PRESSURE

Gas Pressure

- Gas molecules inside a volume (e.g. a balloon) are constantly moving around freely.
- They frequently collide with each other and with the surface of any enclosure.

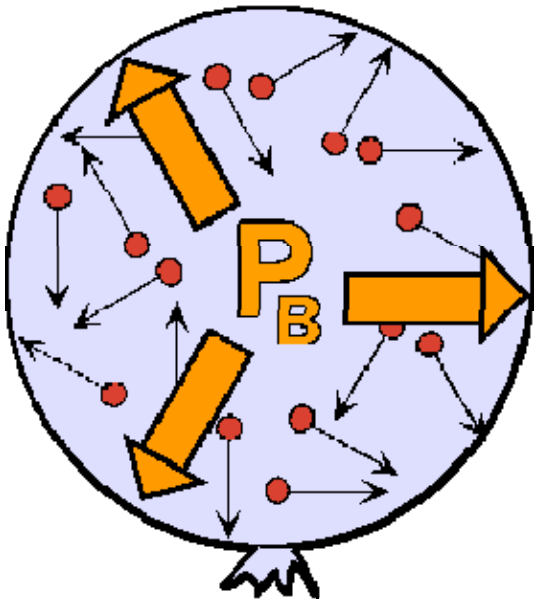


Figure 1: The internal gas pressure in a balloon, P_B, is given by the impacts of moving gas molecules, as they collide with the skin of the balloon from the inside.

- The force of impact of a single one such collision is too small to be sensed.
- Large number of impacts of gas molecules exerts a considerable force onto the surface of the enclosure
- The larger the number of collisions per area of enclosure, the larger the pressure:

$$Pressure = \frac{Force}{Area}$$

- There is not only gas inside the balloon, there is also gas on the outside.Figure 2).

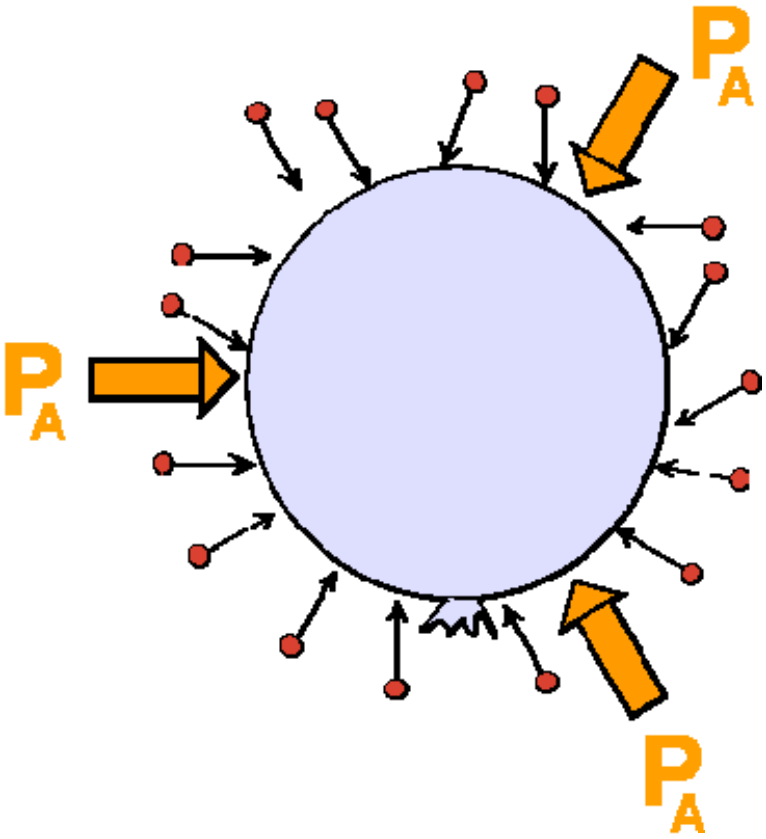


Figure 2: The atmospheric pressure outside a balloon, P_A, is given by the impacts of moving gas molecules, as they collide with the skin of the balloon from the outside.

- The rate, at which the skin of the balloon is bombarded by air molecules, is dependent on how tightly the gas molecules are packed:

$$\boldsymbol{Density\ (Gas) = \frac{Mass\ (Gas)}{Volume}\ OR\ \rho = \frac{m}{V}}$$

Kg/m^3

- Gas is compressible, so its density depends on the force that is used to compress it
- In the atmosphere, the force that compresses the air at the surface is just the weight of all the air in the atmospheric column above it (Figure 3).

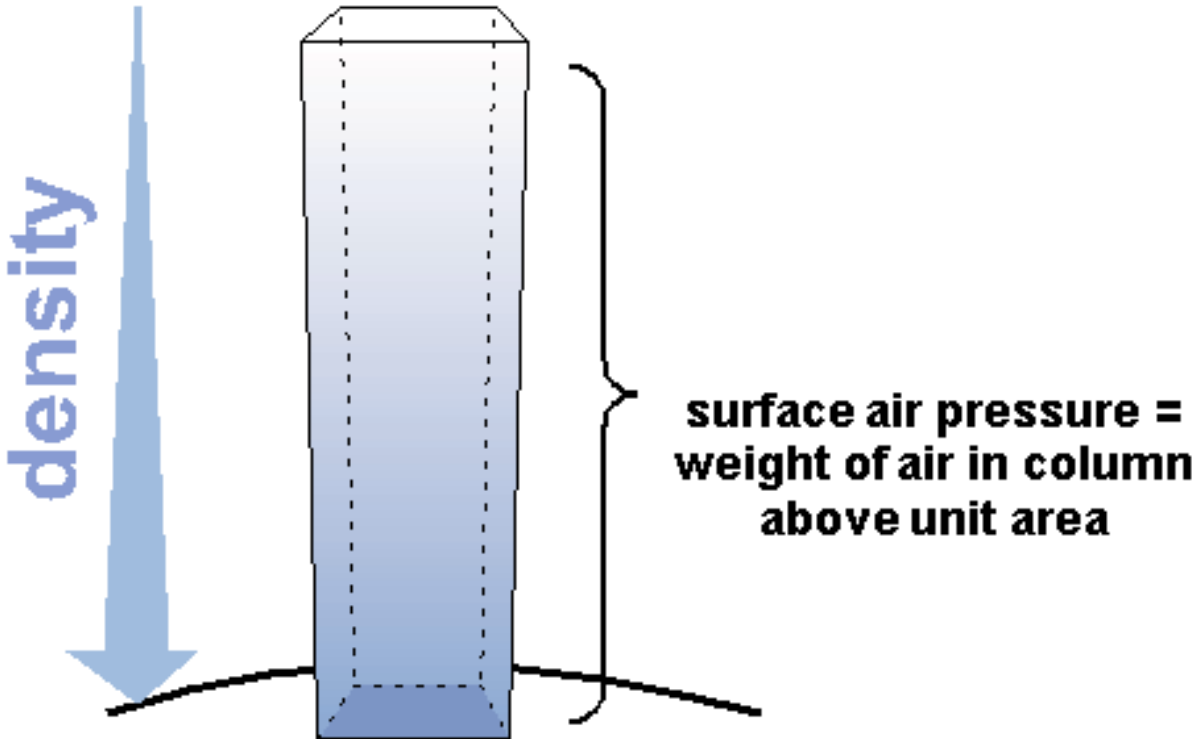


Figure 3: Surface pressure and density in an air column

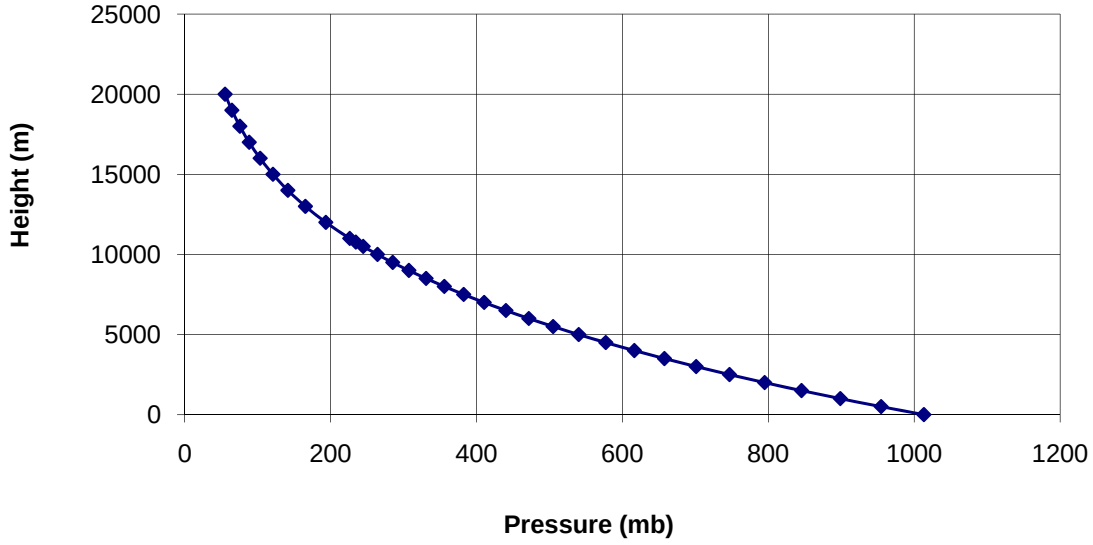
- The higher we go in the atmosphere, the less air remains in the column above us.
- Atmospheric pressure always decreases with height.
- Air density decreases with height, because the overload to compress the air gets less and less, as we go higher.

Why are there more air molecules close to the surface?

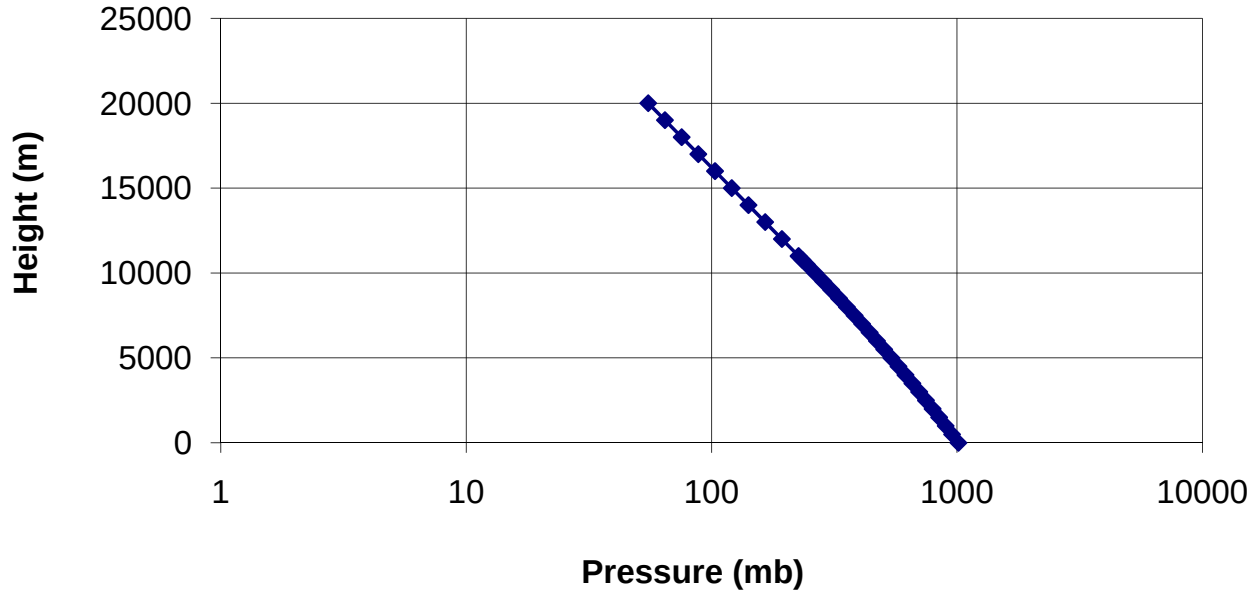
1) **Gravity** - attracts air molecules
- closer molecules are held more strongly

2) **Compressibility of air** - fluid can be compressed
More molecules above more compression

- Negative relationship - decreases with height
- Linear graph paper - (exponential curve)



- Semi-logarithmic graph paper



Units of Pressure

(read: Lab Manual Lab 3 notes)

Atmospheric Science we use

a) millibars (mb)

10^{-3} - milli
bar - pressure

Sea level pressure - 1013.25 mb

b) Pascals (Pa)

kPa - kilo Pascal 10^{3} - kilo
hPa - hecto Pascal 10^{4}

Sea level pressure
101.325 kPa = 101325 Pa = 1013.25 hPa = 1013.25 millibars

Ideal Gas Law (or Equation of state)

Use three variables to describe the atmosphere

Variable	*Unit*
Temperature (T)	K kelvin
Pressure (P)	Pa
Density (ρ)	kg m^{-3}

Temperature scales

	Kelvin (K)	Celsius (°C)	Fahrenheit (°F)
Boiling Point	373	100	212
Freezing Point	273	0	32
BP - FP	100	100	180
Relative size of 1 degree	1	1	~0.55

Density = $\frac{\text{Mass}}{\text{Volume}}$

Ideal Gas Law	**$P=\rho RT$**

R - Gas constant 287 J kg^{-1} K^{-1} J - joule

What does this state?

a) Temperature is set constant (T=ct)

P=ρRT

b) Density is set constant (ρ=ct)

P=ρRT

c) Mass is set constant (m, T = ct)

$$P = \frac{m}{V} RT$$

Example of calculation

What is the pressure of air when the temperature is 15°C and the density is 1.225 kg m^{-3}?

What does this means in the atmosphere?

If we take a parcel of air e.g. "balloon"

Assume: can expand or contract freely but cannot exchange heat

- Space occupied by the air molecules within the parcel defines the air density (m/v)
- Average speed to the molecules directly related to the Temperature
- Molecules colliding against the sides of the parcel determine the air pressure inside

Surface: Temperature of the parcel is the same as the surrounding air	
Now lift the air parcel to region where the air pressure is lower Lower pressure outside -	

- No other energy source apart from that inside the baloon- uses some of its own energy to expand the parcel

- Referred to as an **ADIABATIC** Process - air molecules move more slowly after parcel expands
- Decrease in average molecular speed $\Rightarrow$ lowers parcel T

If parcel comes back to the surface