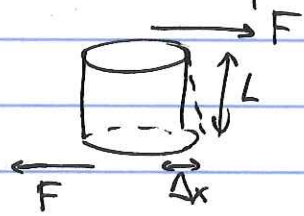
PHYS 107 - Week 10 - Wednesday

* Fluids (statics, not kinematics yet)
  - no resistance to deformation (ideal fluid)
  - yields to shear forces (shear modulus $S = 0$)



$$\frac{F}{A} = S\frac{\Delta x}{L} = 0$$

fluids flow easily without F required

Examples: liquids, gasses, even glasses

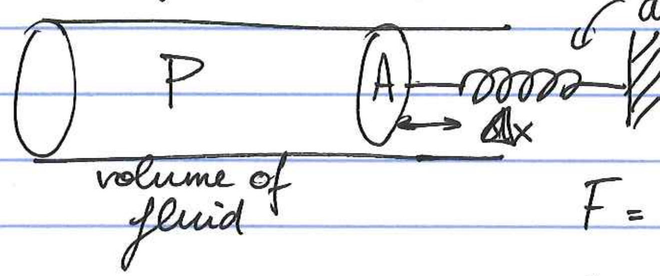
Two quantities describe the fluid:

1) Pressure P
2) Density ρ

* Density: $\rho = \frac{M}{V} = \frac{\text{mass}}{\text{volume}}$ in units $\frac{kg}{m^3}$

H_2O : $1000\ kg/m^3 = 1\ g/cm^3 = 1\ kg/\ell$ (definition of ℓ)
air : $1.29\ kg/m^3$
blood : $1060\ kg/m^3$ sinks
ice : $920\ kg/m^3$ floats
neutron star : $5\times10^{17}\ kg/m^3$ ~ nucleus of an atom

* Measuring pressure : use the definition

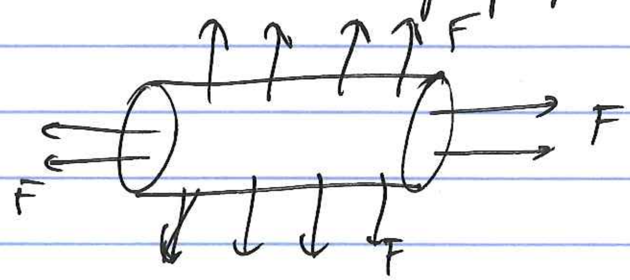


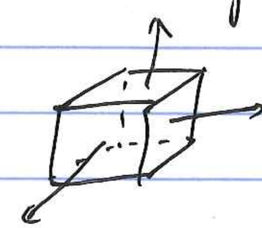
atmospheric pressure or vacuum

$$F = k\Delta x = PA$$

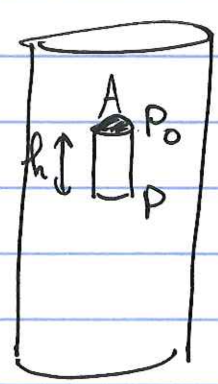
$$\hookrightarrow P = \frac{k\Delta x}{A}$$

* Pressure is always perpendicular to the surface

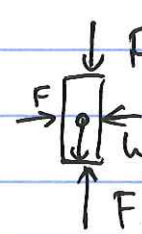




* Fluids under gravity : pressure will change with depth in a fluid.



Consider small volume of height h



$F = P_0 A$

$W = mg = \rho A h g$

$F = PA$

$$\hookrightarrow P_0 A + \rho A g h - PA = 0 = F_{net}$$

$$\hookrightarrow P = P_0 + \rho g h$$

Pressure increases with depth

$$P = P_0 + \rho g h$$

What is the pressure on a scuba diver at 10 m depth?

$P = P_0 + \rho g h$ with $P_0 = 1$ atm $\approx 10^5$ Pa

$P = 10^5\, Pa + (10^3 \frac{kg}{m^3})(10\, m/s^2)(10\, m) = 2 \times 10^5\, Pa$

↳ double pressure; or air pressure corresponds to the column of 10 m height

What is the extra force on the eardrum with $A = 1\, cm^2$

$F_{extra} = P_{extra} A = (10^5\, Pa)(10^{-4}\, m^2) = 10\, N$

(assuming that inside the ear still $P_0 = 10^5\, Pa$)

Q Shaw

* What is the height of the atmosphere?
↳ at what height is $P_0 = 0$?

$$\overset{10^5\,Pa}{\overset{\shortparallel}{P}} = \overset{0}{\overset{\shortparallel}{P_0}} + \rho g h \implies h = \frac{P}{(1.29\frac{kg}{m^3})(10\frac{m}{s^2})} = \frac{P}{\rho g}$$

$$\to h = 8\ km$$

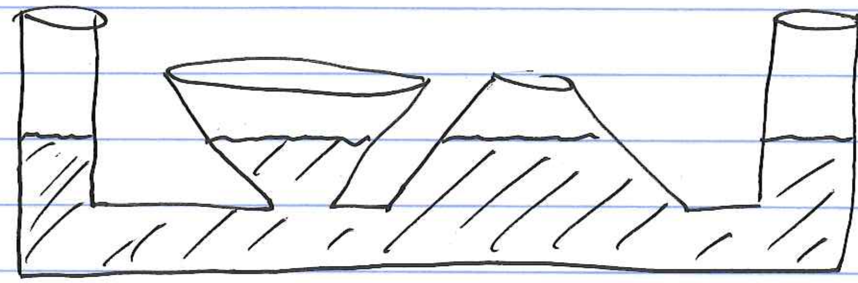
Does this make sense? Mt Everest is higher, but still $\frac{P}{3}$

↳ which assumption is incorrect?

$\rho \neq$ constant : gasses are compressible : higher P → higher ρ

liquids are <u>in</u>compressible
constant ρ

* Pascal's principle:

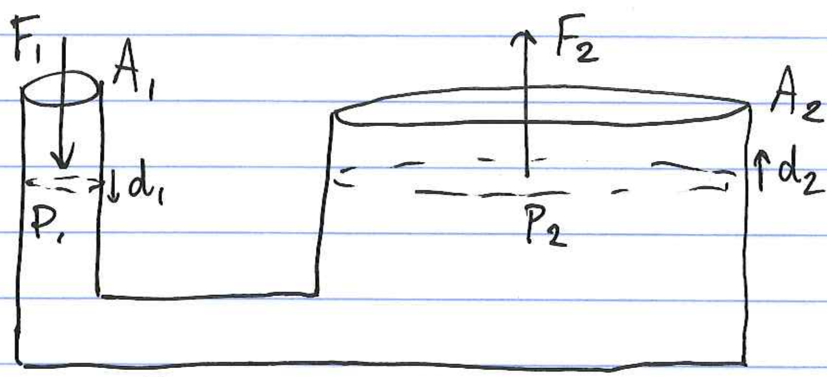


Pressure is the same everywhere at the same height / depth

Any change in P at one point is transmitted to all parts of the liquid

Q Water bottle

* Hydraulics



$$P_1 = \frac{F_1}{A_1} \quad = \quad P_2 = \frac{F_2}{A_2}$$

$$\hookrightarrow \frac{F_1}{A_1} = \frac{F_2}{A_2} \rightarrow F_2 = F_1\left(\frac{A_2}{A_1}\right) \gg F_1$$

force amplification

Force is amplified but volume is still constant

$$A_1 d_1 = A_2 d_2 \longrightarrow d_2 = \left(\frac{A_1}{A_2}\right) d_1 \ll d_1$$

Work is conserved $\longrightarrow$ energy is conserved

$$F_2 d_2 = F_1 \left(\frac{A_2}{A_1}\right)\left(\frac{A_1}{A_2}\right) d_1 = F_1 d_1$$

↳ power steering, brakes on a car