Unit 1 - Fluids

Sunday, January 29, 2017 10:39 AM

PHYS 226

Fluids

13-1 Phases of matter

1. Solid – fixed shape, size
   - moderate forces do not sig. change. shape or size – not readily compressible.
2. liquid – takes on shape of container
   - not readily compressible.
3. gas – no fixed shape or volume.
   - expands of fill container.

Plus.

4. plasma – ionized atoms – high temp. ionized gas.

also.

- colloids
- liquid crystal
- sol/gel.

Types. of simple solids.

- ionic
- metatic
- covalent
- molecular

come back to this later.

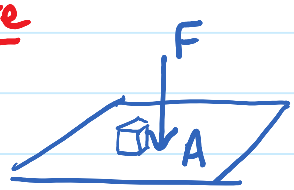
Density

$$\rho = \frac{m}{V} \; [=] \; \frac{kg}{m^3} \quad \Rightarrow \quad m = \rho V$$

Specific gravity

$$s.g. = \frac{\rho}{\rho_w} \quad \text{where } \rho_w = 1.00\,\frac{kg}{L}$$
$$= 1000\,\frac{kg}{m^3}$$
$$= 1.00\,\frac{g}{cm^3} = 1.00\,\frac{g}{mL}$$

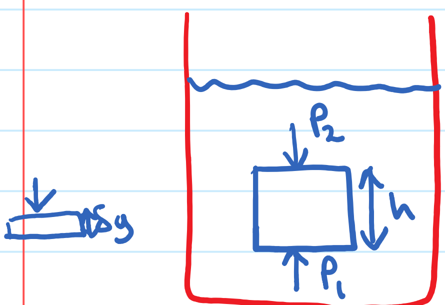
Pressure

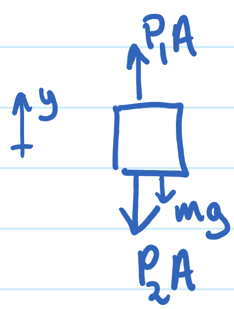


$$P = \frac{F}{A} \;[=]\; \frac{N}{m^2} = Pa$$

$$1\,atm = 1.013\times10^5\,\frac{N}{m^2} = 1.013\,bar = 760\,mmHg$$
(p347).

Pressure is an <u>energy density</u> $\quad P \;[=]\; \frac{N}{m^2} = \frac{N\cdot m}{m^3} = \frac{J}{m^3}$





$$F_y^{net} = P_1A - P_2A - mg \quad \text{(FBD)}$$
$$F_y^{net} = 0 \quad \text{(NI)} \leftarrow \text{water is stationary}$$
$$(P_2 - P_1)A = -mg \;\; (*)$$

If $\rho = $ const, $m = \rho V$ & $V = Ah$

$$(P_2 - P_1)\cancel{A} = -\rho \cancel{A} h g$$

$$P_2 - P_1 = -\rho g h$$
$$\Delta P = -\rho g h$$

or $\boxed{P_2 = P_1 - \rho g h}$ $\quad (\rho = \text{const})$

$\boxed{\text{P.13.21}}$ (Giancoli P364).

For $\rho \neq$ constant $\quad \Delta P \to \delta P \quad P_1 \to P \qquad P_2 = P + \delta P$

$$m = \rho\delta V = \rho A \delta y$$

$$(*)\quad (P_2 - P_1)A = -mg$$

$$(\cancel{P} + \delta P - \cancel{P})\cancel{A} = -\rho \cancel{A} \delta y g$$

$$\boxed{\frac{\delta P}{\delta y} = -\rho g} \quad (13\text{-}4)$$

Pascal's Principle

A change in pressure in a confined fluid is transmitted throughout the fluid.

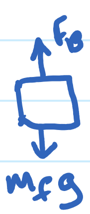
- see Fig. 13-9 (p346).

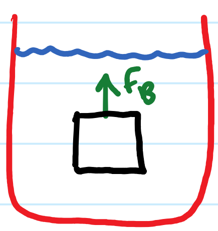
http://hyperphysics.phy-astr.gsu.edu/hbase/pasc.html

P.13.20 (Giancoli P.364)

Archimedes' Principle.

Imagine using a Star Trek transporter to replace water with an object - the buoyant force on the object depends only on the mass of water displaced.





$$F_B = m_f g = \rho_f V_f g$$

Q.

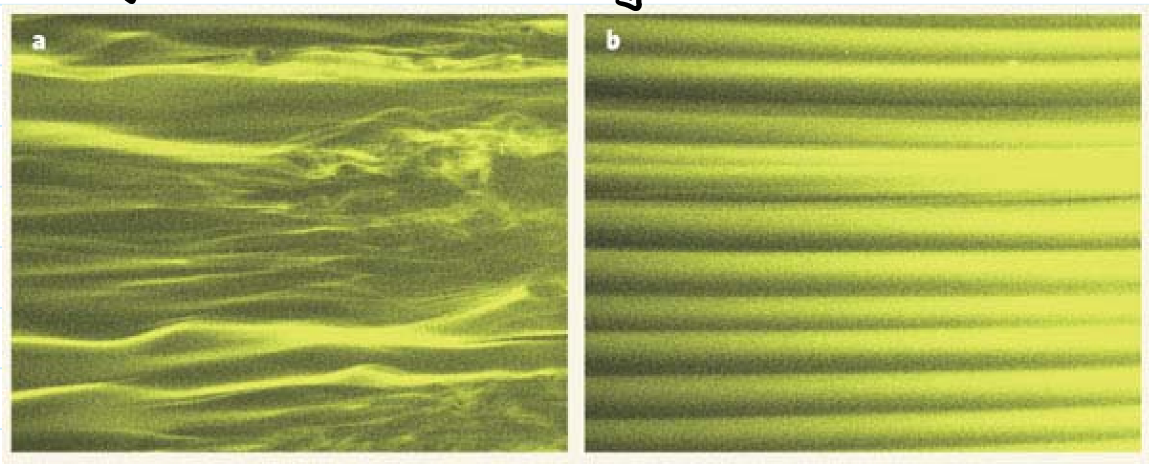
A really big ship is floating in a really small lake. (a) If the ship sinks, does the water level in the lake rise, fall, or stay the same? (b) If the crew of the ship throw some of their bowling ball cargo overboard (to prevent the ship from sinking), does the water level rise, fall, or stay the same?

How would compressibility affect all these?

hexafluoride toy boat floats on dense and invisible gas

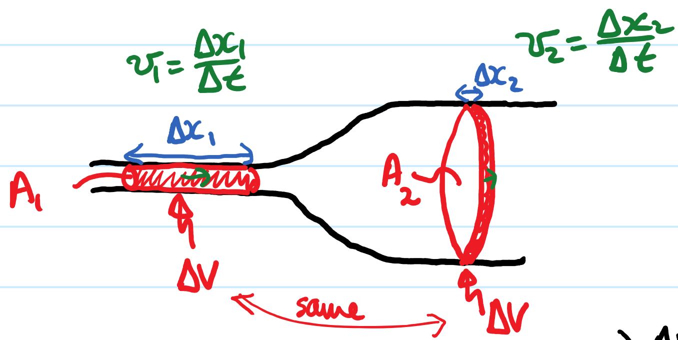
1-2 Hydrodynamics.

Turbulent & laminar flow.



See Fig. 13-21 (p. 352)

Ideal Fluid.
- incompressible ($\rho = \text{const}$)
- laminar flow (not turbulent)
- no friction (viscosity $\eta = 0$)



$\Delta V = \Delta x_1 A_1 = \Delta x_2 A_2$

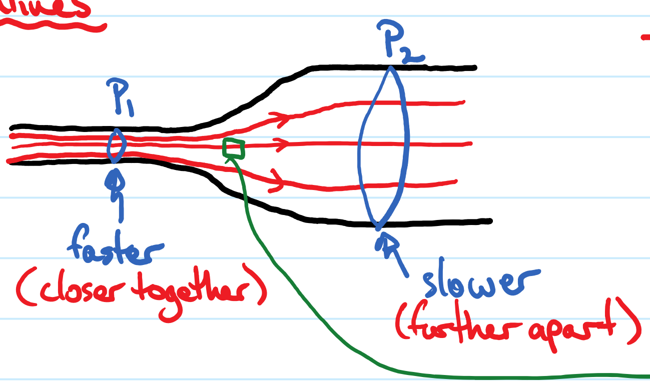
$v_1 = \frac{\Delta x_1}{\Delta t} \Rightarrow \Delta x_1 = v_1 \Delta t$ & $\Delta x_2 = v_2 \Delta t$

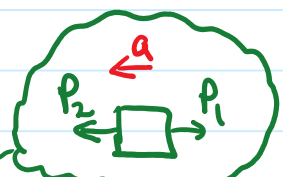
$\Rightarrow \Delta V = v_1 \Delta t A_1 = v_2 \Delta t A_2$

$\Rightarrow \frac{\Delta V}{\Delta t} = v_1 A_1 = v_2 A_2 = \text{const.}$

$\boxed{\text{Continuity eq}^{\underline{n}}}$

Streamlines





Force that slows the water down is the higher pressure of the slower moving fluid.

higher pressure of the slower moving fluid.

$\Rightarrow$ faster flow has lower pressure

Bernoulli's Principle.

Bernoulli's Eq$\underline{n}$.

$$P + \rho g h + \frac{1}{2}\rho v^2 = \text{const.}$$

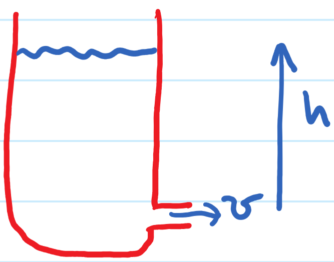
from conservation of energy assuming $\eta = 0$ so that there is no energy dissipation

units of $\frac{J}{m^3}$ energy density

$\rho = \frac{m}{V}$

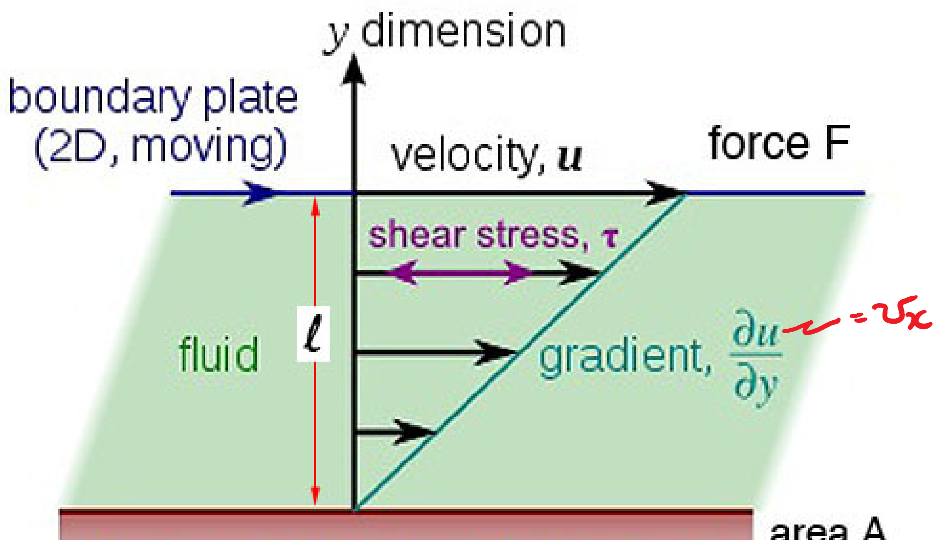
$\boxed{P13.54}$ (p. 365)

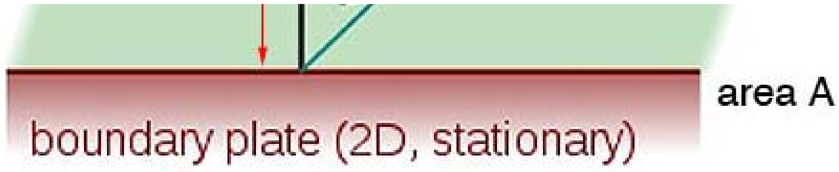
Torricelli's Theorem.



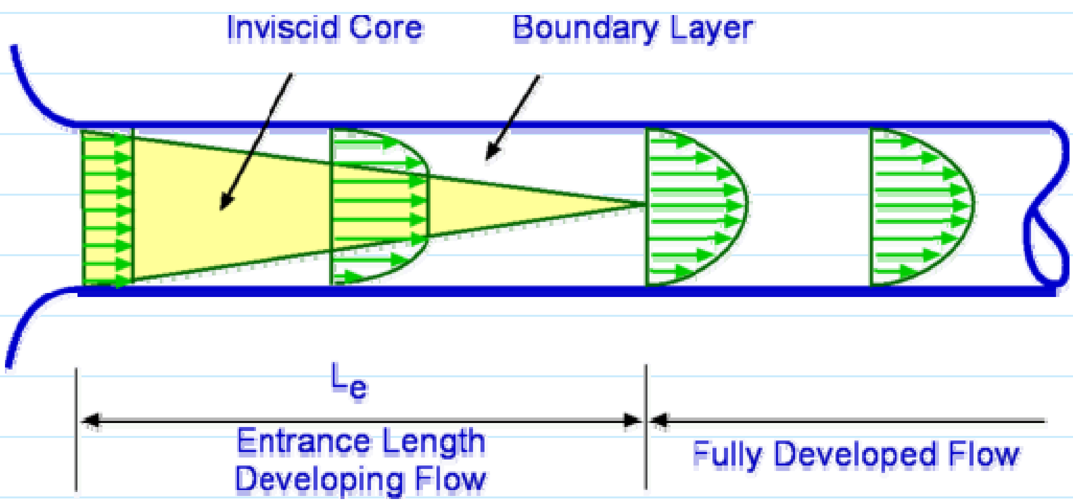
$v = \sqrt{2gh}$ ← same as v for falling object

Viscosity





$$\tau = \frac{F}{A} = \eta \frac{\partial u}{\partial y}$$



↑ diffusion of momentum (mv_x)

http://hyperphysics.phy-astr.gsu.edu/hbase/ppois.html

P.13.67 (p.366) time permitting.

Poiseuille Equation .- viscous flow.

$$Q = \frac{\pi R^4 (P_1 - P_2)}{8 \eta l} \qquad \eta = \text{viscosity.}$$

P_1 R P_2

l

$$Q = \frac{\Delta V}{\Delta t} \; [=] \; \frac{m^3}{s}$$