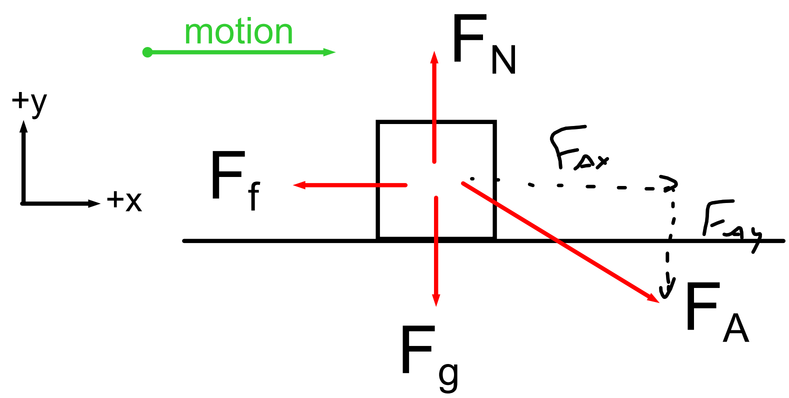
$$\boxed{F_N = F_g - F_{Ay}}$$

← lifting the object slightly ground feels less weight pushing down

∴ ground pushes back up with a smaller force.

Forces in 2 Dimensions

What if the applied force was at an angle down?
What changes?



$$\boxed{ma_x = F_{Ax} - F_f}$$

$$F_{Net,y} = \Sigma F_y = F_N - F_{Ay} - F_g$$

$$ma_y = 0\ N$$

$$\therefore F_N - F_{Ay} - F_g = 0$$

$$\therefore \boxed{F_N = F_g + F_{Ay}}$$

← slightly pushing down on object into the ground

ground feels a "heavier" object

so pushes back with a bigger force

In these problem types you will be expected to provide the following:

- FBD (free body diagram)
- givens - write as a vector, but will use only magnitude in equations
- base equations used to derive the big awesome equations
- substitutions
- intermediate values for mixed operations
- final answer rounded to proper number of sig figs.

In time you will develop your own style or way of presenting the information.

Remember, you are telling a story using mathematics as the language. And, typically, they start with "once upon a time there was a net force....".

Forces Applied At Angles

Ex. 1: Wendy pushes a couch by applying a force of 250**.** N [E 20^{o} down]. The couch moves against a kinetic friction force of 132.6 N. The couch has a mass of 28.7 kg.

a) What is the horizontal acceleration of the couch?

b) What is the coefficient of kinetic friction between the feet of the couch and the floor?

Ex. 2: Nicolas pulls a wagon by applying a force of 150**.** N [N 40 ^{o} up]. The wagon is moving with a constant speed. The coefficient of kinetic friction between the runners and the grass is 0.421.

a) What is the force of kinetic friction opposing this motion?

b) What is the mass of the wagon?