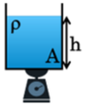
# MIND MAP

## Fluid Mechanics

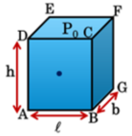
### Fluid Mechanics- Statics & Dynamics

**Force By Liquid**

Reading =mg= ρagh

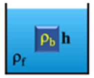


**Force Applied by Liquid on Vertical Surface**



$$F = \left(P_0 + \frac{\rho g h}{2}\right) h\ell$$

**Buoyant Force**



Buoyant force is equal to weight of the fluid displaced.

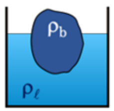
Buoyant force depends on $g_{eff}$

Buoyant force acts opposite to $g_{eff}$

$BF = \rho_f g h A$

**Archimedes Principle**

Loss of weight of a body submerged (partially or completely) in a fluid is equal to the weight of the fluid displaced.



Weight of fluid displaced = $\rho_\ell V_S g$ = BF

If $\rho_b < \rho_\ell$ ; then body will float

If $\rho_b = \rho_\ell$ ; body will just float with fully submerged

If $\rho_b > \rho_\ell$ ; then body will sink

**Law of Floatation**

For Floating : $\frac{V_S}{V_b} = \frac{\rho_b}{\rho_\ell}$

Fraction of vol. submerged = ratio of density of body and fluid

**Conditions of Ideal Fluid Flow**

Fluid is Incompressible and Non- Viscous).

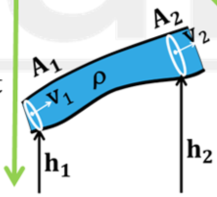
Flow is Irrotational & Steady

| Volume flow rate. | Mass flow rate |
|---|---|
| Volume flowing through per unit time. | Mass flowing through per unit time. |
| $\frac{dV}{dt} = Av$ | $\frac{dm}{dt} = \rho A v$ |

**Bernoulli's Principle**

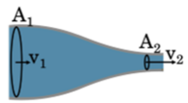
$$P + \rho g h + \frac{1}{2}\rho v^2 = \text{Constant}$$

Based on law of conservation of energy

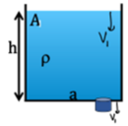


**Equation of Continuity**

$A_1 v_1 = A_2 v_2$



**Speed of Efflux: Torricelli's Law**



$v = \sqrt{2gh}$

The value of this force acting on unit area at any point is called Pressure at that point.

$$\text{Pressure} = \frac{dF_1}{dA_1} \longrightarrow \text{Scalar Quantity}$$

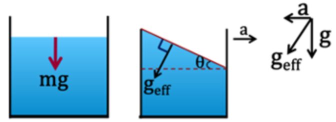
SI unit is $N/m^2$ = Pascal (Pa)

1 bar = $10^5$ Pa

1 atm = 101325 Pa ≈ $10^5$ Pa

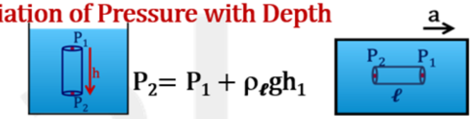
1 atm = 1.01325 bar ≈ 1 bar

**Ideal fluid cannot sustain shear stress**



$\tan\theta = \frac{a}{g}$

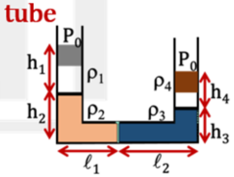
**Variation of Pressure with Depth**



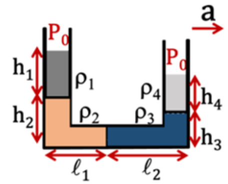
$P_2 = P_1 + \rho_\ell g h_1$

$P_2 = P_1 + \rho a \ell$

**U-shaped tube**

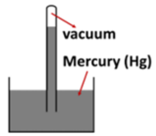


$P_0 + \rho_1 g h_1 + \rho_2 g h_2 - \rho_3 g h_3 - \rho_4 g h_4 = P_0$



$P_0 + \rho_1 g h_1 + \rho_2 g h_2 - \rho_2 a \ell_1 - \rho_3 a \ell_2 - \rho_3 g h_3 - \rho_4 g h_4 = P_0$

**Barometer**




**Pascal's Law**

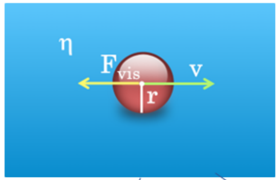
Whenever external pressure is given at any part of fluid it is transmitted undiminished and equally in all direction

# MIND MAP

## Fluid Mechanics

### Viscosity

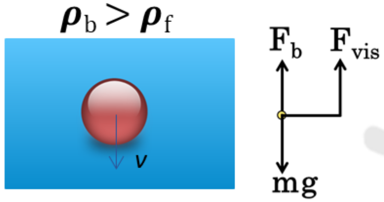
**Stokes' Law**



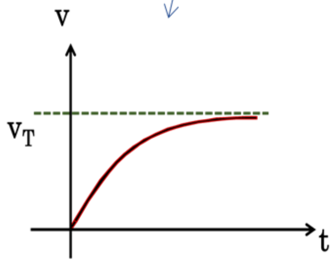

$F_{vis} = 6\pi\eta r v$

$\overrightarrow{F_{vis}}$ is opp. to $\vec{v}$

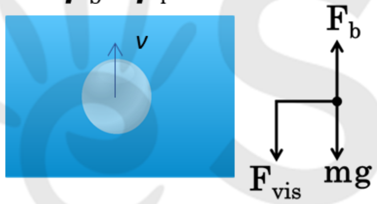
$\rho_b > \rho_f$



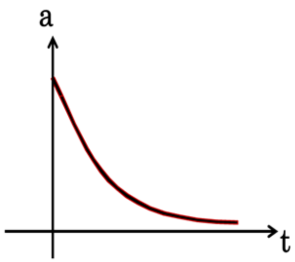

$V_T = \frac{2}{9}\frac{(\rho_b - \rho_f)r^2 g}{\eta}$




$\rho_b < \rho_f$




$V_T = \frac{2}{9}\frac{(\rho_f - \rho_b)r^2 g}{\eta}$



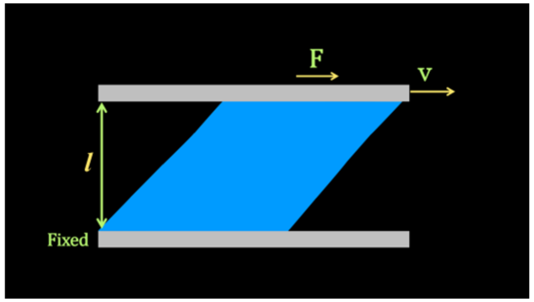

**Reynolds Number ($R_e$)**

$$R_e = \frac{\rho v d}{\eta}$$

| | |
|---|---|
| If $R_e < 1000$ | Flow is steady |
| If $1000 < R_e < 2000$ | Flow is unstable |
| If $R_e > 2000$ | Flow is turbulent |

Largest velocity till which flow is steady is called Critical Velocity.


Viscosity exists when there is relative motion between layers of the liquid.




$F = \eta A\left(\frac{v}{\ell}\right) \longrightarrow$ Velocity gradient

$\eta \downarrow$ Coefficient of viscosity

SI unit of η is Poiseuille (Pl)

CGS unit is Poise

1 Poise = 0.1 Poiseuille

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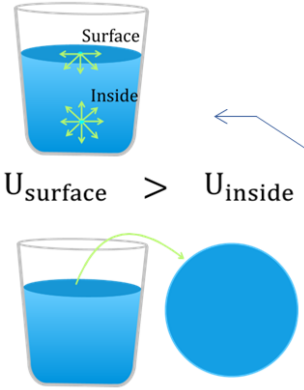
## Fluid Mechanics

### Surface Tension

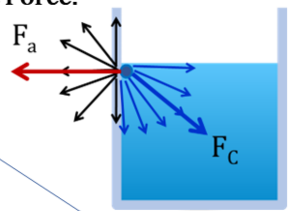
#### Surface tension




$U_{surface} > U_{inside}$

Surface Tension (S) $= \dfrac{\text{Force}}{\text{Length}} = \dfrac{F}{L}$

Force between different types of molecules is called Adhesive Force.



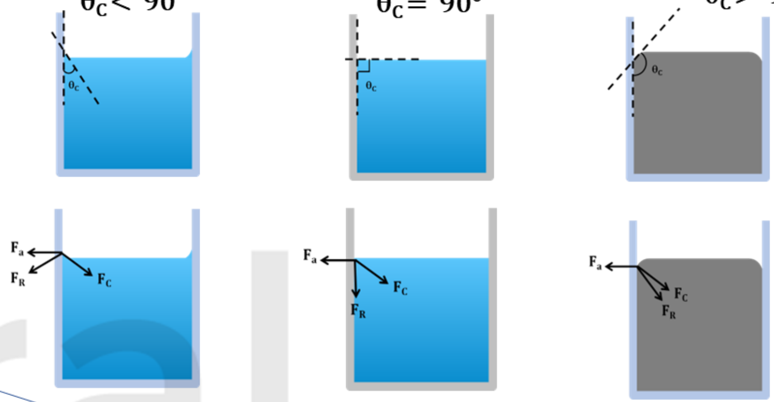

Force between same types of molecules is called Cohesive Force.

#### Contact Angle (θc)

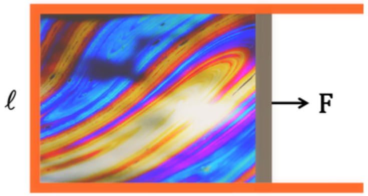
Glass Vessel – Water $\theta_C < 90°$

Silver Vessel – Water $\theta_C = 90°$

Glass Vessel – Mercury $\theta_C > 90°$



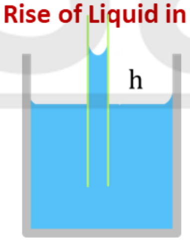

#### Surface Energy




Surface Energy = Surface Tension × Surface Area

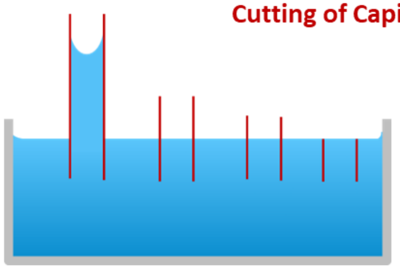
$$U = S \times (\ell d) \times 2$$

#### Rise of Liquid in Capillary Tube




$$h = \frac{2S}{\rho g R} = \frac{2S}{\rho g r}\cos\theta_C$$

#### Cutting of Capillary Tube



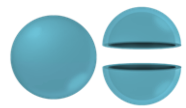
$$h = \frac{2S}{\rho g R} = \frac{2S}{\rho g r}\cos\theta_C$$

#### Excess Pressure

Inside a Drop in Air

$\dfrac{2S}{R}$

Thin Soap Bubble in Air



$\dfrac{4S}{R}$

Air Bubble in Water


$\dfrac{2S}{R}$