CHAPTER 6
FLUID DYNAMICS

* With increase in temperature:
  In Gases → Viscocity Increase
  In Liquid → Viscosity Decrease

* VISCOUS DRAG

Force exerted by fluid on an object while moving through a fluid

Viscous Drag depends on:

1. Size, orientation, shape
2. Velocity
3. Co-efficient of Viscosity

* IDEAL FLUID

A fluid is ideal if it is:

1. Non-viscous $\eta = 0$
2. Incompressible $V =$ constant

As $\rho = \frac{m}{V}$ So $\rho =$ constant

* STOCKE'S THEOREM

For spherical objects moving with small speed

$F_d = 6\pi\eta r v$

* TERMINAL VELOCITY

Maximum uniform velocity at which viscous drag become equal to weight of the body

* Viscous Drag depends on
  - a. Terminal velocity
  - b. Maximum Velocity
  - c. Average Velocity
  - ✓d. Instantaneous velocity

* Maximum value of drag force is equal to weight of the body

$$V_t = \frac{2\rho g r^2}{9\eta}$$

If ρ = same

$$V_t \propto r^2$$

* 8 rain drops combine to form a bigger one. If each rain drop has $V_t = 4 m/s$ what will be V_t' of bigger drop.

Shortcut :

$$r' = n^{1/3} r$$

where n : number of drops

So Ans :

$$r' = (2^3)^{1/3} r$$

$$r' = 2r$$

Finding Terminal Velocity Of Final Drop:

$$V_t' = n^{2/3} V_t$$

Ans:

$$V_t' = (2^3)^{2/3} (4)$$
$$= 4 \times 4$$
$$V_t' = 8 ms^{-1}$$

* Terminal Velocity is constant and maximum (when a body attains terminal velocity, no further increase in velocity takes place)

* According to Stoke's Law, drag force depends on instantaneous velocity
(The drag force increases as the speed of the object increases)

FLUID FLOW

Two Types : 1. Streamline Flow
2. Turbulent Flow

In a streamlined flow, the velocity of the liquid in contact with the containing vessel is minimum.

A body placed in streamline fluid experience greater viscous drag than the body placed in turbulent fluid.

The speed at which streamline flow converts into turbulent is known as critical speed.

EQUATION OF CONTINUITY

→ Hydrodynamical equation

" For steady flow the mass flow into the volume must be equal to the mass flow rate out"

i) Volume of Fluid through A_1

$$\Delta V_1 = S_1 \times A_1$$

ii) $\Delta V = Av\,\Delta t$

iii) $A_1 v_1 = A_2 v_2$ (v : velocity)

iv) $Av = \frac{\Delta V}{\Delta t} = \text{constant}$

v) $\frac{\Delta m}{\Delta t} = \rho \frac{\Delta V}{\Delta t}$

* Speed of fluid through any pipe is inversely proportional to cross-sectional area of pipe

$$v \propto \frac{1}{A}$$

vi) $d_1^2 v_1 = d_2^2 v_2$ vii) $r_1^2 v_1 = r_2^2 v_2$

Equation of continuity is based on law of conservation of mass
Bernoulli's Equation ~~of~~ is based on law of conservation of energy

* Water comes out from faucet. As the water moves down its volume decreases bcz due to gravity its ~~a~~ velocity increases.

BERNOULLI'S EQUATION

* The relationship between the pressure, flow speed and height for flow of an ideal fluid is called Bernoulli's Equation

* Statement: " With a horizontal flow of fluid, points of greater fluid speed will have less pressure than points of slower fluid speed"

* The pressure energy decrease with increase in velocity. This is in accordance with law of conservation of energy. As can be seen from Bernoulli's equation that in the absence of external work / heat transfer and friction; the sum of pressure energy, K.E and P.E remains constant. Assuming that P.E is not in picture

(no change in height) we see that the pressure energy will decrease bcz of increase in K·E and vice versa.

* The sum of pressure, K·E per unit volume, P·E per unit volume remains constant

$$P + \frac{K \cdot E}{Volume} + \frac{P \cdot E}{Volume} = constant$$

$$P + \frac{\frac{1}{2}mv^2}{volume} + \frac{mgh}{V} = constant$$

$$P + \frac{1}{2}\left(\frac{m}{V}\right)v^2 + \left(\frac{m}{V}\right)gh = constant$$

$$P + \frac{1}{2}\rho v^2 + \rho gh = constant$$

* $P + \frac{1}{2}\rho v^2 + \rho gh = k$, the dimention of P/k are Same as:

Ans: Angle

* According to Bernoulli's equation

$$Pressure \propto \frac{1}{Speed}$$

This pressure is basically the pressure applied on walls of container

JETS AND NOZZLES

Jet → High speed fluid coming out of a narrow opening
Nozzle → A device providing jet.

AEROFOIL

Above aerofoil : v → increase
Below aerofoil : v → constant
Upward Force

SPEED OF EFFLUX (TORICELLI'S THEOREM)

* Relates the speed of fluid flowing out of an orifice to the height of fluid above the opening.

* Statement:
"The speed of efflux, v, of a fluid through a sharp edged hole at the bottom of a tank filled to a depth h is the same as the speed that the body (fluid) would acquire in falling freely from a height 'h' $v = \sqrt{2gh}$ "