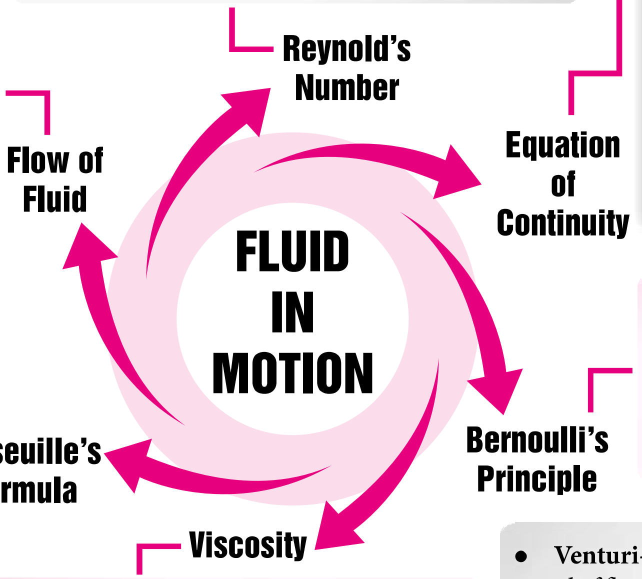
BRAIN MAP

CLASS XI

FLUID IN MOTION



Flow of Fluid

- **Streamline flow :** The flow in which path taken by a fluid particle under a steady flow is a streamline in direction of the fluid velocity at that point.
- **Laminar flow :** The liquid is flowing with a steady flow and moves in the form of layers of different velocities and do not mix with each other, is called laminar flow.
- **Turbulent flow :** The flow in which velocity is greater than its critical velocity and the motion of particles becomes irregular is called turbulent flow.
- **Critical velocity :** The velocity of liquid flow upto which the flow is streamlined and above which it becomes turbulent is called critical velocity.
- In compressible flow, the density of fluid varies from point to point, whereas in incompressible flow, the density of the fluid remains constant throughout. Liquids are generally incompressible while gases are compressible.
- Rotational flow is the flow in which the fluid particles while flowing along path-lines also rotate about their own axis. In irrotational flow, particles do not rotate about their axis.

Reynold's Number

- Reynold's number $= \dfrac{\text{Inertial force per unit area}}{\text{Viscous force per unit area}}$

or $N_R = \dfrac{v\rho d}{\eta}$

Where v = velocity of liquid, ρ = density of liquid, d = diameter of tube, η = coefficient of viscosity of liquid.

▸ On the basis of Reynold's number, we have,

$0 < N_R < 2000 \rightarrow$ streamline flow.

$2000 < N_R < 3000 \rightarrow$ streamline to turbulent flow.

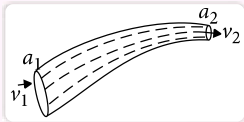
$3000 < N_R \rightarrow$ purely turbulent flow.

Equation of Continuity

- According to conservation of mass, mass of liquid entering per second at wider end = mass of liquid leaving per second at narrower end

$a_1 v_1 \rho_1 = a_2 v_2 \rho_2$

$a_1 v_1 = a_2 v_2$

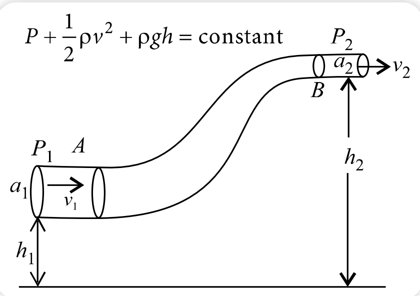


(If liquid is incompressible, $\rho_1 = \rho_2 = \rho$)

or av = constant

Bernoulli's Principle

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



- It states that for a steady flow of an incompressible and non-viscous liquid the sum of the pressure (P), kinetic energy per unit volume (K) and potential energy per unit volume (U) remains constant throughout the flow.

Poiseuille's Formula

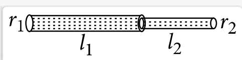
- The rate of volume of fluid coming out of a narrow tube is

$$\frac{V}{t} = \frac{\pi P r^4}{8\eta l}$$

where P = pressure difference, l = length of tube, r = radius of cross-section of the tube.

▸ Liquid resistance, $R = \dfrac{8\eta l}{\pi r^4}$

▸ Series combination of tubes ($V_1 = V_2$)

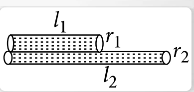


$$\frac{V}{t} = \frac{P}{\left[\dfrac{8\eta l_1}{\pi r_1^4} + \dfrac{8\eta l_2}{\pi r_2^4}\right]}$$

Here, $P = P_1 + P_2$

P_1 and P_2 are the pressure difference across the first and second tubes.

▸ Parallel combination of tubes ($P_1 = P_2$)

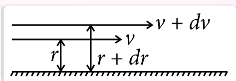


Here, $V = V_1 + V_2$

$$\frac{V}{t} = P\left[\frac{\pi r_1^4}{8\eta l_1} + \frac{\pi r_2^4}{8\eta l_2}\right]$$

Viscosity

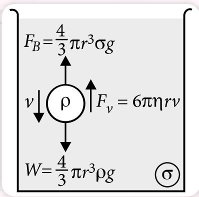
- The property of fluid due to which it opposes the relative motion between its different layers in a steady flow is called viscosity.



▸ Tangential force between the layers, $F = -\eta A(dv/dr)$, where η = a constant called coefficient of viscosity.

▸ SI unit of η is = N s m^{-2} or Poiseuille (Pl), Dimensions of $[\eta] = [ML^{-1}T^{-1}]$

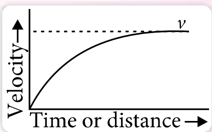
- **Stokes' law :** The viscous drag opposing the motion is $F_v = 6\pi\eta r v$



▸ Terminal velocity : $v = (2/9)[r^2(\rho - \sigma)g/\eta]$

where ρ = density of sphere, σ = density of fluid medium, r = radius of sphere.

- The variation of velocity with time (or distance)



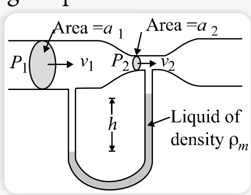
Venturi-meter and Torricelli's law

- **Venturi-meter :** It is a device to measure the speed of flow of incompressible fluid.

▸ Volume of the fluid flowing out per second

$$Q = a_1 v_1 = a_1 a_2 \sqrt{\frac{2h\rho_m g}{\rho(a_1^2 - a_2^2)}}$$

▸ $v_1 = \sqrt{\dfrac{2h\rho_m g}{\rho} \times \dfrac{a_2^2}{a_1^2 - a_2^2}}$



- **Torricelli's law :**

▸ If the container is open at the top to the atmosphere then speed of efflux $v_1 = \sqrt{2gh}$.

▸ Horizontal range, $R = v_1 \times t$

$$= \sqrt{2gh} \times \sqrt{\frac{2(H-h)}{g}} = 2\sqrt{h(H-h)}$$

R will be maximum if $h = \dfrac{H}{2}$, i.e., $R_{max} = H$

▸ In general as shown in figure, speed of outflow,

$$v_1 = \sqrt{2gh + \frac{2(P - P_a)}{\rho}}$$