Chapter 11 Fluids

Fluid - any substance that can be compressed with added pressure

ex: air and water

Check Q?

Why does the cartesian diver sink?

Mass Density = rho = ρ

- Mass per volume (for fluids AND solids)
- Can change for a given liquid due to pressure

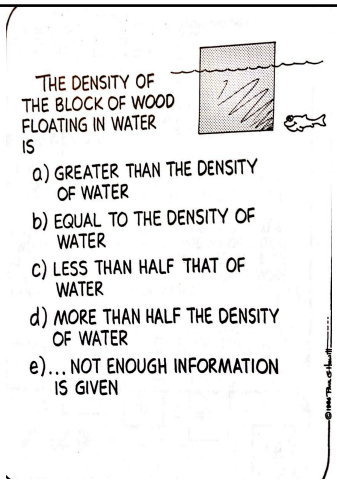
$\rho = m/V$ m = mass (kg), V = volume (m^3)

units = kg/m^3

Specific Gravity = sg = density compared to water ... NOT UNITS

- sg = 1 for water..if sg> 1 = sinks, if sg < 1 = floats

Check Q?

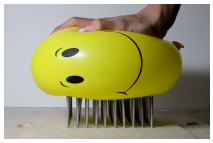


Pressure vs Force - Bed of Nails Demo

Pressure = force per area

P = F/A

units = N/m^2 = Pascals = Pa



P is INVERSELY proportional to area

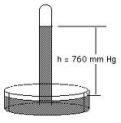
***P is NOT a vector!

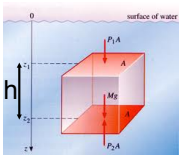
***ALWAYS acts $\perp$ to surface

Soda Can Demo

Normal atmospheric pressure

- 1 atm (used in Chemistry)
- **1×10^5 Pa** (This is what we use)
- 760 mmHg
- 14.7 lbs/in^2 = psi





Floating Cube in water

$\Sigma F_y = F_2 - F_1 - Mg = P_2A - P_1A - Mg = 0$

since $V = Ah$ then $m = \rho V = \rho Ah$

so...

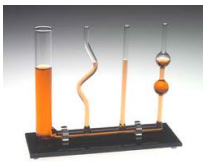
$P_2A - P_1A = \rho Ahg$ and the A's cancel

$P_2 = P_1 + \rho gh$ OR $\Delta P = \rho gh$

***Side pressure cancel!

***only HEIGHT of liquid ABOVE point determines pressure!!!!

Demo - equilibrium tubes

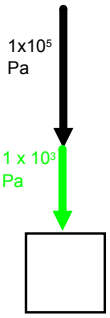


Absolute vs Gauge pressure

Absolute Pressure = TOTAL

Pressure = add them all up

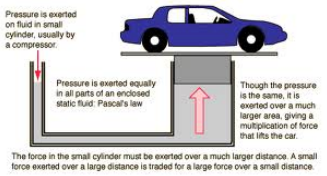
Gauge Pressure= pressure ABOVE ATM pressure



Pascal's Principle

Any change in pressure is applied to all parts of a fluid undiminished if **completely enclosed**

$F_1/A_1 = F_2/A_2$



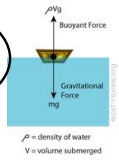
Archimedes Principle

Buoyant force is equal to the weight of the volume of liquid displaced

$F_b = mg_\ell = \rho V g_\ell$

ℓ = liquid

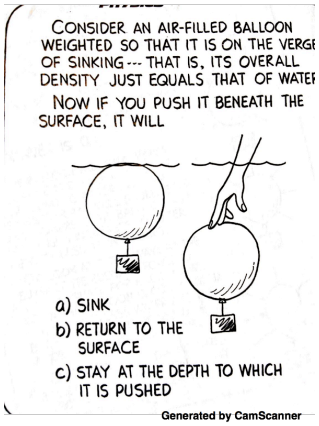
o = object



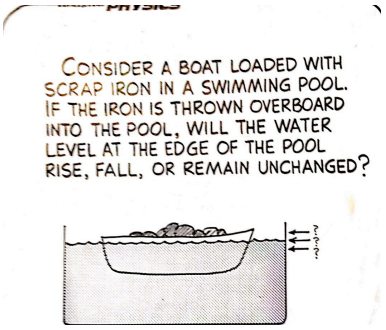
IF $F_b = mg_o$ then floats

***note F_b does not HAVE to = mg_o

Check Q?



Check Q?

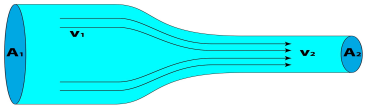


Law of Continuity

For a non-compressible liquid the volume flow rate must remain constant

$A_1v_1=A_2v_2 = Q$ = volume flow rate

units = m^3/s



Demos

--- ping pong ball and hair dryer

--- ball and box

--- paper and blowing

Bernoulli's Equation

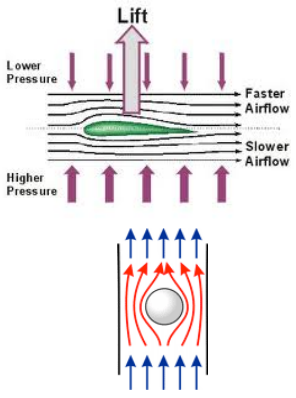
-conservation of energy

Types of energy: "pressure", gravitational potential, and kinetic

$P_1 + U_{go} + KE_o = P_2 + U_{gf} + KE_f$

$P_1 + \rho gh_o + 1/2\rho v_o^2 = P_2 + \rho gh_f + 1/2\rho v_f^2$

means if v ↑ then P ↓



Toricelli's theorem - bottle with hole demo

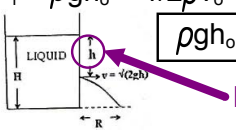
Bernoulli's EQ with following assumptions

1) Fluid is moving slowly at top relative to hole at bottom

2) pressure is equal at top and hole

$P_1 + \rho gh_o + 1/2\rho v_o^2 = P_2 + \rho gh_f + 1/2\rho v_f^2$

$\rho gh_o = 1/2\rho v_f^2$



h = height of liquid ABOVE hole!!!

Poiseuille principle - (Pwah-zah)

(for viscous fluid "thick")

key concepts (Q = vol flow rate)

* more viscous = slower flow

* bigger area = faster flow

* bigger ΔP = faster flow

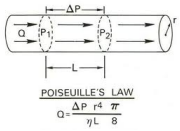
$$Q = \frac{\pi R^4 (P_2 - P_1)}{8 \eta L}$$

η = eta = coefficient of viscosity (units = Pa s = Poisse = P)

ideal fluid = 0 P = infinite flow rate

L = length of "pipe"

R = radius of end of "pipe"



POISEUILLE'S LAW

$$Q = \frac{\Delta P}{\eta L} \frac{r^4}{8} \pi$$