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*
- 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

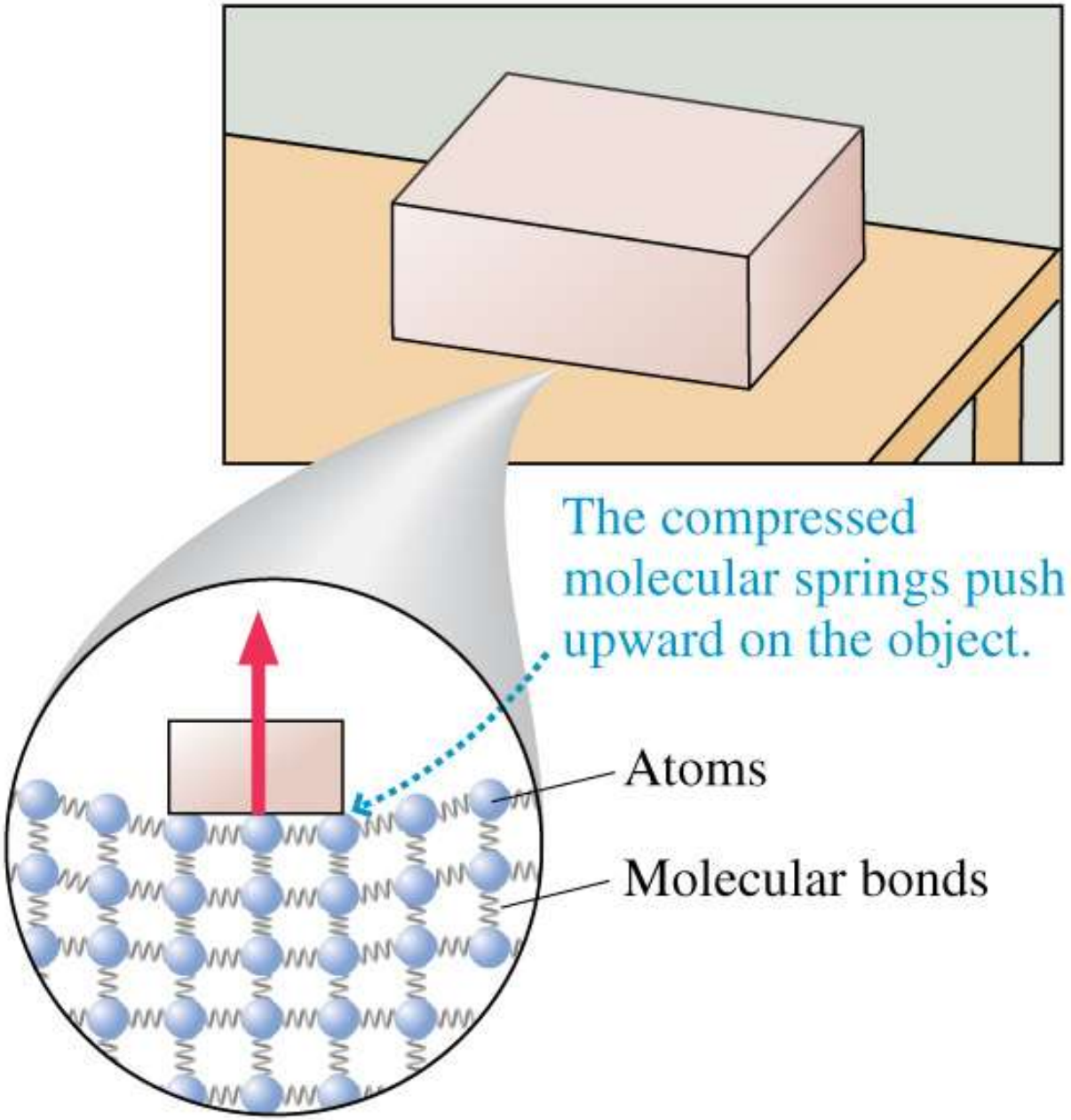
- Gravitation $\Rightarrow$ Weight W = mg

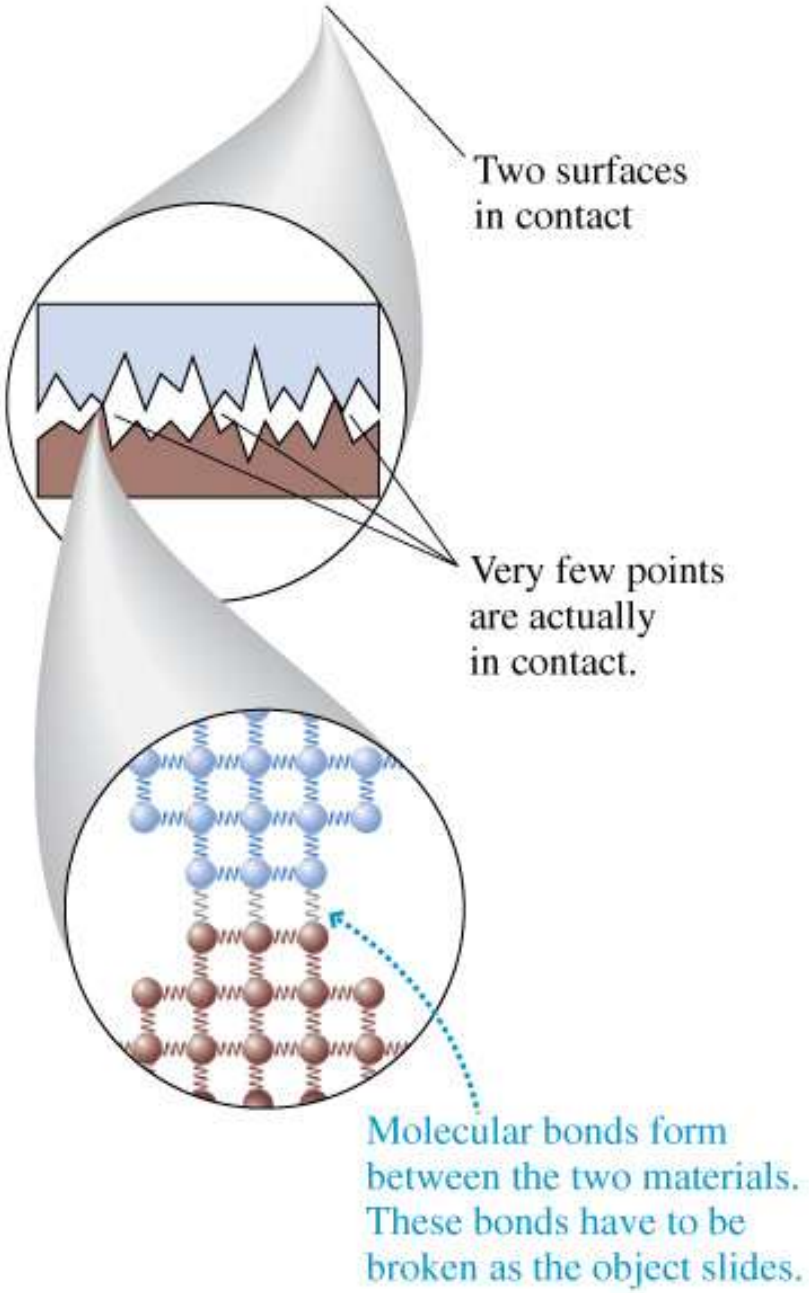
- Mostly only aware of EM when we see static cling or use fridge magnets

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

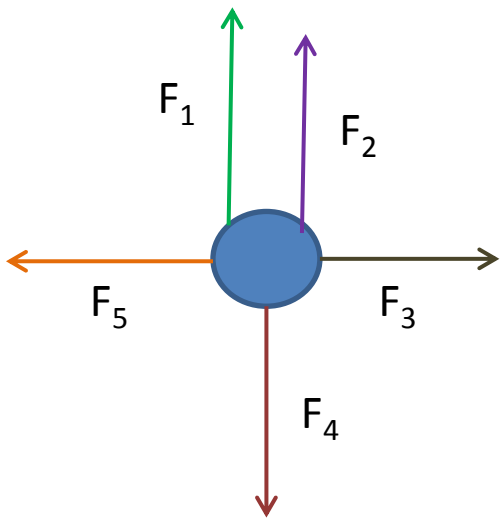




Free Body Diagram

- 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

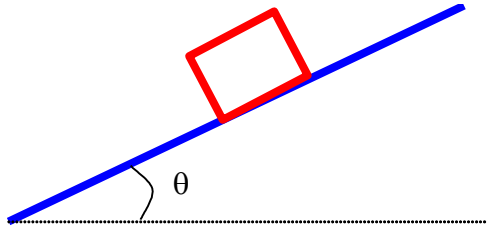
- Upward force components must balance downward force components

$$F_1 + F_2 = F_4$$

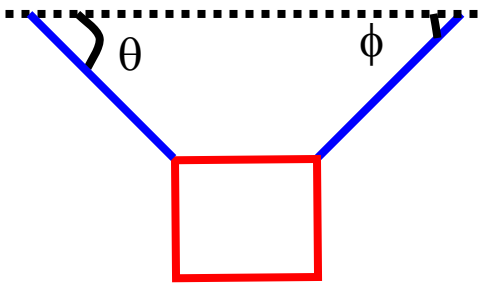
- Right force components must balance left force components

$$F_3 = F_5$$

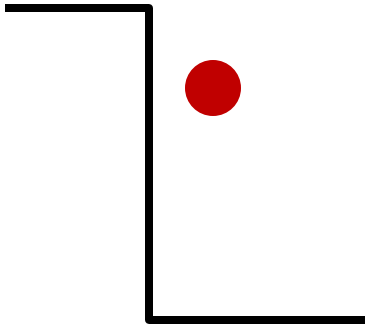
A block of mass M is sliding up a frictionless incline and is slowing down.



A sign of mass M is hanging by two strings from the ceiling. It is not moving.

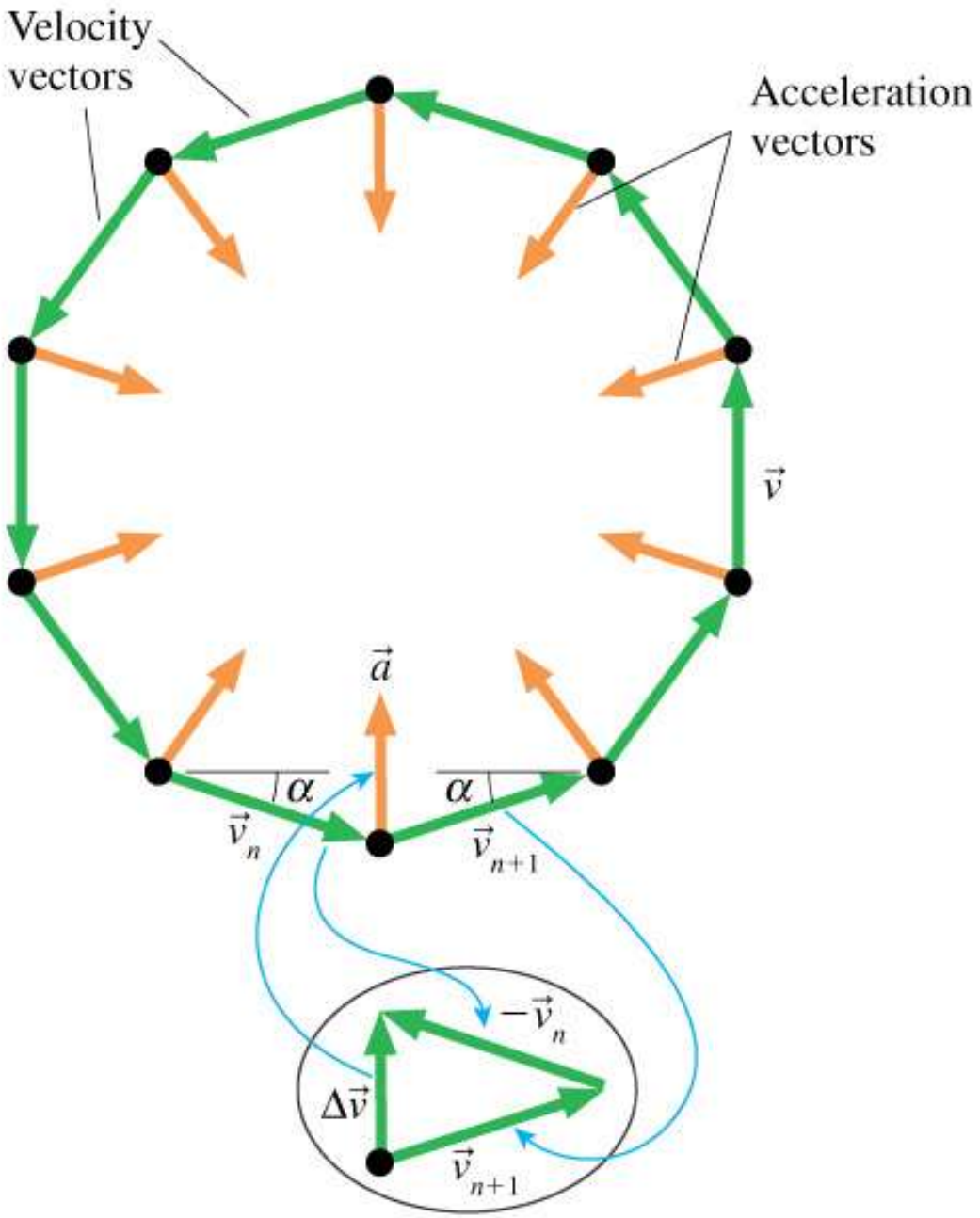


A ball of mass M has been dropped over a cliff. Ignore air resistance.



UCM

$$a_c = \frac{v^2}{R}$$



Non-Uniform Motion