MASTERJEE CLASSES

BRAIN MAP

CLASS XI

MECHANICAL PROPERTIES OF SOLIDS AND FLUIDS

PROPERTIES OF SOLIDS

HOOKE'S LAW

Stress $\propto$ Strain

or Stress = $E \times$ Strain,

(E = modulus of elasticity)

Young's modulus

$$Y = \frac{\text{Normal stress}}{\text{Longitudinal strain}}$$

Bulk modulus,

$$B = \frac{\text{Normal stress}}{\text{Volumetric strain}}$$

Compressibility, $k = 1/B$

Modulus of rigidity

$$G = \frac{\text{Shearing stress}}{\text{Shearing strain}}$$

Poisson's ratio

$$\sigma = \frac{\text{Lateral strain}}{\text{Longitudinal strain}}$$

RELATION BETWEEN Y, B, G AND σ

- $Y = 3B(1 - 2\sigma)$
- $Y = 2G(1 + \sigma)$
- $\sigma = \frac{3B - 2G}{2G + 6B}$
- $\frac{9}{Y} = \frac{1}{B} + \frac{3}{G}$

ELASTIC POTENTIAL ENERGY

$$U = \frac{1}{2} F \times \Delta L = \frac{1}{2} \times \text{stress} \times \text{strain} \times \text{volume}$$

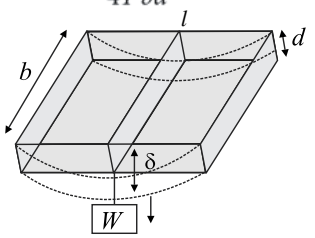
P.E. stored per unit volume of stretched wire,

$$u = \frac{1}{2} \times \text{stress} \times \text{strain} = \frac{1}{2} \times Y \times (\text{strain})^2$$

APPLICATION OF ELASTICITY

Designing beams for bridges

The depression in rectangular beam, $\delta = \frac{Wl^3}{4Y\,bd^3}$



STRESS AND STRAIN

- Stress = $\frac{\text{Restoring force}}{\text{Area}} = \frac{F}{A}$
- Strain = $\frac{\text{Change in configuration}}{\text{Original configuration}}$

ELASTICITY AND PLASTICITY

Elasticity : Ability of a body to regain its original shape, on removing deforming force.

Plasticity : The inability of a body to regain its original size and shape on the removal of the deforming forces.

PROPERTIES OF FLUIDS

VISCOSITY

Coefficient of viscosity:

$\eta = \frac{F}{A\left(-\frac{dv}{dx}\right)}$ where $-\frac{dv}{dx}$ is the velocity gradient between two layers of liquid.

SURFACE TENSION

Surface tension: The property by which the free surface of liquid at rest tends to have minimum surface area.

Surface energy: Work done against the force of surface tension in forming the liquid surface.

FLUIDS IN MOTION

BERNOULLI'S THEOREM

Bernoulli's theorem : For the streamline flow of an ideal liquid, the total energy per unit volume remains constant

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

Basic results on viscosity

Stoke's law : Backward dragging force on a spherical body, $F = 6\pi\eta rv$.

Poiseuille's formula

$$Q = \frac{\pi}{8}\frac{Pr^4}{\eta l}$$

Reynold's number : Determines nature of fluid flow $R = \frac{\rho v d}{\eta}$

FLUIDS AT REST

PRESSURE

Pascal's law

The pressure is same at all points inside the liquid lying at the same depth in a horizontal plane.

Gauge pressure = $P - P_0 = h\rho g$.

ARCHIMEDE'S PRINCIPLE

When a body is immersed fully or partly in a liquid at rest, it loses some of its weight, which is equal to the weight of the liquid displaced by the immersed part of the body.

Apparent weight = $mg\left(1 - \frac{\rho'}{\rho}\right)$

(For fully immersed body)

CAPILLARITY

The phenomenon of rise or fall of liquid in a capillary tube is called capillarity.

Height of the liquid within capillary tube

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

Where, θ = angle of contact, ρ = density of liquid, a = radius of tube

Excess Pressure

In an air bubble

$$\Delta P = \frac{2S}{R}$$

Inside a soap bubble

$$\Delta P = \frac{4S}{R}$$

Inside a liquid drop

$$\Delta P = \frac{2S}{R}$$