ph115 11Sept19
ch14 gases

The atmosphere

Thickness has 2 competing factors
- kinetic energy / random motion of molecules - pushes out
- gravity holding molecules here

No gravity - just escapes! (Helium does this!)
Sources of He...

Not enough energy / too cold? Condenses to gas or liquid

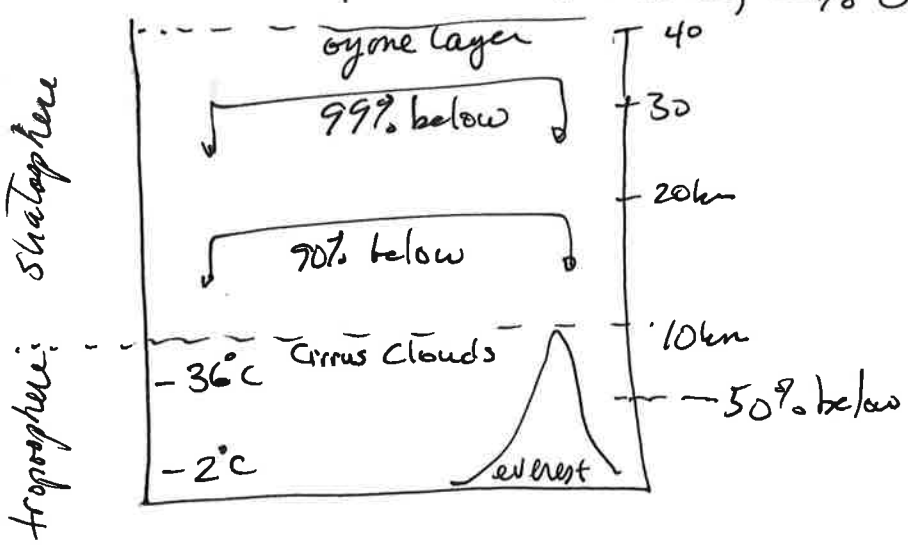
Our atmosphere is a happy compromise

Solar energy gives molecules their energy - ~1600 km/hr!

How tall is atmosphere? No hard boundary, just thins to nothing

99% is below 30km altitude (~100,000 feet)
50% below 5.6 km ~18,000 ft

composition 78% N_2, 21% O_2, 0.9% Ar, traces of others

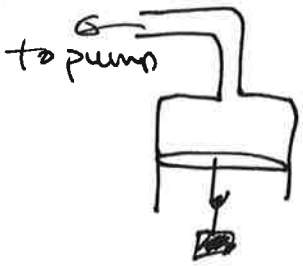


interplanetary space: ~1 molecule per cubic cm!

our atmosphere: ~ $3\times10^{19}/cm^3$, only ~70nm between

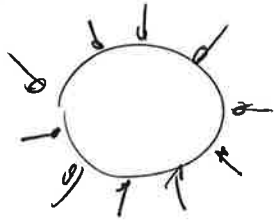
Atmospheric pressure

- like were @ the bottom of a pool - whole atmosphere is sitting on us
- pressure is weight of air above us
  NOT force due to vacuum, always due to fluid/gas



does vaccum "suck" weight up?
NO! w/no vacuum, equal pressure on either side because same density, energy of molecules colliding on either side
- remove molecules above? only ones below push up, net pulling force

- We've adapted to weight of air, don't notice it
  101,325 Pa (N/m^2) or $14.7 lbs/in^2$
- because it is a fluid force, presses in all directions equally (other than small buoyant force), no NET force

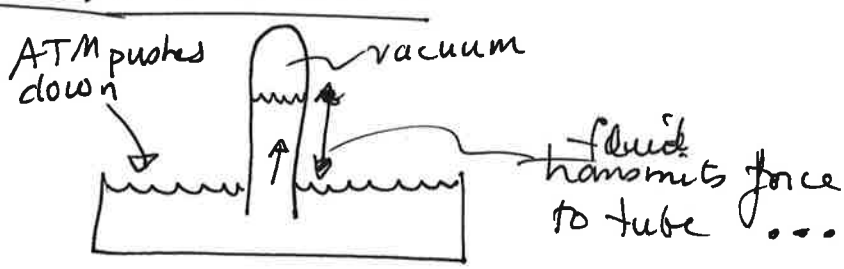


- other than possible compression, no effect
- our bodies balance this pressure

- Sea level, air is about $\rho = 1.25 kg/1m^3$
  20 x 12 x 10 ft room ~ $68 m^3$ ~ 85 kg worth of air
  air in room weighs as much as we do
- 10 km, only $0.4 m^3/kg$ ⇒ need to pressurize planes

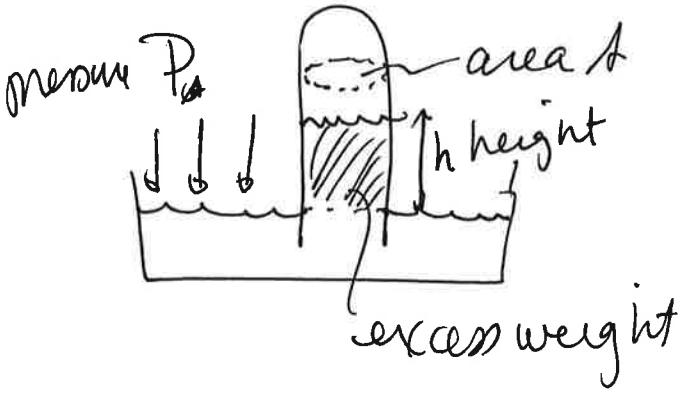
- Unlike vials of liquid, pressure of atmosphere is not uniform on large scales – barometer on weather report!
  - varies with altitude, location, day to day
  - key to weather reporting / forecasting
    - high P coming: cooler, clear
    - low P coming: hotter, rain, storms
    - systems follow currents and H → L press

Barometer / Manometer



... liquid rises

- must be that weight force of fluid that rose equals force due to atmospheric Pressure



i.e. (weight density liq)(vol liq. excess)

$$\parallel$$

$$P \cdot A$$

or $P\underline{A} = (\text{wt density})\,\underbrace{\underline{A} \cdot h}_{\text{cylinder volume}}$ cancel!

So $P = (\text{wt density}) \cdot h$

measure h, get P!

But! larger weight density = smaller heights - practical

1 atm = 101,325 Pa (N/m^2) with water (mass density $1000 \frac{kg}{m^3}$, wt density $9800 N/m^3$)

$h \simeq 10.3 m$! too tall (

(incidentally: same as max height achievable by suction: perfect vac @ top of straw, still only 10.3 m max rise)

use Mercury (Hg) - 13.6 times denser

1 atm = 101,325 Pa = 760 mm = 29.92 in

weight density = (mass density)(gravity) = ρg familiar? $g \simeq 10 m/s^2 = 10 \frac{N}{kg}$

Boyle's law related to Simulation we did

- relates pressure to density
- fixed temperature, piston of gas
  - add more molecules? more collisions w/walls, P ↑
  - Compress volume? more collisions, pressure up

  + Both cases, density ↑ means P ↑
- we always find if P doubles, V halves, vice versa

or $P \propto \frac{1}{V}$, or $P \cdot V = cnst$

at const temp, density (or volume) and P scale oppositely
product same – one up 3x, other down 3x!
(big V)(small P) ~ (small V)(big P)

More: $\text{density} = \frac{\text{num}}{\text{vol}} = \frac{N}{V}$

So really $\frac{PV}{N} = \text{const} \Rightarrow \begin{cases} P\uparrow,\ V\downarrow \text{ or } N\uparrow \\ P\downarrow,\ V\uparrow \text{ or } N\downarrow \\ N\uparrow,\ P\times V \text{ up} \end{cases}$ etc

Microscopically, same model: collisions of molecules w/walls
how many per unit area, time $\Rightarrow$ pressure

Buoyancy of air: same as in liquids!

- object surrounded by air buoyed up by force equal to weight of air displaced
- air density 1000 times less than water ...

$1\,m^3$ air weighs ~ 12N (1.2kg mass)
to lift a 1000N mass (100kg), need $80\,m^3$
about the size of this room

Vacuum isn't practical, but one can use an enclosed area of lower density than air (He, H) – buoyant force scales as difference in density between gas; air
(heated air)