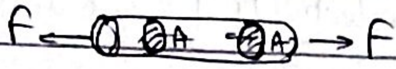
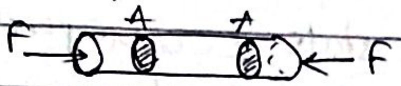
Stress : $\boxed{\sigma = \frac{F_R}{A}}$ unit : N/m^2

Longitudinal stress

a) Tensile stress

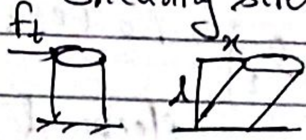


b) Compressive stress



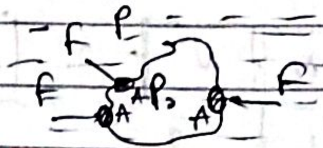
$$\boxed{\sigma = \frac{F}{A}}$$

Shearing stress



$$\boxed{\sigma = \frac{F_t}{A}}$$

Volume stress

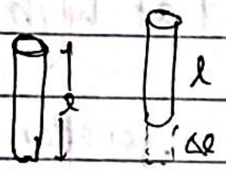


$$\boxed{\sigma = \frac{F}{A} = \Delta P}$$

$$\boxed{\Delta P = P - P_o}$$

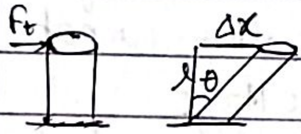
Strain : $\boxed{E = \frac{\text{Change in Dimension}}{\text{Original Dimension}}}$: Unitless

Longitudinal strain



$$\boxed{E = \frac{\Delta l}{l}}$$

Shear strain



$$\boxed{E = \frac{\Delta x}{l}}$$

$$\boxed{\tan\theta = \frac{\Delta x}{l} = \theta}$$

Volume strain

$$\boxed{E = -\frac{\Delta V}{V}}$$

Hook's Law : Within Elastic limit, stress $\propto$ strain

stress = E strain

$\boxed{E = \frac{\text{stress}}{\text{strain}}}$ N/m^2 E → Modulus of Elasticity

i) Young's Modulus of Elasticity (Y)

$$Y = \frac{\text{longitudinal stress}}{\text{longitudinal strain}} = \frac{F}{A} \times \frac{l}{\Delta l}$$

$$\boxed{Y = \frac{F\,l}{A\,\Delta l}}$$

ii) Bulk Modulus of Elasticity (k):

$$k = \frac{\text{Volume stress}}{\text{Volume strain}} = \frac{f}{A} \times \left(-\frac{V}{\Delta V}\right) = \frac{-PV}{\Delta V}$$

$$\boxed{k = \frac{-PV}{\Delta V}}$$

Volume increase ↑ ⇒ Pressure ↓

Gases has two Bulk Moduli

a) Isothermal Bulk Modulus (K_{iso}) — $\boxed{K_{iso} = P}$

b) Adiabatic Bulk Modulus (K_{adi}) — $\boxed{K_{adi} = \gamma P}$

$\gamma = \frac{C_P}{C_V}$ as $C_P > C_V$ $\therefore \gamma > 1$

$$\boxed{\therefore K_{adi} > K_{iso}}$$

- **Compressibility**:- Reciporal of Bulk Modulus

$$C = \frac{1}{K} = \frac{-\Delta V}{PV}$$

$$\boxed{\therefore C = \frac{-\Delta V}{PV}}$$

→ least for gases

→ maximum for solids.

iii) Shear Modulus of Elasticity / Modulus of Rigidity.

$$G = \frac{\text{Shear stress}}{\text{Shear strain}} = \frac{f}{A} \times \frac{l}{\Delta x} = \frac{f}{A\theta}$$

$$\boxed{G = \frac{f}{A\theta} = \frac{f l}{A \Delta x}}$$

* Elastic Energy

i) Elastic potential Energy of stretched wire.

$$U = \frac{1}{2} \times \text{stretching force} \times \text{extension in the wire}$$

$$U = \frac{1}{2} \times F \times l = \frac{1}{2} \times \left(\frac{F}{A}\right) \times \left(\frac{l}{L}\right) \times AL$$

$$\boxed{U = \frac{1}{2} \times \text{stress} \times \text{strain} \times \text{Volume}}$$

Specific Heat capacity → [0, ∞)

$$\boxed{c = \frac{Q}{m\Delta T}}$$

→ at const. volume $c_v = \frac{Q}{m\Delta T}$

→ at const pressure $c_p = \frac{Q}{m\Delta T}$

work done path function

$$\boxed{W = \int_{V_i}^{V_f} P\,dV}$$

Molar specific Heat capacity

$$\boxed{C = \frac{Q}{n\Delta T}}$$

→ at const. volume $C_v = \frac{Q}{n\Delta T}$

→ at const. pressure $C_p = \frac{Q}{n\Delta T}$

$n \rightarrow$ moles.

Relationship

$\boxed{C_v = Mc_v}$ $\boxed{C_p = Mc_p}$

M ↓ molar mass

$C_p - C_v = R$

$\boxed{C_v = \frac{f}{2}R}$ $\boxed{C_p = R\left(1 + \frac{f}{2}\right)}$

$\boxed{\gamma = \frac{C_p}{C_v}}$ $\boxed{\gamma = 1 + \frac{2}{f}}$

$\gamma_m > \gamma_d > \gamma_p$

$1.66 > 1.4 > 1.33$

$5/3 > 7/5 > 4/3$

① In adiabatic process, P T & V are releated as.

1) $\boxed{TV^{(\gamma-1)} = \text{constant}}$

2). $\boxed{PV^{\gamma} = \text{constant}}$

First Law of Thermodynamics:

$$\boxed{\Delta Q = \Delta U + W}$$

Work Done:

$$dW = PdV = P(V_f - V_i)$$

$\boxed{PV = nRT}$

WORK DONE DIFFERENT PROCESS:

① Adiabiatic Process:

$$\boxed{W_{ad} = \frac{nR(T_f - T_i)}{(1-\gamma)} = \frac{P_fV_f - P_iV_i}{(1-\gamma)}}$$

② Isothermal Process:

$$\boxed{PV = \text{Constant}}$$

$$\boxed{W_{iso} = nRT\log_e\left(\frac{V_2}{V_1}\right)} \boxed{= 2.303\,nRT\log_{10}\left(\frac{V_2}{V_1}\right)}$$

$$\boxed{W_{iso} = nRT\log_e\left(\frac{P_1}{P_2}\right)}$$

$$\boxed{W_{iso} = 2.303\,nRT\log_{10}\left(\frac{P_1}{P_2}\right)}$$

Increase in Internal Energy:

i) Melting process, $\Delta U = mL$

2) Boiling process, $\Delta U = mL - (V_2 - V_1)$

Cyclic Process, $\boxed{Q = W}$

Amount of heat given to the system	$\rightarrow$	(+)
Work done on the system	$\rightarrow$	−ve
Work done By the system	$\rightarrow$	+ve
Heat given by the system	$\rightarrow$	−ve

1 cal = 4.2 J

$1 J = 10^7$ erg

$1 L = 10^3$ cc

* $\boxed{1 cc = 10^{-6} m^3}$ * $\boxed{1 cm^3 = 10^{-6} m^3}$ * $\boxed{Q = mL}$

Q → Heat, m → mass

* Internal Energy depends on Temperature.

* Volume ↑ ⇒ W → +ve & Volume ↓ ⇒ Work. D ⇒ −ve

* A gas perform most work, when it expands isobarically

In adiabiatic : $\boxed{P^{1-\gamma} \cdot T^{\gamma} = \text{constant.}}$

Fraction of given heat energy utilised in doing external work :

$$\boxed{\frac{\Delta W}{\Delta Q} = \left(1 - \frac{1}{\gamma}\right) = 1 - \frac{C_v}{C_p}}$$

Trick

$$T V^{\gamma - 1} = \text{const}$$

$$P V^{\gamma} = \text{const}$$

$$P^{1-\gamma} T^{\gamma} = \text{const} \text{ or } P \propto T^{\frac{\gamma}{\gamma - 1}}$$

Magnetism

① Magnetic field due to iron core in toroid:

$$B = \mu_0 (H + I)$$

$$B = \mu_0 H + \mu_0 I$$

$$B = B_0 + B_M$$

$$B = \mu_0 \mu_r H$$

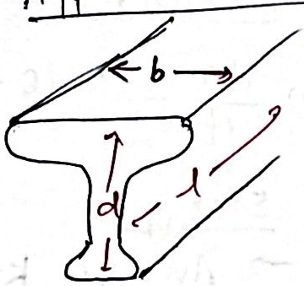
$$\boxed{B = \mu_m H}$$

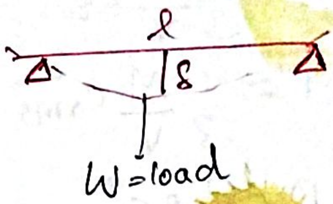
Relative permeability:

$$\boxed{\mu_r = \frac{\mu_m}{\mu_0}} = \frac{\mu_0 (1 + \chi)}{\mu_0}$$

$$\boxed{\mu_r = 1 + \chi}$$

Application of Elasticity



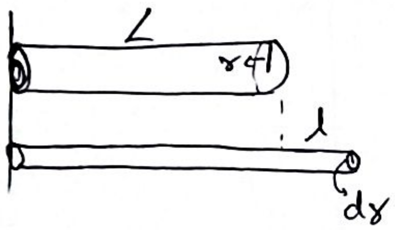


$$\boxed{\delta = \frac{W l^3}{4 b d^3 Y}}$$

ii) Elastic Potential Energy per unit Volume.

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

Poisson's Ratio (σ) :



i) Longitudinal strain $\alpha = \frac{l}{L}$

ii) Lateral strain $\beta = \frac{-dr}{r}$

$$\sigma = \frac{\text{lateral strain } (\beta)}{\text{longitudinal strain } (\alpha)} = \frac{-dr/r}{l/L} = -\frac{dr}{r} \times \frac{L}{l}$$

Theoretical $\sigma \longrightarrow -1$ & 0.5 But,

practically $\sigma \longrightarrow 0$ & 0.5

Thermal stresses & Thermal strain

stress $= \frac{F}{A}$

$F = A(\text{stress})$

$\boxed{F = A\, Y \alpha \Delta T}$

$\boxed{\Delta l = l \alpha \Delta T}$

Thermal strain $= \frac{\Delta l}{l}$

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

$$\text{Thermal stress} = Y(\text{strain})$$
$$= Y \frac{\Delta l}{l}$$
$$= Y \frac{(\cancel{l} \alpha \Delta T)}{\cancel{l}}$$

$\boxed{\text{Thermal stress} = Y \alpha \Delta T}$