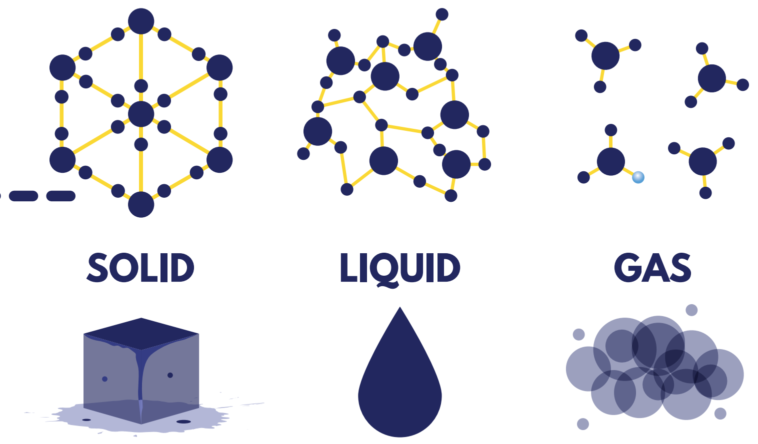
MECHANICAL PROPERTIES OF FLUIDS

INTRODUCTION

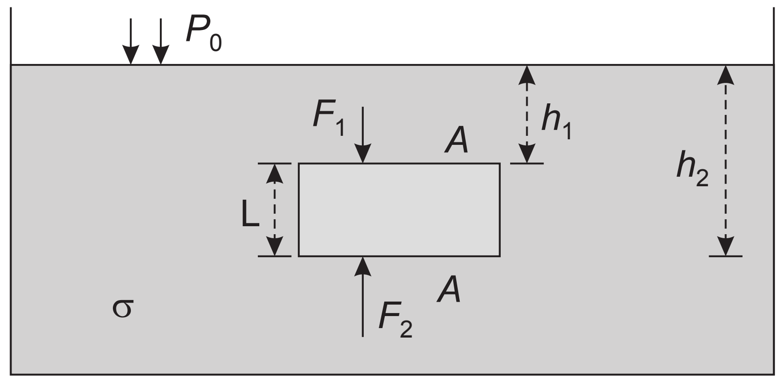
Anything which can flow like liquid & Gases known as fluids.



Pressure

$P = \frac{F_{\perp}}{A}$

Force acting per unit Area.



Gauge Pressure

Exass Pressure over the atmospheric pressure (Po - P_{atm} measured with instrument.

$P_{gauge} = P - P_0 = \rho gh$

Atmospheric Pressure

Force exerted by atmospheric column on unit area at mean sea level.

(P_0 = 1.013 × 10^5 N/m²)

Hydraulic Paradax

Water is filled to a height H behind a dam of width w. The resultant pressure on dam will be –

$P_{net} = \rho gH$

Archimedes Principle

"Whenever a body is immersed inside a liquid then an up thrust forces states acting on it, whose magnitude is equal to the weight of the liquid displaced".

Upthrust Force – $|F_B|$
= (ρ_e × g × Vd) = weight of liquid displaced.

ρ_l = density of liquid.

g = gravity : Vd = volume of liquid displaced.

Law of Floating

$\frac{\rho_b}{\rho_l} = \frac{V_s}{V}$

V = volume of body

V_s = volume of submerged part.

ρ_b = density of body.

ρ_e = density of liquid.

Case – I $[V_s < V \rightarrow \rho_b < \rho_l]$

Case – 2 $[V_s = V \rightarrow \rho_b = \rho_l]$

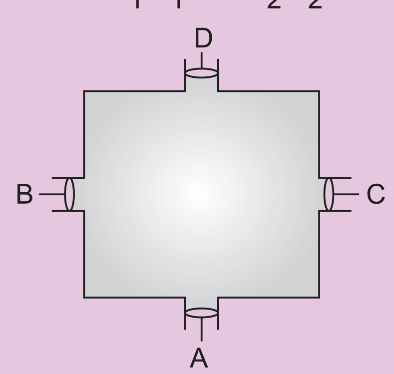
Case – 3 $[V_s > V \rightarrow \rho_b > \rho_l]$

Pascal Law

Whenever external pressure is applied on any part of fluid contained in a vessel. It is transmitted undiminished and equally in all direction is known as Pascal law.

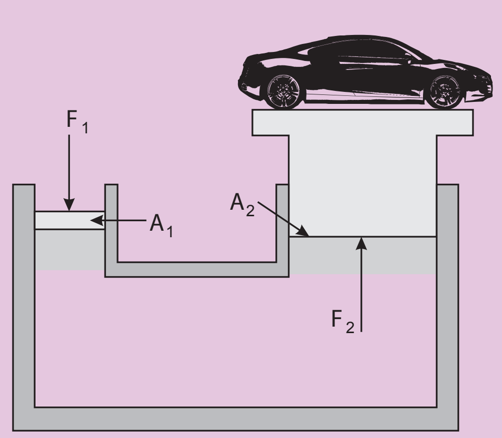
Hydraulic Brakes

$A_1d_1 = A_2d_2$



Hydraulic lift

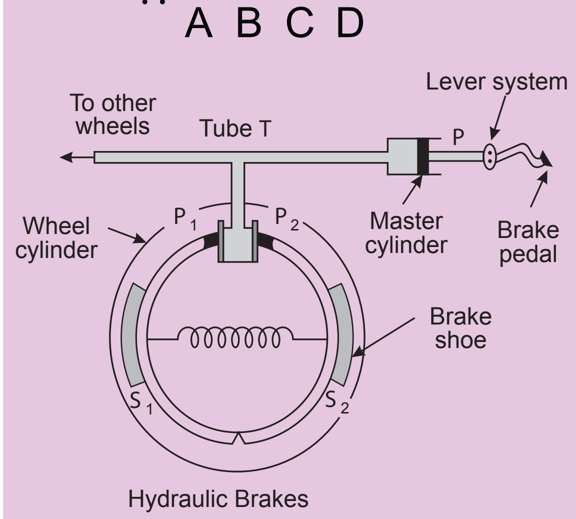
$P_1 = \frac{F_1}{A_1} = P_2 = \frac{F_2}{A_2}$, $\therefore F_2 = \frac{F_1A_2}{A_1}$



Hydraulic Machine

$P_A = P_B = P_C = P_D$

$\therefore \frac{F_A}{A} \frac{F_B}{B} \frac{F_C}{C} \frac{F_D}{D}$



HYDRODYNAMICS

Equation of Continuity

$A_1V_1 = A_2V_2$

Characteristics of Ideal Fluids

Incompressible

- Non – viscous
- Irrotational
- Steady (Liminas)

Bernoulli Theorem

$P + \rho gh + \rho V^2 = \text{Constant}$

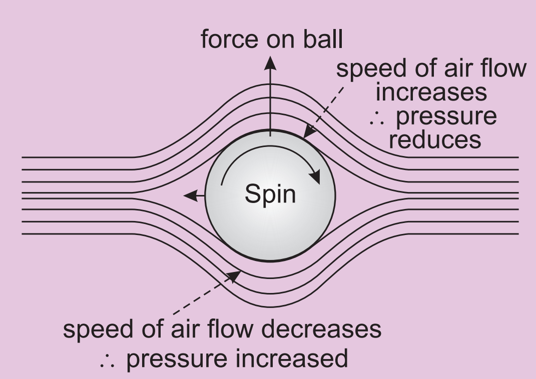
P = Pressure; V = Volume

ρ = density ; h = height

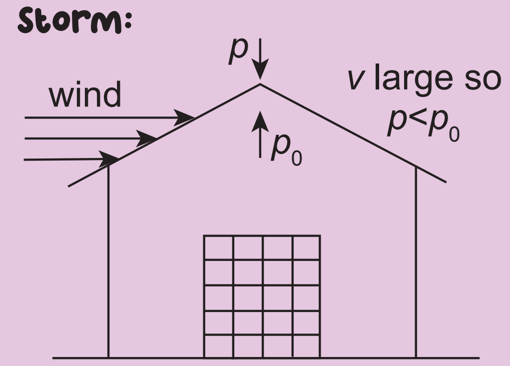
g = gravity

Applications

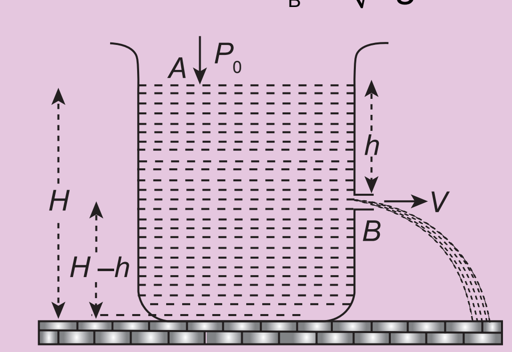
Magnus Effect:



Blowing off of thin Roof in Storm:



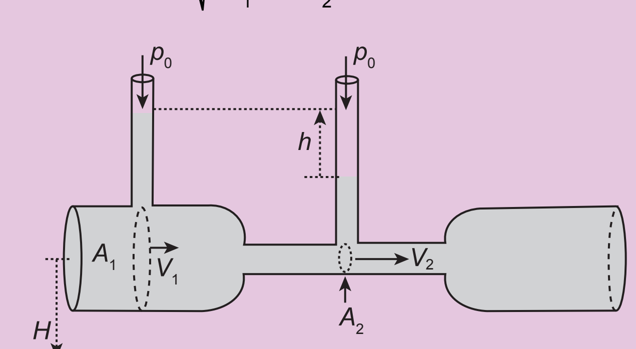
Speed of Efflux: $V_B = \sqrt{2gH}$



H = Height from the Top

Venturi meter: The entering velocity of fluids is given by

$V_1 = A_2\sqrt{\frac{2gh}{A_1^2 - A_2^2}}$

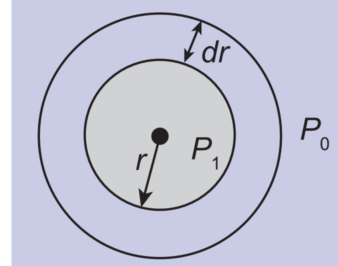
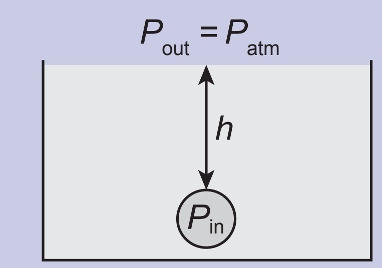
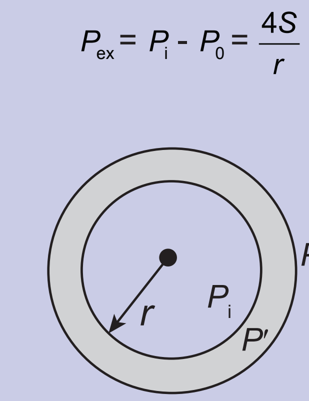


SURFACE TANSION

Surface energy

Additional potential energy exhibited by liquid molecules present at the surface of the molecules.

Excess Pressure inside a Curved Liquid Surface

Excess pressure inside the drop	Excess pressure inside a cavity or air bubble in liquid	Excess pressure inside a soap bubble
$P_{ex} = (P_i + P_0)\frac{2S}{r}$	$P_{ex} = \frac{2S}{r} + \rho gh$ $P_{inside} = P_{atm} + \frac{2S}{r} + \rho gh$ $P_{out} = P_{atm}$	$P_{ex} = P_i - P_0 = \frac{4S}{r}$
		

Cohesive Force and Adhesive Force

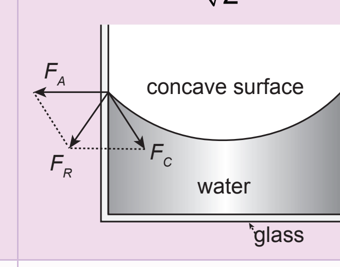
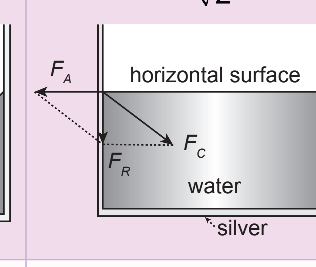
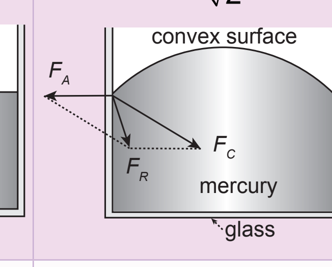
Cohesive Force:– Attractive force between the molecules of same materials.

Adhesive Force:– A Hr active force between the molecules of different materials.

ANGLE OF CONTACT

Shape of Meniscus

Angle between tangent plane at the liquid surface and tangent plane at point of contact of solid.

Relation between cohesive and adhesive force	$F_A > \frac{F_C}{\sqrt{2}}$ 	$F_A = \frac{F_C}{\sqrt{2}}$ 	$F_A < \frac{F_C}{\sqrt{2}}$ 
Angle of contact	θ < 90° (Acute angle)	θ = 90° (Right angle)	θ > 90° (Obtuse angle)
Shape of meniscus	Concave	Plane	Convex
Wetting property	Liquid wets the solid surface	Liquid does not wet the solid surface	Liquid does not wet the solid surface
Level of Liquid	Liquid rises up	Liquid neither rises nor falls	Liquid does not wet the solid surface
Example	Glass-Water	Silver-Water	Glass-Mercury

Capillarity

It is property due to which liquid elevates & depressed in a capillary Tube. The Rise in height of liquid in capillary tube is given by – $h = \frac{25\, Cos\theta}{r\rho g}$

VISCOSITY

Newton's Law of Viscosity:–

Viscous force→ $F = \eta A \frac{dv}{dx}$

A = Area

Velocity Gradient= $\frac{dv}{dx}$

Stoke's Law:–

When a small sphere of radius r is moving with velocity v through a homogeneous fluid. Then viscous force acting on sphere – $F_v = 6\pi\eta rv$:

where → η = Coefficient of viscosity: Unit of η = Poise.

Terminal Velocity

Constant velocity achieved before net force on a body becomes zero.

Reynold Number

It tell us about the nature of fluid flow $Re = \frac{\rho Vd}{\eta}$

where ρ = density: V = velocity: d = pipe parameter.

Critical Speed:– Maximum value of speed for which fluid will remain laminar. $[VC = R_e\eta/\rho d]$