Mechanical Properties Of Fluids

- **Pressure:** Average pressure (P_{av}) is normal force (F) acting per unit area (A)

  $P_{av} = \frac{F}{A}$ (Scalar quantity)

- **Pascal's law :** Pressure exerted at any point on a liquid in a container is transmitted undiminished in all directions.
- Applications of Pascal's law
  - Hydraulic brakes
  - Hydraulic lift

- **Effect of gravity on pressure** $\rightarrow P = P_a + h\rho g$.

  Here,

  $P \rightarrow$ Absolute pressure at any depth h of a liquid

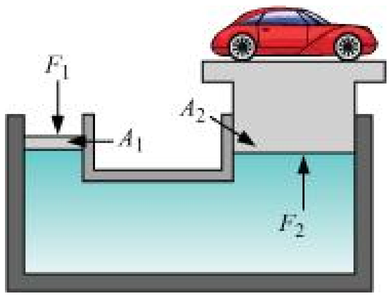
  $P_a \rightarrow$ Atmospheric pressure

  $\rho \rightarrow$ Density of the liquid

- The liquid pressure at a point in a liquid depends upon the depth of the point below the liquid surface. This is known as hydrostatic paradox.

- **Hydraulic system** $\rightarrow$ It works on Pascal's Law, according to which, ratio of force exerted to area will be same at all cross-sections.

  $\therefore \frac{F_1}{A_1} = \frac{F_2}{A_2}$



- Therefore, a large force is experienced in the larger cross-section if a smaller force is applied in the smaller cross-section.

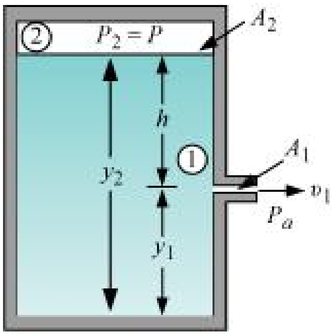
- **Stream-lined flow** → An orderly flow of liquid in which tangents at any point give the direction of flow is called streamlined flow.
- **Equation of continuity** → *av* = Constant

Where,

a = Area of cross-section

v = Velocity of flow

- **Bernoulli's theorem** → $P+\frac{1}{2}\rho v^2+\rho gh=\text{Constant}$
- **Torricelli's law** → Speed of efflux $fluidoutflow$ from an open tank is given by a formula identical to that of a freely falling body.



$v_1=\sqrt{2gh}$

- **Magnus effect** →When a ball is given a spin in a streamline of air molecules, it will follow a curved path forming a convex towards the greater pressure side.

- **Viscosity** → The viscous force directly depends on the area of the layer and the velocity gradient.

$$F = -\eta A \frac{dv}{dx}$$

Where, η refers to coefficient of viscosity

- **Stoke's formula** → $F = 6\pi\eta r v$,

Where,

r → Radius of the ball

v → Terminal velocity attained by the ball

- **Critical velocity** → Maximum velocity of flow up to which a liquid can have streamlined flow in a tube

$$v_c = \frac{R_e \eta}{\rho r}$$

Where, R_e is Reynolds's number

  - If $R_e < 1000$, then the flow is streamline.
  - If $R_e > 2000$, then the flow is turbulent.
  - If $1000 < R_e < 2000$, then the flow is unstable.

- **Surface tension :** Surface tension is the force acting per unit length on either side of an imaginary line on the water surface.

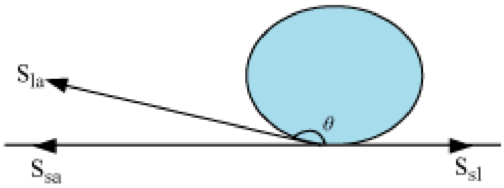
$$S = \frac{F}{l}; \text{ unit is } N/m$$

- Surface tension decreases the surface area to minimum.
- **Surface energy :** Change in surface energy is the product of surface tension and change in surface area under constant temperature.
  - To increase the surface area of liquid, work is done against the force of surface tension.
  - The work done is stored in a form of potential energy in liquid surface film.

- Potential energy per unit area is called the surface energy of the surface film.

Angle of Contact

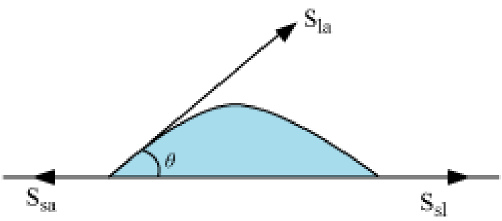
- The angle between the tangent to the liquid surface at the point of contact and the solid surface inside the liquid is called the angle of contact.
  - **Case I**



$Waterandoilysurfaceinterface$

$$Cos\theta = \frac{S_{sa} - S_{sl}}{S_{la}}$$

  - If $S_{sa} < S_{sl}$, then the angle of contact is obtuse and the molecules of the liquid are strongly attracted to themselves and weakly attracted to those of the solid.
  - A lot of energy is used in creating the liquid–solid interface.
  - **Case II**



$Waterandglasssurfaceinterface$

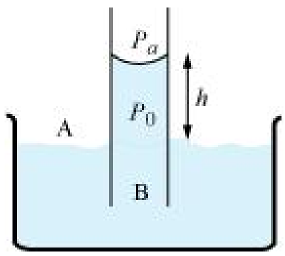
  - If $S_{sa} > S_{sl}$, then the angle of contact is acute and the molecules of the liquid are strongly attached to those of the solid.
  - Not enough energy is required to create the liquid–solid interface.

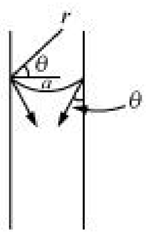
Excess Pressure

- For a curved surface in equilibrium, the concave side will have more pressure than the convex side.
- Excess pressure inside a liquid drop $= \frac{2S}{R}$

- Excess pressure inside a soap bubble $= \frac{4S}{R}$

Capillary Rise





$$h = \frac{2S\cos\theta}{a\rho g}$$

Effect of Impurities on Surface Tension of Liquid

- When a liquid consists of soluble impurities, the surface tension of the liquid increases.
- When a sparingly soluble impurity like phenol is dissolved in water, the surface tension decreases.

Effect of Temperature on Surface Tension of Liquid

- The surface tension of liquid decreases with increase in the temperature of the liquid.