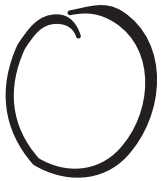
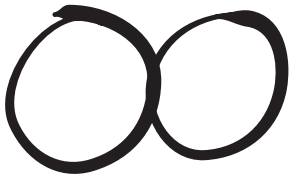
Gas

can be single atoms
or molecules

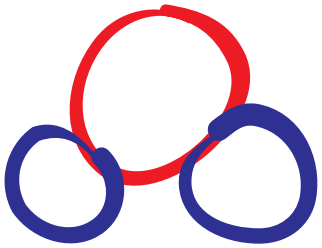


Helium He

Nitrogen N_2

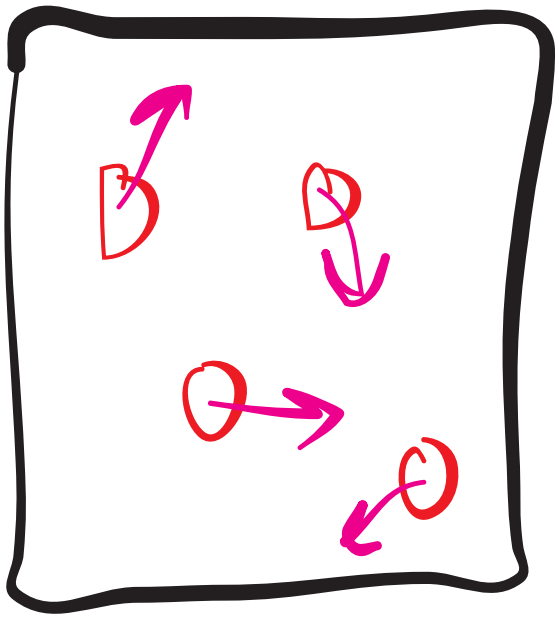


Oxygen O_2

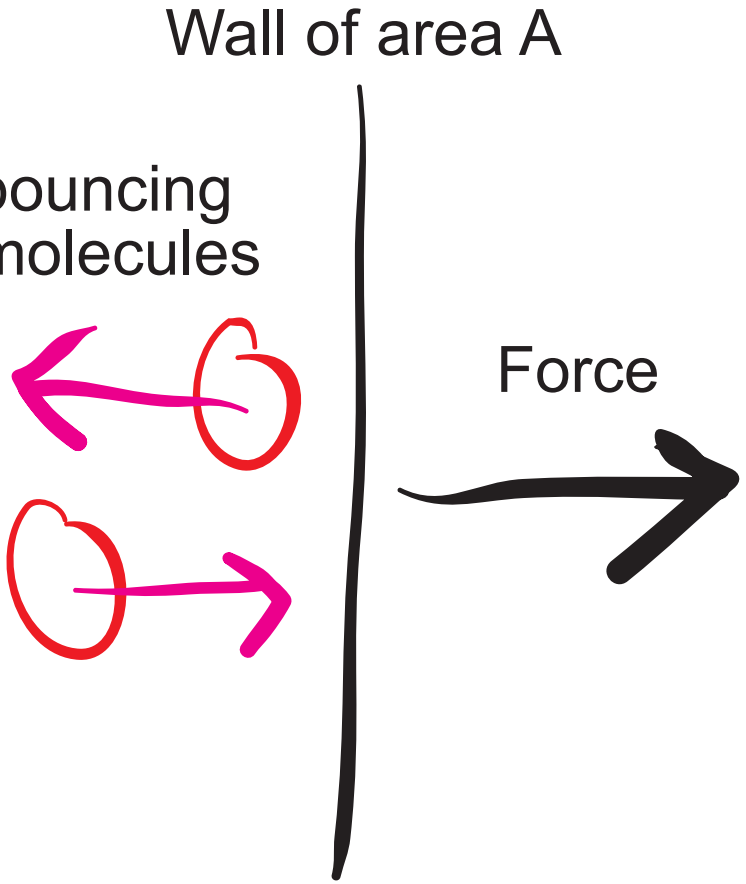


Water H_2O

Pressure



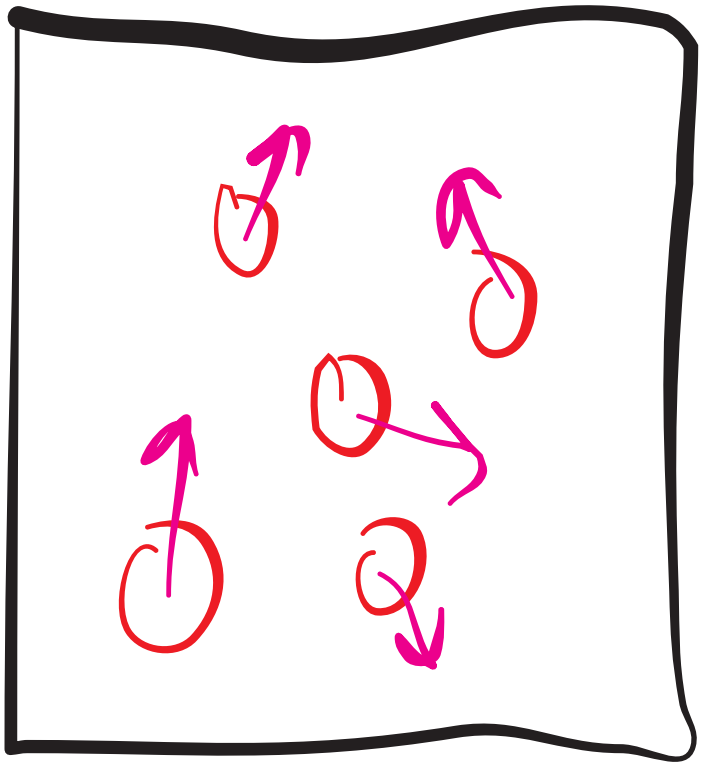
gas particles
in a box



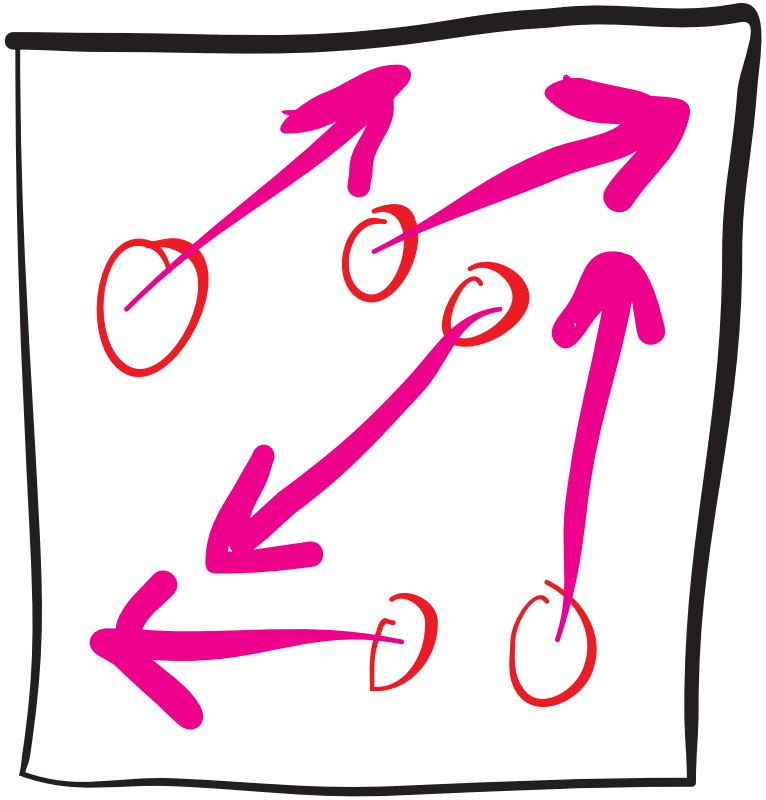
Pressure = Force / Area

Temperature

Low Temperature



High Temperature



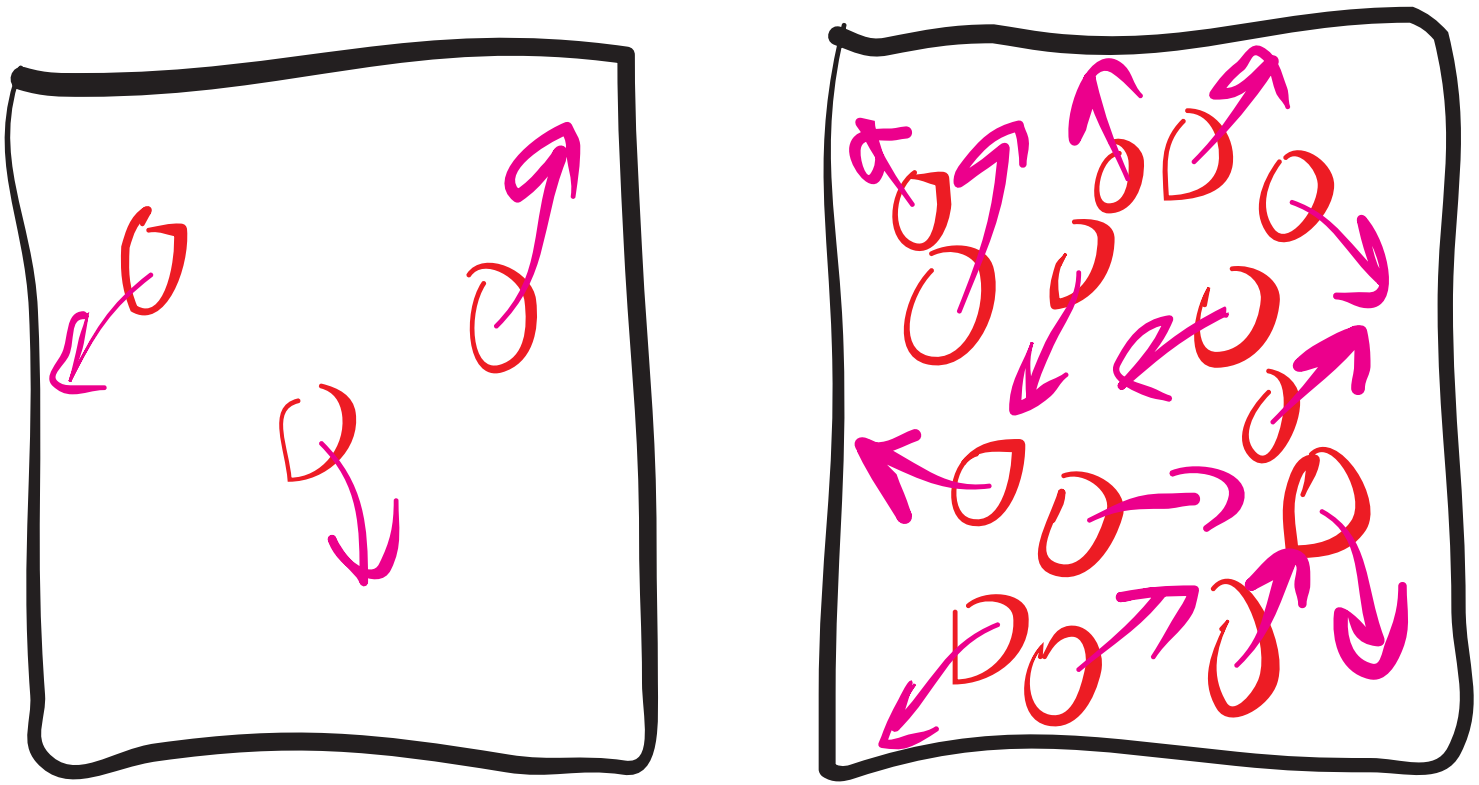
Thermal motion = Kinetic energy

Higher temperature, higher kinetic energy, faster motion
more force, greater pressure

Density

Low density

High density



More particles hitting the box, higher pressure

Ideal Gas Law

Combine what we already know

$$PV = nRT$$

or

$$P = \text{number density} \times R \times T$$

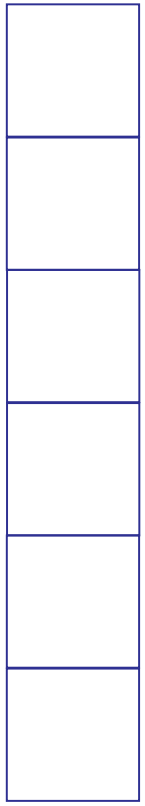
P pressure
V volume
n number of moles
R constant (fudge factor)
T temperature

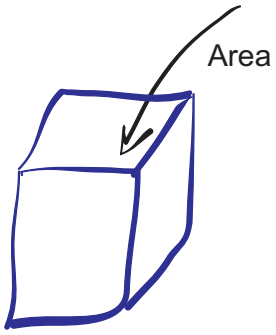
pressure is proportional to density of particles times temperature

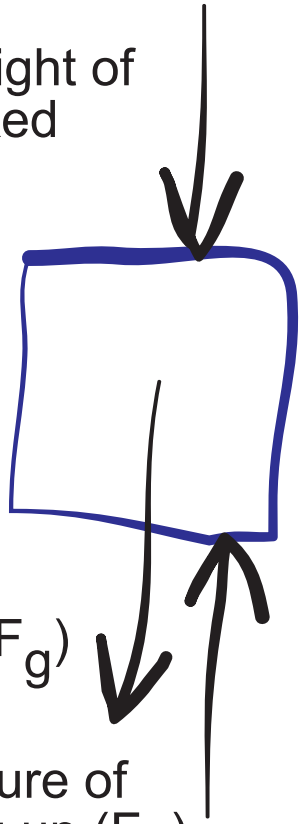
More particles, higher pressure

Higher temperature, higher pressure

Atmosphere







Force from weight of all boxes stacked on top (F_t)

Force of gravity of the air in the box (F_g)

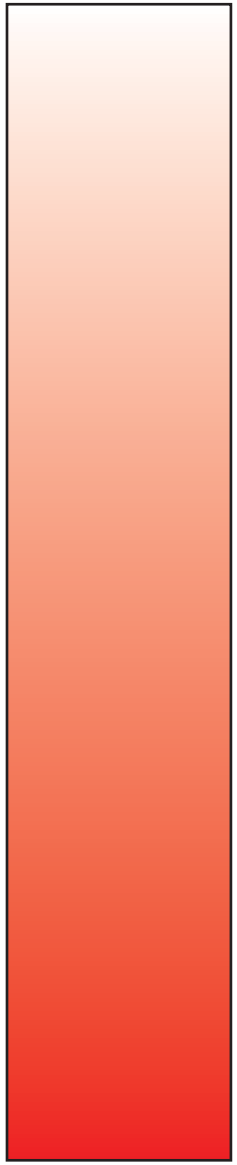
Force from pressure of air below pushing up (F_b)

If there are N boxes on top, then

$F_b = (N + 1) \times F_g$

$F_t = (N) \times F_g$

(Air is not accelerating so forces cancel out)



What does pressure really mean

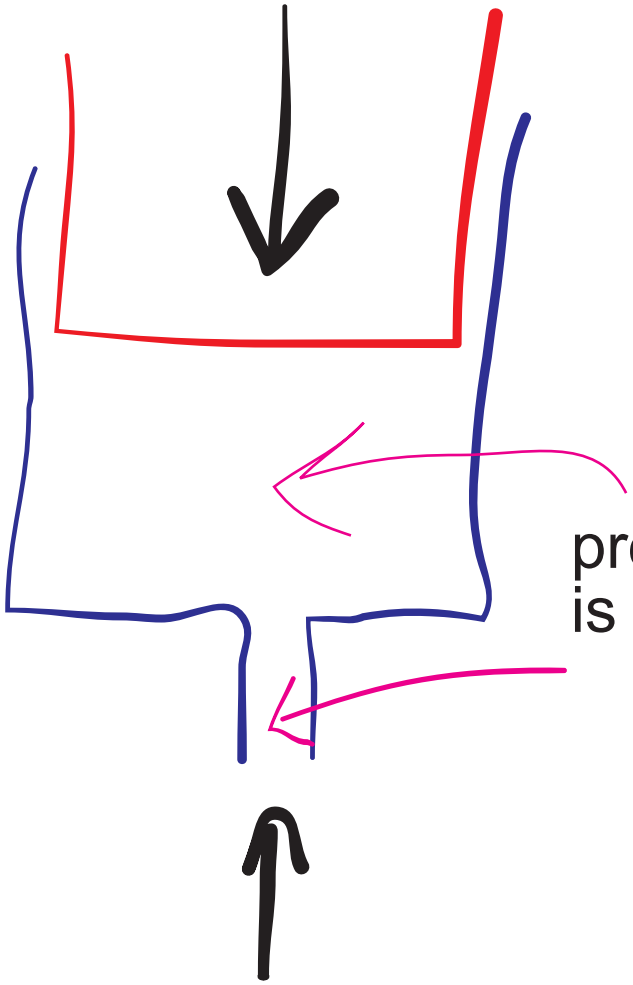
Atmospheric pressure at sea level
    100,000 newtons per square meter, 100,000 pascals (Pa)
    (~10,000 kg per square meter or 14.7 pounds per square inch)
Pressure at Denver
    83,000 Pa (12.2 psi)
Pressure at Mount Everest
    33,000 Pa (4.9 psi)

At sea level, equivalent to a bus on top of you
    or 1 ton per square foot

Pressure difference between top and bottom of wing
    2,000 Pa (1/3 psi)

Hydraulic pump

Large force (heavy weight)
Large area



pressure = force / area
so
force = pressure times area

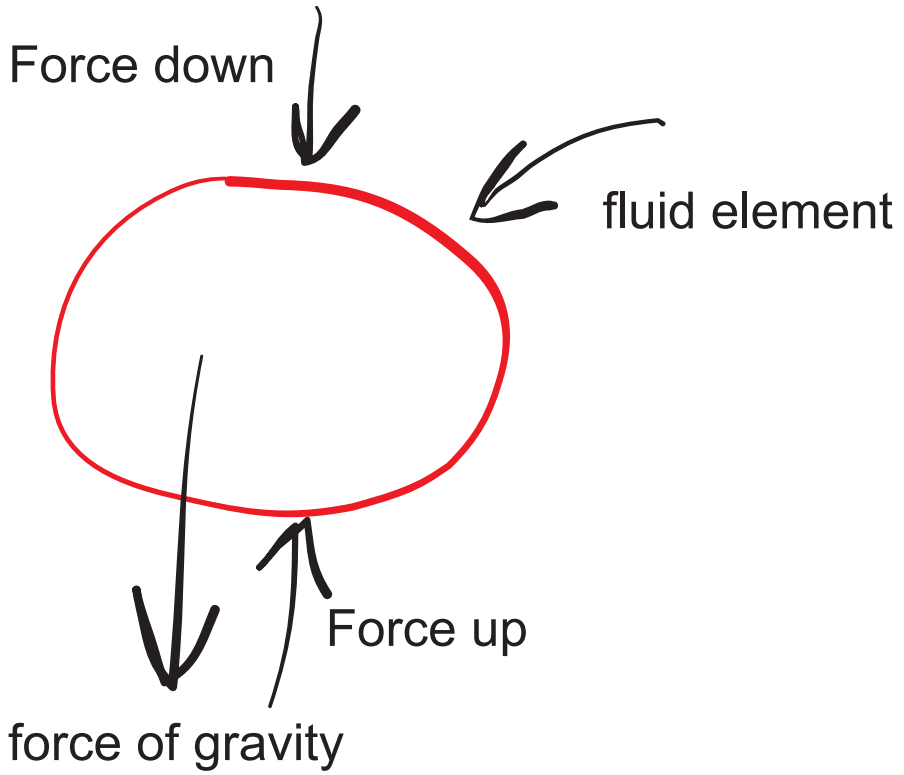
pressure of the fluid
is the same everywhere

Small force (easy to push)
Small area

Buoyancy

Archimedes' principle:

An object partially or wholly immersed in a fluid is acted upon by an upward buoyant force equal to the weight of the fluid it displaces.



Consider part of the fluid

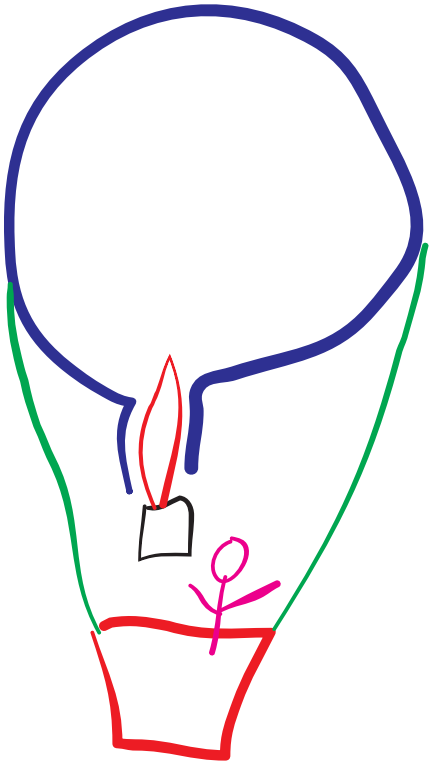
Total Force = force up - force down - force of gravity = 0

If the object has a different mass, the force of gravity will be different

- if mass is greater than the fluid
  - Total Force is negative, object falls
- if mass is less than the fluid
  - Total Force is positive, object goes up
- if mass is the same
  - Total Force = 0, object stays where it is

Hot Air Balloon

pressure inside = pressure outside



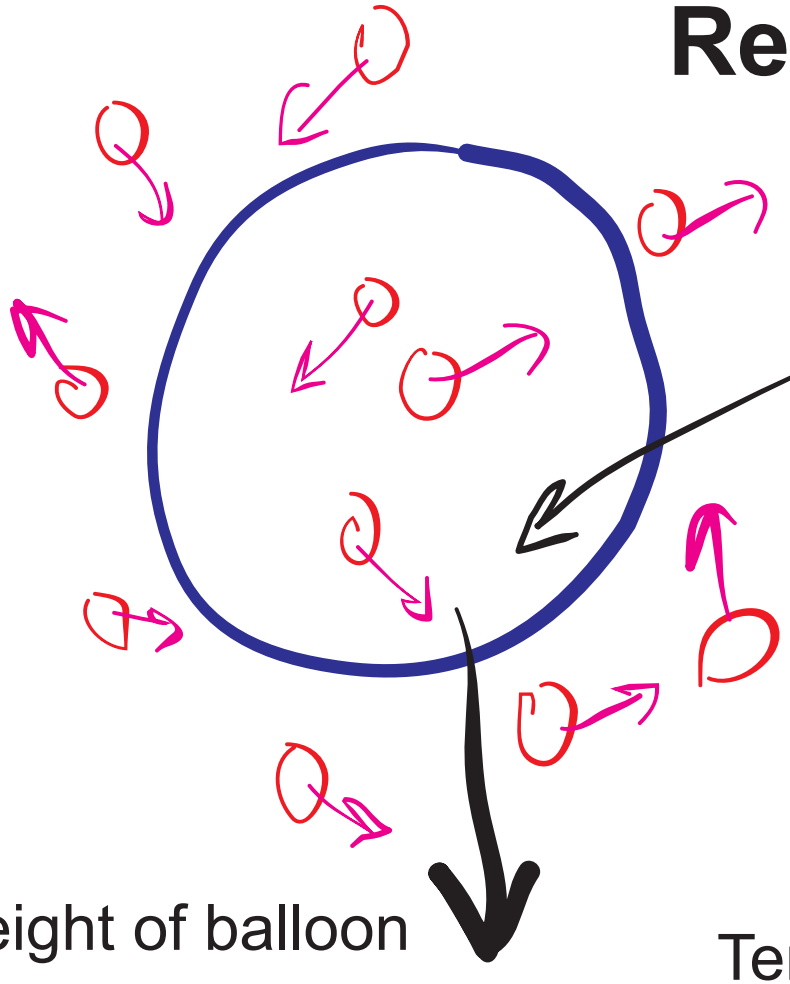
pressure is proportional to density times temperature

Hot air has higher temperature and same pressure so density is lower

So weight of balloon is less than air around it

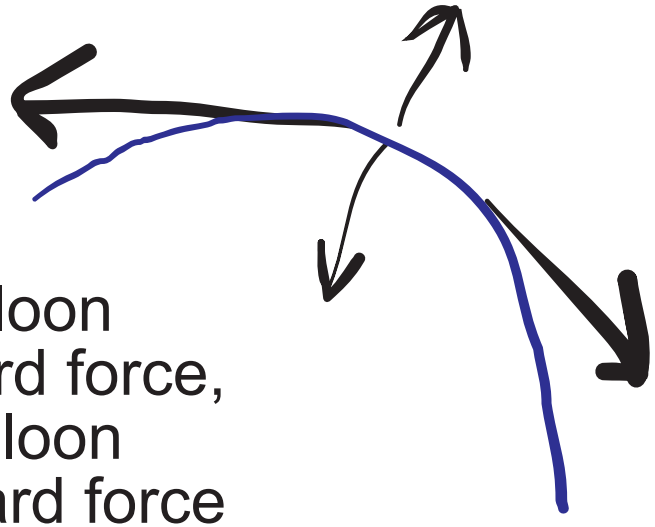
Balloon rises

Regular balloon



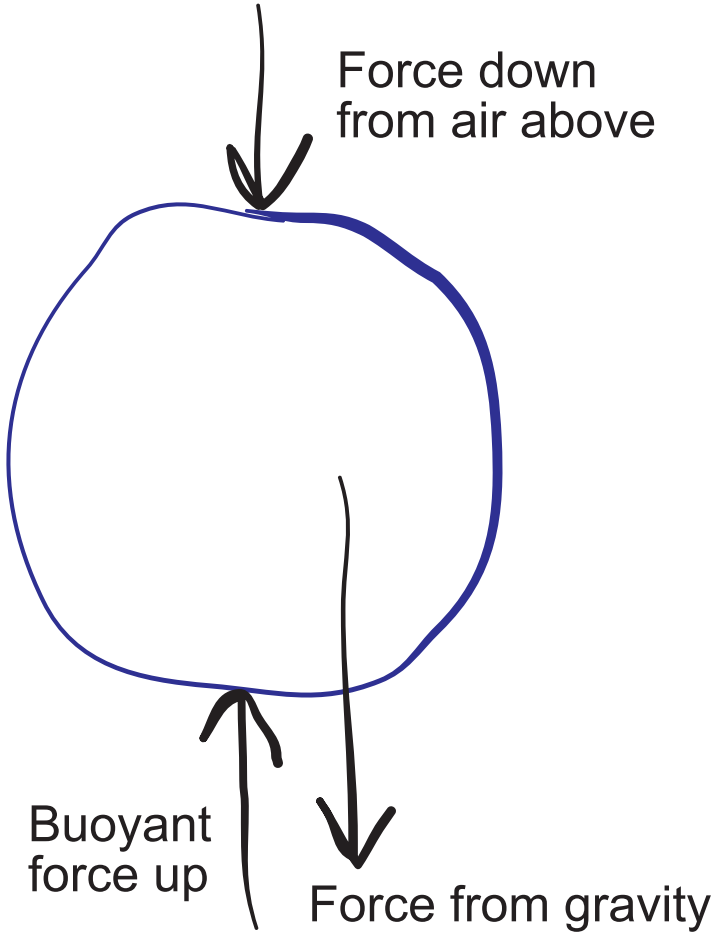
Pressure inside greater than pressure outside (needs to stretch balloon)

Weight of balloon



Tension on balloon produces inward force, pressure of balloon provides outward force to balance.

Helium Balloon



Force due to gravity =
weight of balloon + weight of helium

If
weight of helium is less
than weight of air (yes)
and
weight of helium + weight of balloon is
less than weight of air (depends on balloon)
then
balloon goes up

Bubbles

Surfactant molecule (SOAP)