

Newton's Laws

1. An object travels in a straight line unless acted upon by a net external force.
2. $\sum \vec{F} = m\vec{a}$
3. When two objects interact, each exerts an equal but opposite force on the other.

Need to know types of forces; weight, normal, tension, spring, and friction

An object travels in a straight line unless acted upon by a net external force.

- Constant velocity motion is natural.
- *Inertia* [OHQ](#)
- Only changes in velocity need to be explained

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

- External forces make objects accelerate
- Forces are vectors
- Forces originate from one body acting on another
- *If you cannot identify the body that exerts the force, the force probably does not exist*

When two objects interact,
each exerts an equal but opposite
force on the other.

- Hardest law to understand (Hollywood seldom feels that it is true)
- Our sense of how much we weigh and how strongly we push or pull actually comes from the reaction

Fundamental Forces

- Gravitation
 - acts between objects with mass
 - long range
- Electromagnetism
 - acts between objects with charge
 - long range
- Strong Interaction
 - acts between objects with color charge, .e.g. quarks
 - short range (nucleus sized)
 - holds nucleus together
- Weak Interaction
 - acts between all particles
 - short range
 - beta decay

Forces at a Human Scale

- Gravitation $\Rightarrow$ Weight $W = mg$
- Acts straight down to centre of earth
- m is a constant
- g is a constant (9.81 m/s^2) unless you climb very high
- So weight is a constant it does not change!

Forces at a Human Scale

- Mostly only aware of EM when we see static cling or use fridge magnets
- Even though most objects are electrically neutral, EM interactions between millions of atoms of objects in contact leads to most of the forces we are familiar with

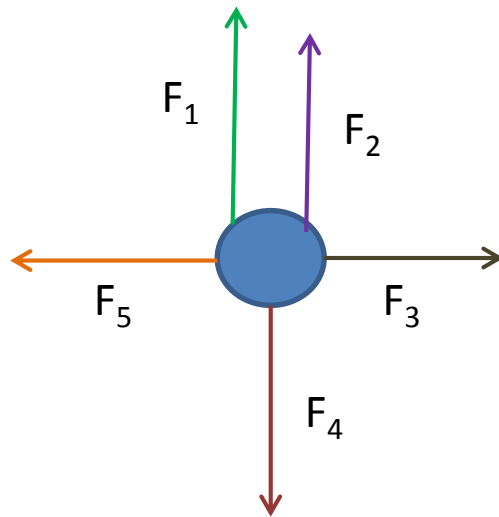
Common Contact Forces

- normal
- tension
- friction ($f_s^{\max} = \mu_s n$, $f_k = \mu_k n$)
- air resistance
- buoyancy
- elastic or spring force ($F = kx$)
- Coulomb force (later)
- Magnetic force (later)

Free Body Diagram

- Shows you know which forces are acting
 - typically you can guess the type of force acting and its direction but not its magnitude
- Shows you understand change in velocity
 - typically can guess the direction but not magnitude
- Necessary to explain equations you will use

Example: Forces In Equilibrium



Stationary, $a = 0$

- Upward force components must balance downward force components

$$F_1 + F_2 = F_4$$

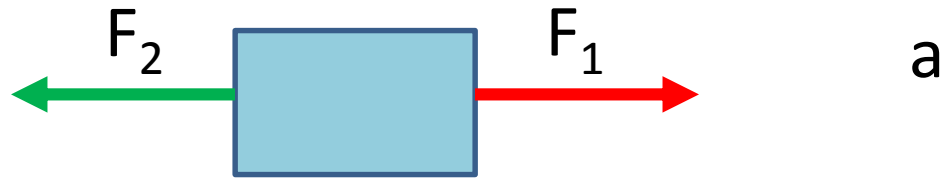
- Right force components must balance left force components

$$F_3 = F_5$$



We know the direction of the only two forces acting on a block. What can we say if

- a) $F_1 = F_2$?
- b) $F_1 > F_2$?
- c) $F_1 < F_2$?



We know the direction of the only two forces acting on a block but not their magnitude. What can we say about the forces if

- a) $a \rightarrow ?$
- b) $a = 0 ?$
- c) $a \leftarrow ?$