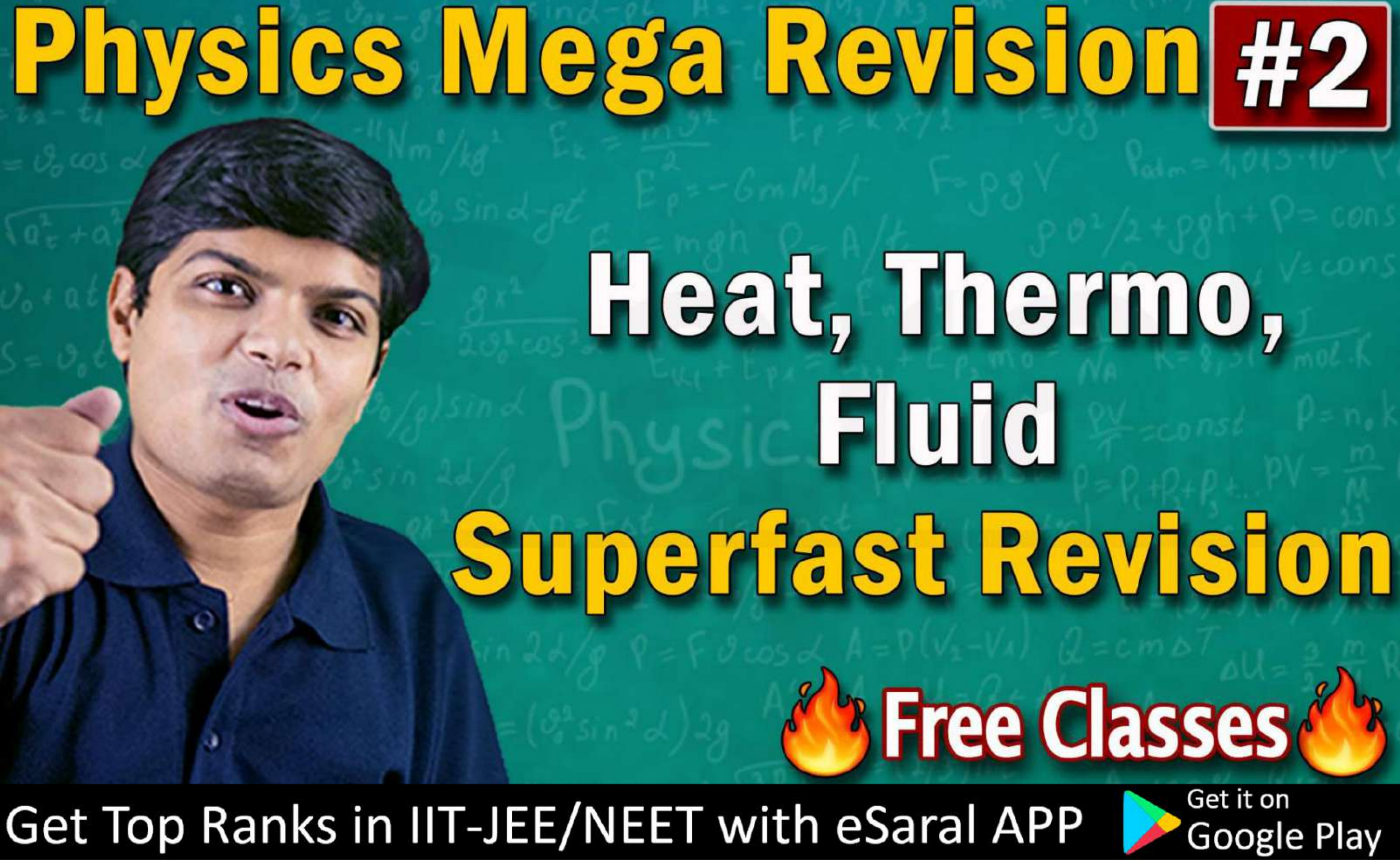
Physics Mega Revision
#2
Heat, Thermo, Fluid
Superfast Revision
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Complete Physics Mega Revision Timetable

15 Feb
Electrostatics
Current electricity
Capacitor
🎁 Surprise Gift 🎁

16 Feb
Calorimetry
Elasticity
Thermal Expansion
Heat Transfer
KTG
Thermodynamics
Fluid Mechanics

17 Feb
Magnetic effect of current
Manetism and matter
Emi
AC

18 Feb
UD
Vector
Kinematics 1D
Kinematics 2D
NLM
Friction
Circular motion
Work power energy
COM
Rotation motion

19 Feb
Ray optics
Optical Instruments
Wave optics
EM Waves
Errors in measurement

20 Feb
Gravitation
SHM
Wave on string
Sound wave

21 Feb
Dual nature of radiation
X-rays
Nuclear physics
Radioactivity
Semi conductor
Communication system

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PHYSICS WAHI jo Deewana BANA DE

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किस्से

Calorimetry

Superfast Revision

Calorie

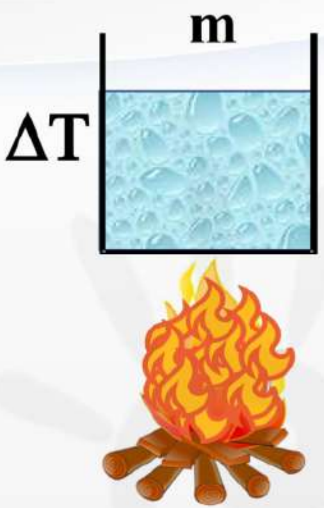
1 calorie is the amount of heat required to the raise the temperature of 1 gm of water from 14.5°C to 15.5°C at 1 atm pressure.

1 Calorie = 4.18 J

Zeroth Law of Thermodynamics

If bodies 'A' & 'B' are in thermal equilibrium with each other & bodies 'B' & 'C' are in thermal equilibrium with each other then bodies 'A' & 'C' must be in thermal equilibrium with each other.

If two bodies are in thermal equilibrium with each other then their temperature is same.



$$\Delta Q = ms\Delta T$$

↓

Specific Heat Capacity

Heat Capacity

Heat capacity $(C) = m \times s$

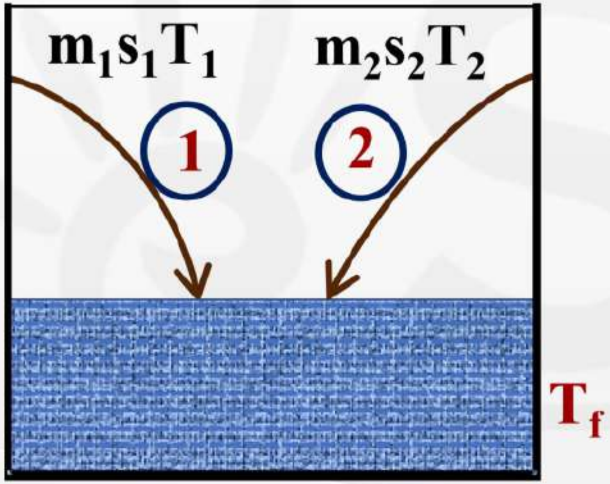
$$\Delta Q = C\Delta T$$

Molar Heat Capacity

Heat required to raise the temperature of 1 mole of substance by 1°C.

In an Isolated System

$T_2 > T_1$



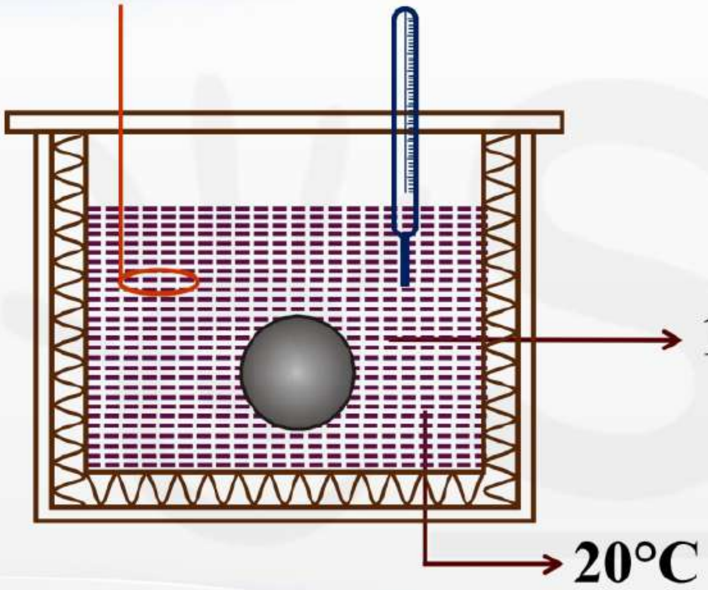
M-1 : Heat gain = Heat loss

$$m_1 s_1 (T_f - T_1) = m_2 s_2 (T_2 - T_f)$$

M-2 : Σ Heat gain = 0

$$m_1 s_1 (T_f - T_1) + m_2 s_2 (T_f - T_2) = 0$$

Calorimeter



Principle of Calorimetry

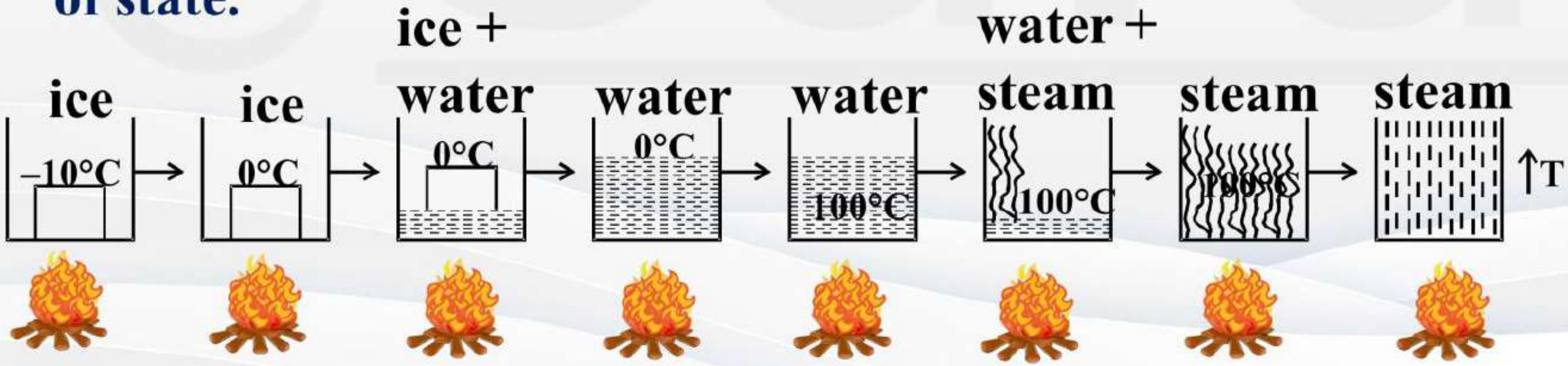
This is based on energy conservation principle

What is specific heat capacity of iron?

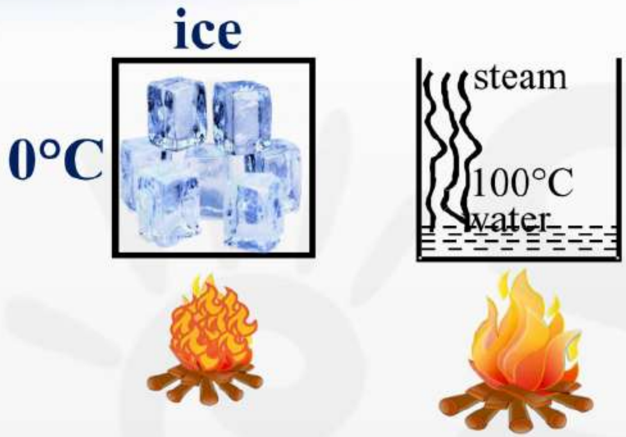
$$m_w s_w\ (T_f - 20) + m_c s_c\ (T_f - 20) = m_i s_i\ (100 - T_f)$$

Change of State

- **During the change of state temperature of substance do not change on supplying the heat.**
- **Both solid & liquid state (or liquid & vapor state) of the substance co-exist at thermal equilibrium during the change of state.**



Latent Heat

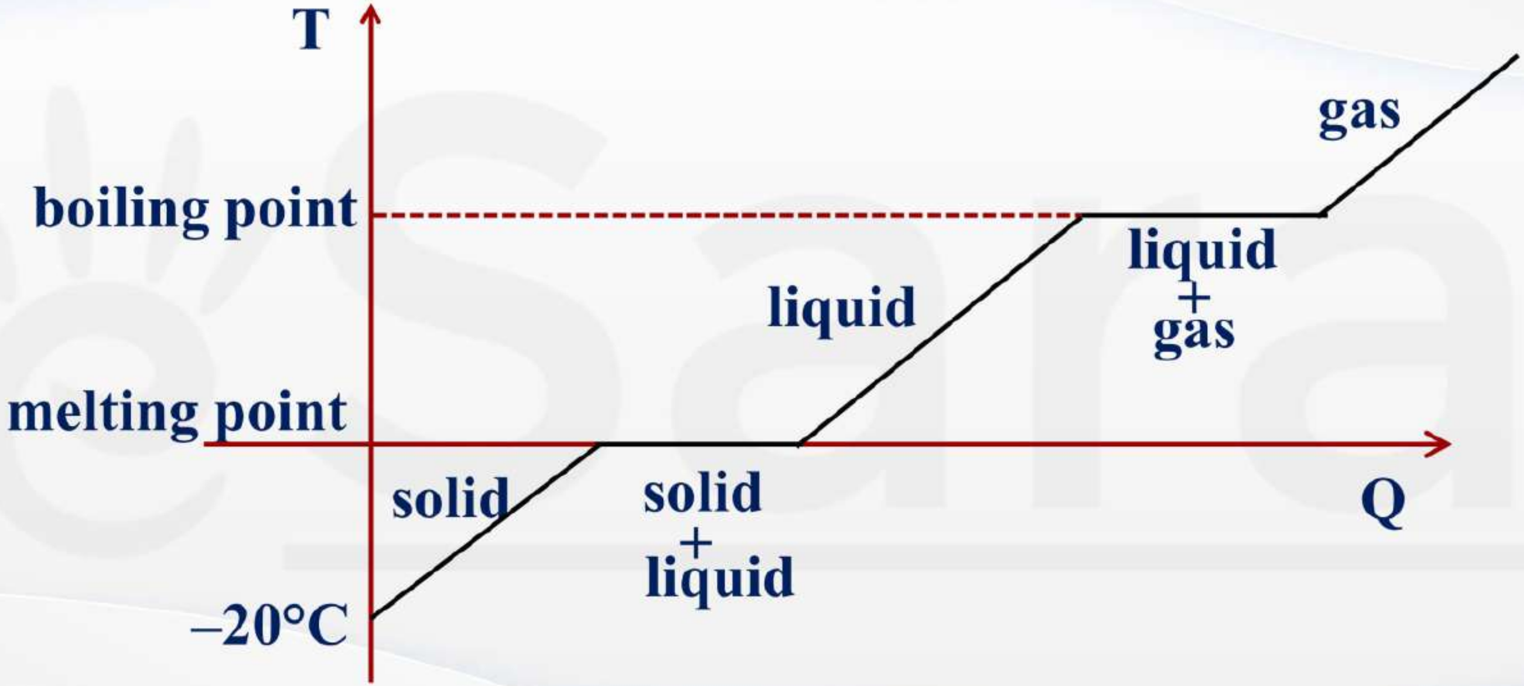


$\Delta Q = mL$ → Latent Heat

Latent heat of fusion for ice = 80 cal/g

Latent heat of vaporization for water = 540 cal/g

Graph Between T v/s Heat Supplied



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- **ARR-46**, RPMT
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- Biology faculty at Rao Academy, Kota
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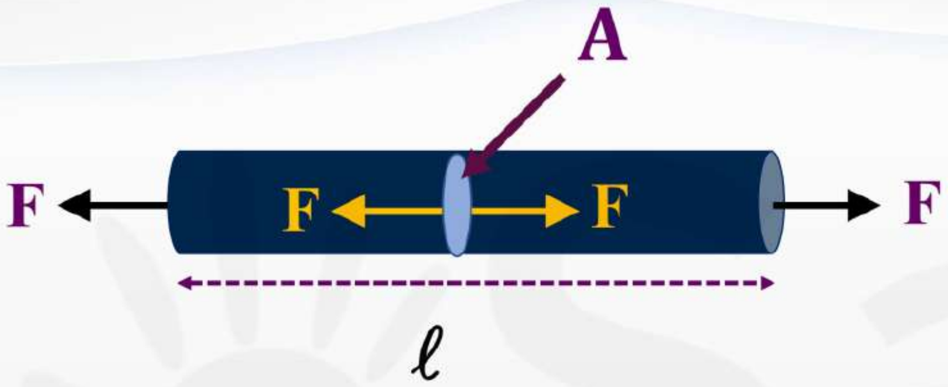
- **Mentored** over thousands of doctors

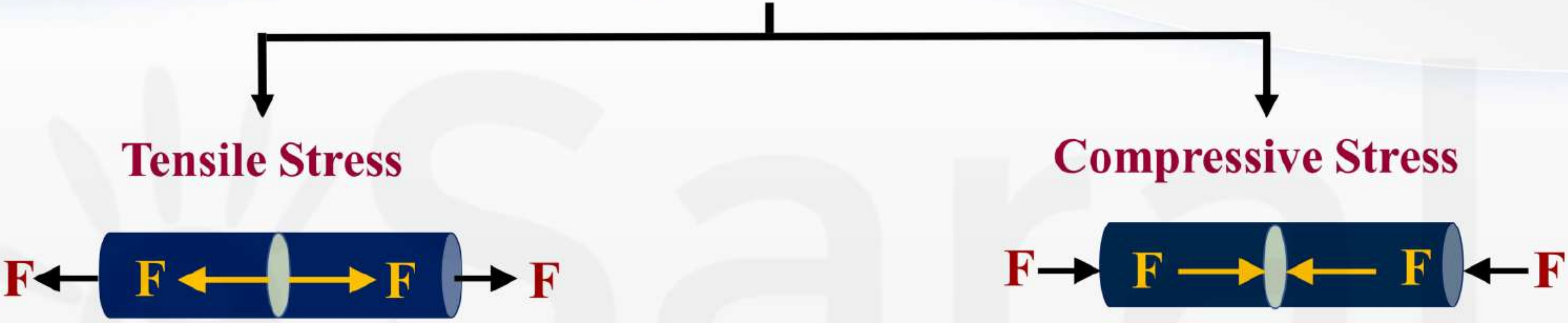
Elasticity

Superfast Revision



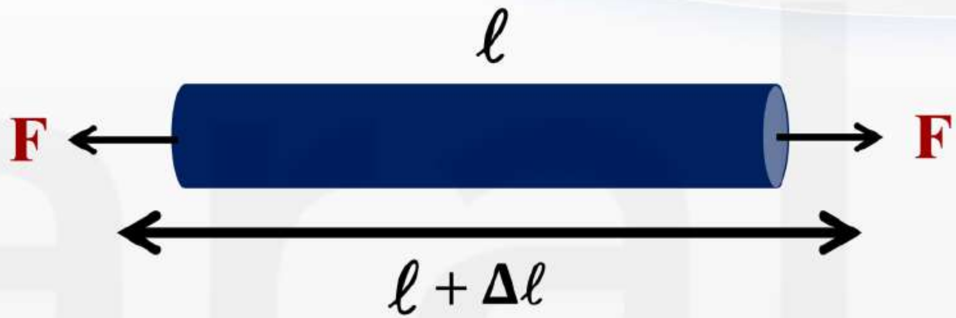
$$\text{Stress} = \frac{\text{Restoring force}}{\text{Area of cross section}} = \frac{F}{A}$$

Longitudinal Stress



Strain

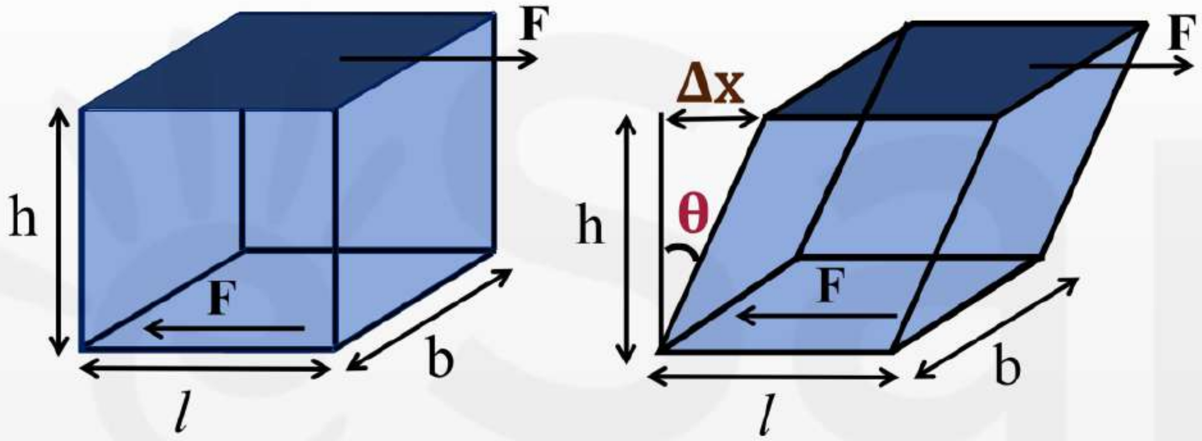
Associated with each type of stress there is a corresponding type of strain.



Longitudinal Strain $= \dfrac{\Delta\ell}{\ell}$

Unitless and dimensionless quantity.

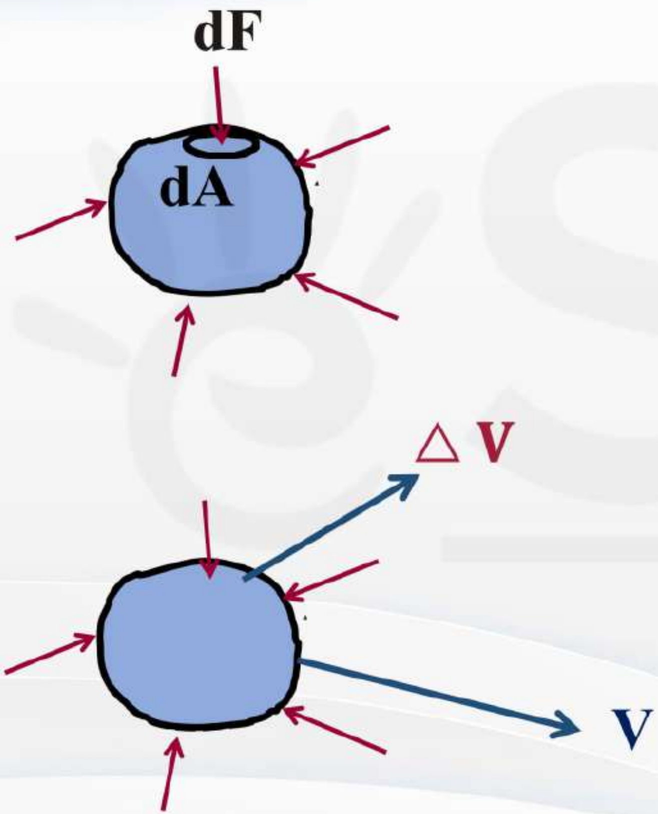
Tangential or Shear Stress & Strain



$$\text{Shear Stress} = \frac{F}{\text{Area}} = \frac{F}{l \times b}$$

$$\text{Shear Strain} = \frac{\Delta x}{h} = \tan\theta \approx \theta \text{ (for small } \theta\text{)}$$

Volumetric Stress & Strain



$$\text{Volumetric stress} = \frac{dF}{dA}$$

$$\text{Volumetric Strain} = \frac{\triangle V}{V}$$

Hooke's Law

For small deformation, Stress and Strain are proportional to each other

$$\text{stress} = k \text{ strain}$$

k → **Modulus of elasticity**

Hooke's Law

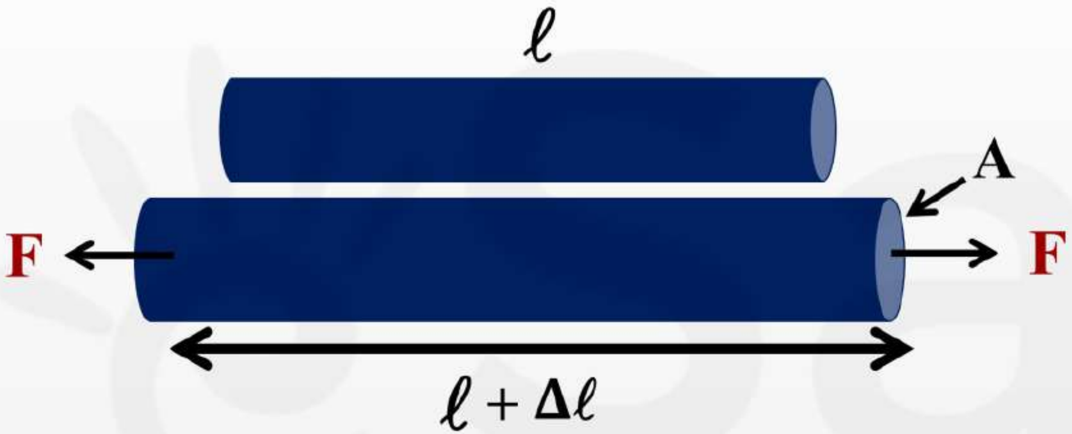
Longitudinal stress = Y (Longitudinal strain)

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

↓

Young's Modulus

Young's Modulus (Y)



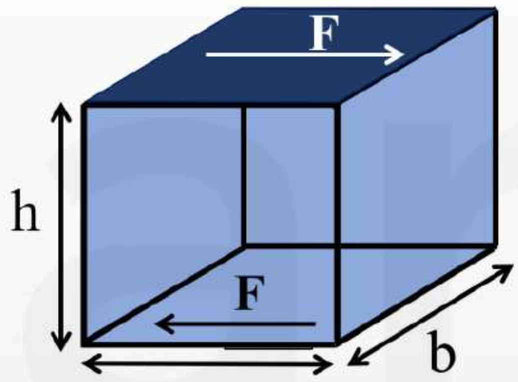
$$Y = \frac{\text{Longitudinal stress}}{\text{Longitudinal strain}}$$

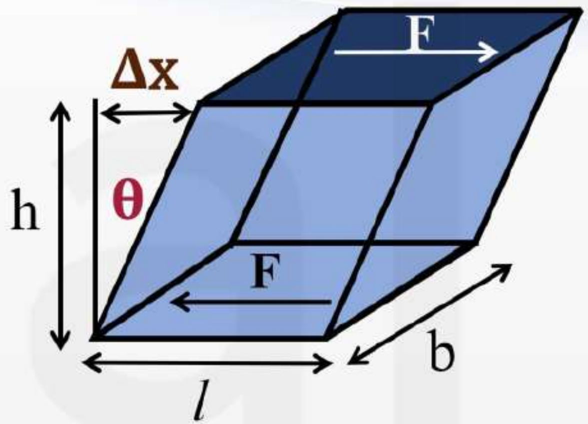
$$Y = \frac{F}{A}\frac{\ell}{\Delta\ell}$$

Shear Modulus / Modulus of rigidity / Torsional Modulus [G or η]

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

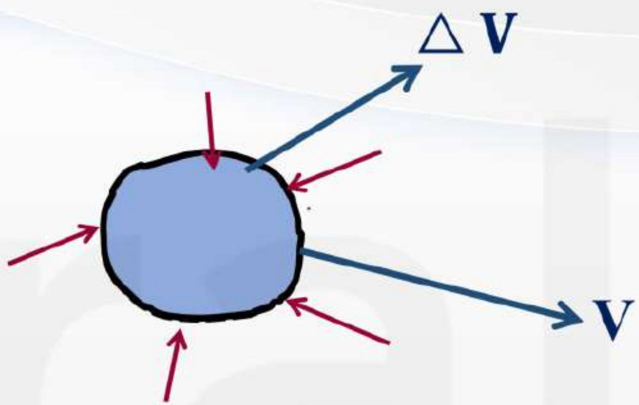
$$G = \frac{F}{A\frac{\Delta x}{h}} = \frac{F}{A\,\theta}$$





Bulk Modulus (B)

Volumetric stress = B (Volumetric strain)



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

$$B = -\frac{\Delta P}{\frac{\Delta V}{V}}$$

ΔP is excess (additional) pressure which caused ΔV.

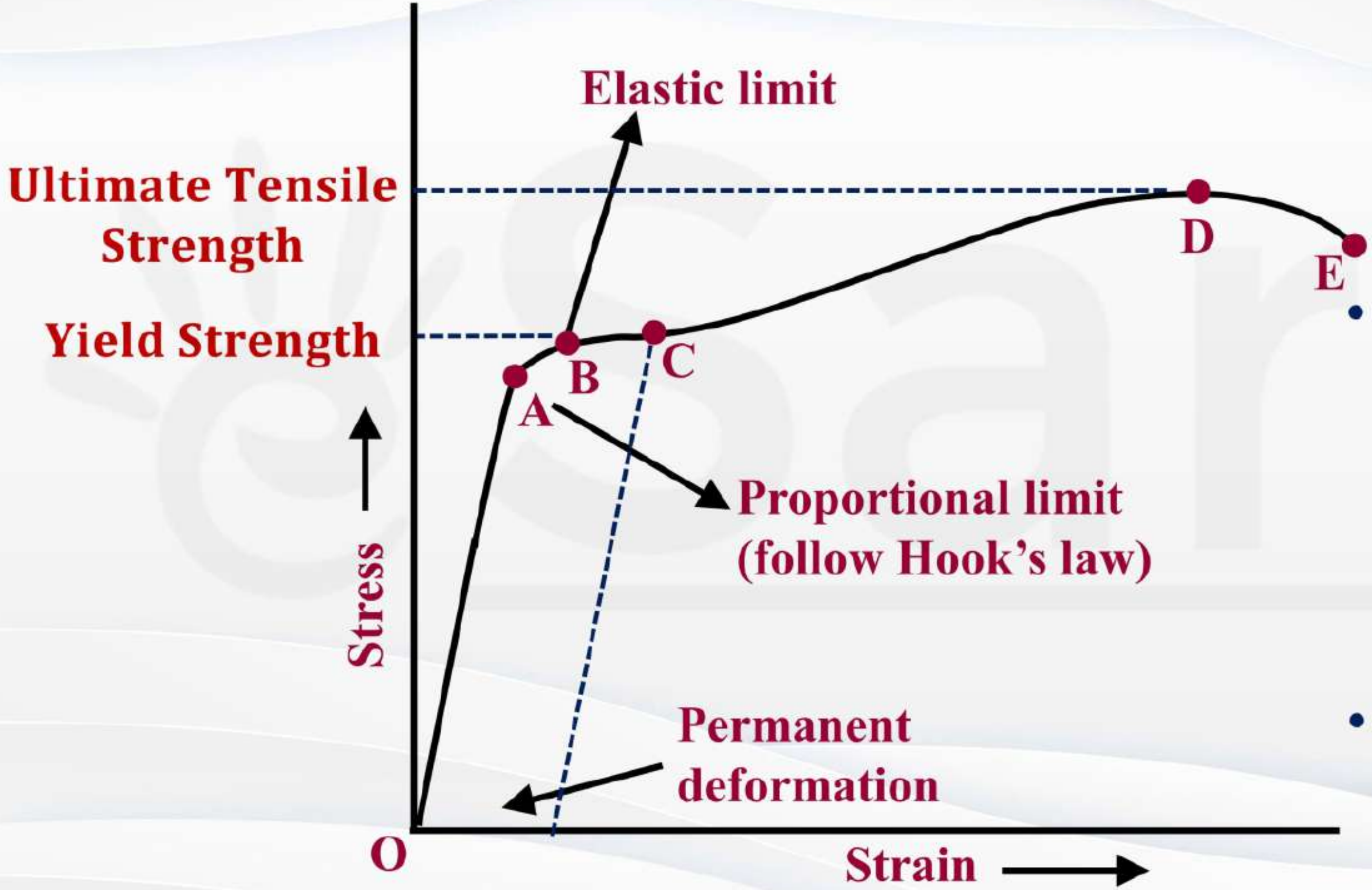
Poisson's Ratio (σ)

$$\sigma = -\frac{\Delta d/d}{\Delta \ell/\ell}$$

where d is a diameter of cross-section & ℓ is length

σ deals with corresponding change in diameter with change in length

Stress-Strain Curve



- If the ultimate strength and fracture points D and E are close then the material is said to be **Brittle.**
- If they are far apart then the material is said to be **Ductile.**

Breaking Stress

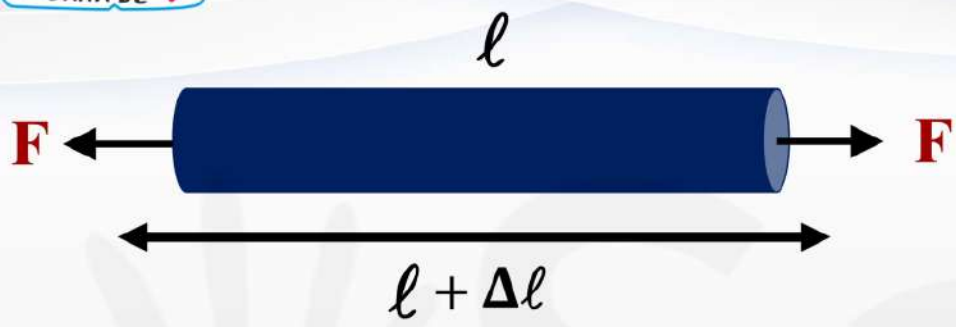
The stress at which material breaks is called **Breaking Stress**.

$$B.S. = \frac{\text{Force}}{\text{Area}}$$

↓

property of a material

Force that a material can bear $\propto$ Area of cross-section



$$U = \frac{1}{2}\frac{AY}{\ell}(\Delta\ell)^2$$

TRICK

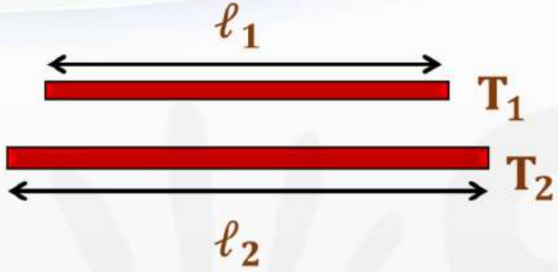
$$U = \frac{1}{2} \times \text{stress} \times \text{strain} \times \text{volume}$$

$$\text{Energy Density} = \frac{1}{2} \times \text{Stress} \times \text{Strain}$$

Lets Meditate !!

Thermal Expansion
Superfast Revision

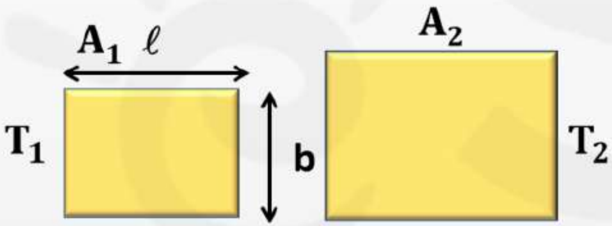
Coefficient of Linear Expansion (α)



$$\frac{\Delta\ell}{\ell_1} = \alpha\,\Delta T$$

$$\ell_2 = \ell_1[1 + \alpha\Delta T]$$

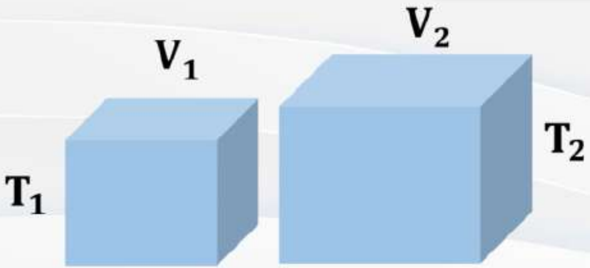
$$\ell_2 = \ell_1[1 + \alpha(T_2 - T_1)]$$



$$\frac{\Delta A}{A_1} = \beta\Delta T$$

$$A_2 = A_1(1 + \beta\Delta T\ )$$

Coefficient of Area Expansion (β)



$$\frac{\Delta V}{V_1} = \gamma\Delta T$$

$$V_2 = V_1(1 + \gamma\Delta T)$$

Coefficient of Volume Expansion (γ)

$$\frac{\Delta \ell}{\ell} = \alpha \Delta T \qquad \frac{\Delta A}{A} = \beta \Delta T \qquad \frac{\Delta V}{V} = \gamma \Delta T$$

[Unit of α, β, γ is $/°C$ or $°C^{-1}$ or $/K$ or K^{-1}]

Calculating Fractional Change or Percentage Change

$$Z = k\,A^x\,B^y \quad ...(1)$$

k → Constant

For small change

$$\frac{\Delta Z}{Z} = x\frac{\Delta A}{A} + y\frac{\Delta B}{B}$$

(%change in Z) = x (%change in A) + y (% change in B)

Time period of a Simple Pendulum

$$T = 2\pi\sqrt{\frac{\ell}{g}}$$

g is constant

$$\frac{\Delta T}{T} = \frac{1}{2}\frac{\Delta \ell}{\ell}$$

$$\frac{\Delta T}{T} = \frac{1}{2}\alpha\,\Delta\theta$$

$\Delta\theta$ → Temperature

$\frac{\Delta T}{T}$ is time lost or gain per second

Time lost or gain in a day

$$= \frac{\Delta T}{T} \times 24 \times 3600$$

When $\theta \uparrow$, $\ell \uparrow$, $T \uparrow$

clock will run slow & time will be lost.

$$T = 2\pi\sqrt{\frac{\ell}{g}}$$

When $\theta \downarrow$, $\ell \downarrow$, $T \downarrow$

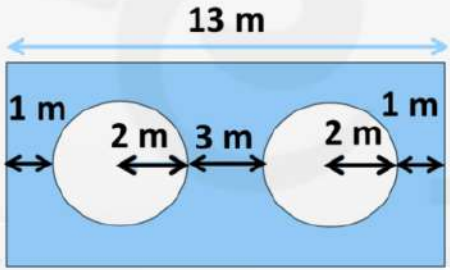
clock will run fast & time will be gained.

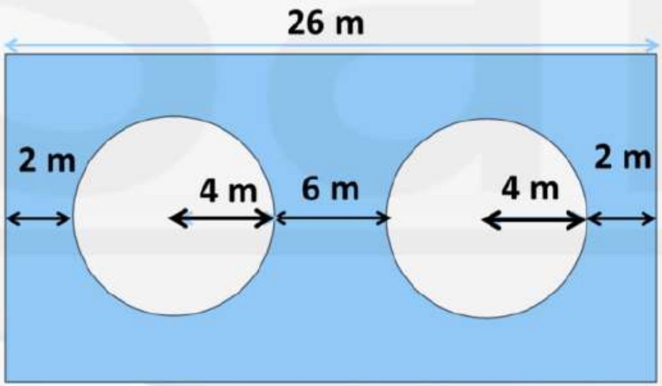
Isotropic Expansion

In this expansion, percentage change in linear dimension at any point and in any direction is same for same change in temperature.

This expansion is similar to uniform photographic enlargement.

Everything will Increase.





Relationship between α, β, & γ

For Isotropic Expansion

$$\beta = 2\alpha$$

$$\gamma = 3\alpha$$

For Anisotropic Expansion

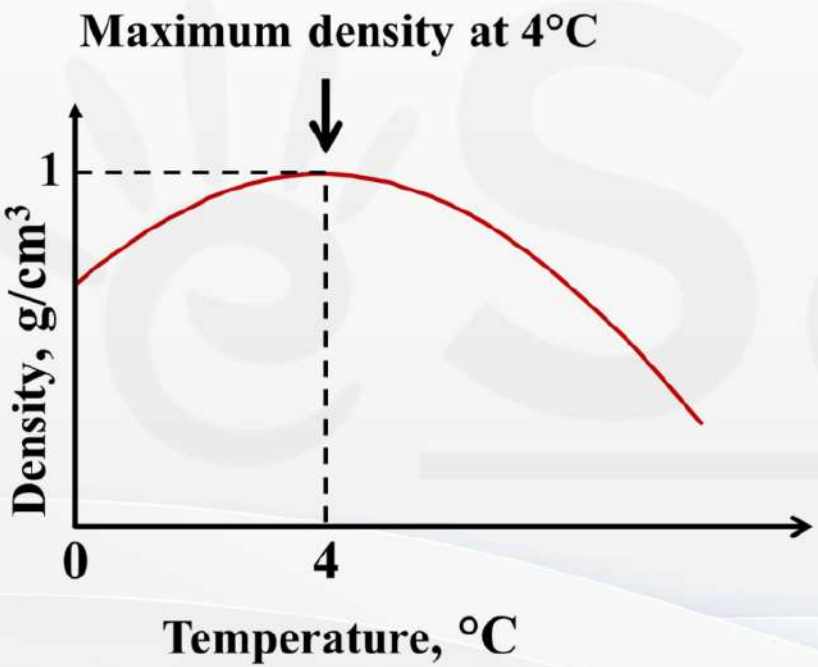
$$\beta = \alpha_{\ell} + \alpha_b$$

$$\gamma = \alpha_{\ell} + \alpha_b + \alpha_h$$

Variation of Density With Temperature

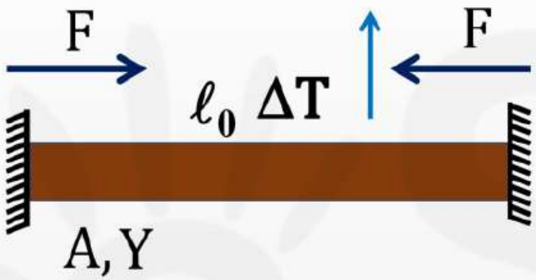
$$\rho = \frac{\rho_0}{1 + \gamma \Delta T} \approx \rho_0(1 - \gamma \Delta T)$$

Anomalous Expansion of Water



- If water at 0 °C is heated, it's volume decreases until the temperature reaches 4 °C.
- Above 4 °C water behaves normally and it's volume increases as temperature increases.

Thermal Stress



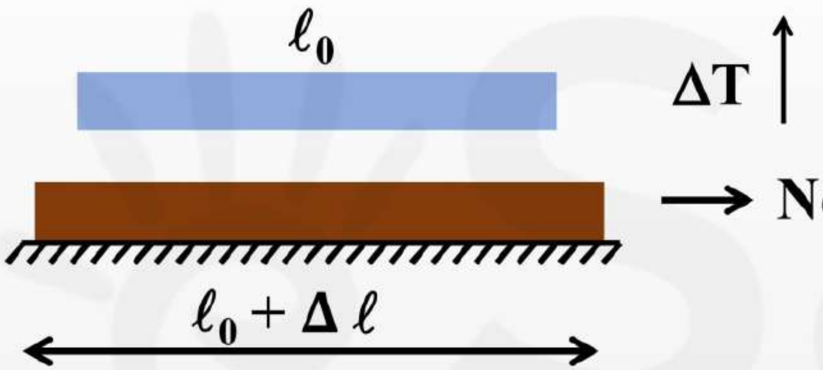
$$\Delta \ell = \ell_0 \alpha \Delta T$$

$$\text{Strain} = \frac{\Delta \ell}{\ell_0} = \alpha \Delta T$$

$$\text{Stress} = \frac{F}{A} = Y \alpha \Delta T$$

→ Thermal stress

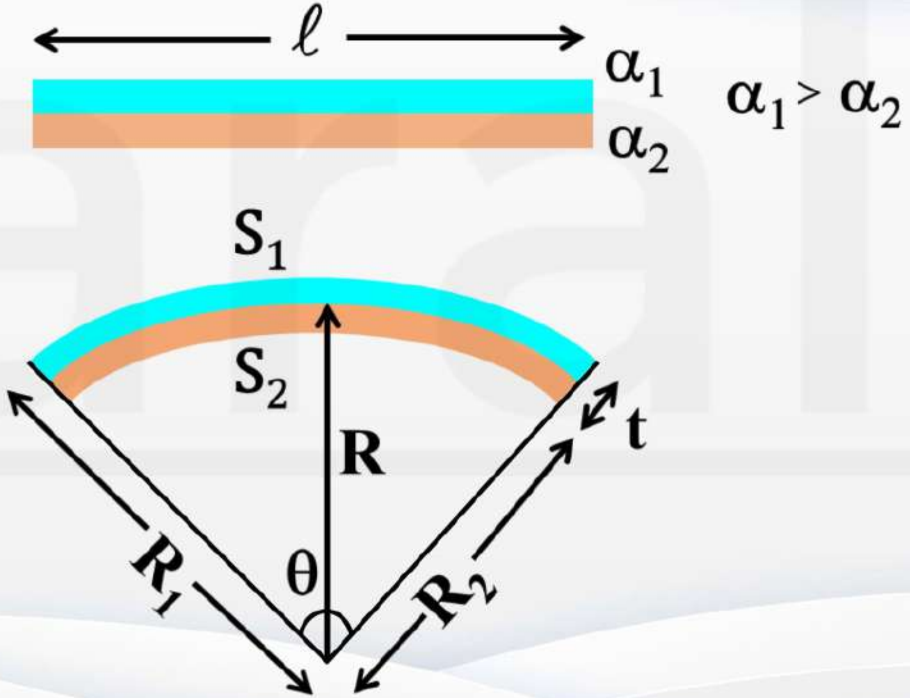
Thermal Stress



→ **No Strain**

Bimetallic Strip

A bimetallic strip is made from two thin strips of metal that have different coefficients of linear expansion.



$$R = \frac{t}{(\alpha_1 - \alpha_2)\Delta T}$$

Lets Meditate !!

Course Details

- Lectures
- Practice
  - Sheets
  - Prev. Yr.
- Tests
  - Topic-Wise
  - Review

- Study Plan
- Doubt Solving
- Mentorship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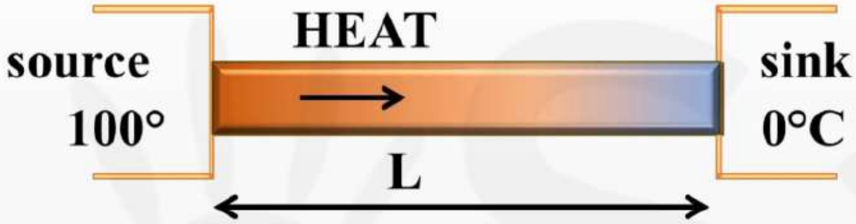
Heat Transfer
Superfast Revision

MODE	MEDIUM	BULK OF MEDIUM
(1) Conduction	Required	Not transferred
(2) Convection	Required	Transferred
(3) Radiation	Not required	

$\left(\frac{dQ}{dt}\right.$

Heat Flow In A Uniform Rod In Steady State



$$\left(\frac{dQ}{dt}\right) = KA\left(\frac{dT}{dx}\right)$$

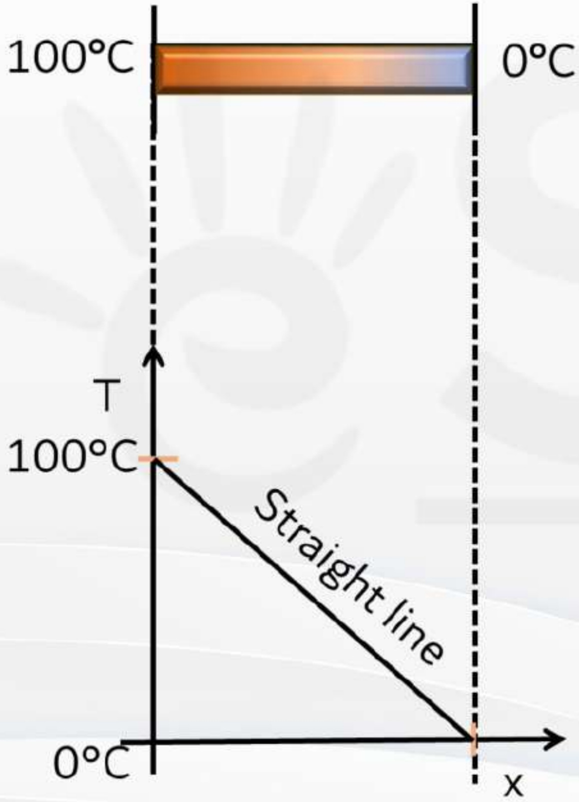
$$\left(\frac{dQ}{dt}\right) = KA\left(\frac{\Delta T}{\Delta x}\right)$$

$$i_H = KA\left(\frac{\Delta T}{\Delta x}\right)$$

In Steady State, temperature of each element of the rod becomes constant w.r.t. to time.

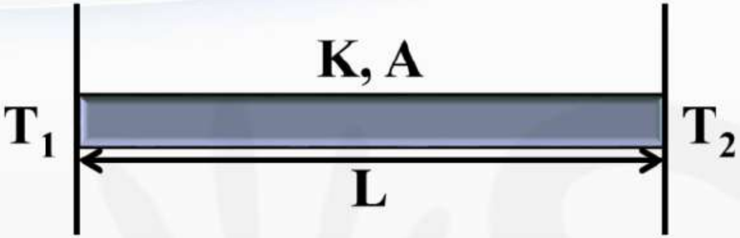
Rate of heat flow from each cross-section of the rod will be same.

Variation of Temperature



$$i_H = KA\left(\frac{dT}{dx}\right)$$

$\left|\frac{dT}{dx}\right|$ **is same**



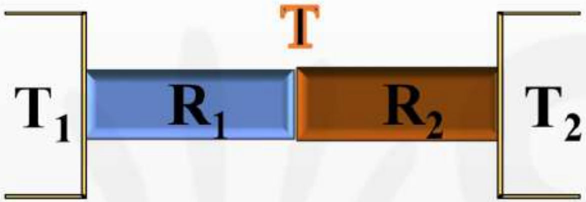
$$i_H = \frac{KA(T_1 - T_2)}{L}$$

$$i = \frac{V_1 - V_2}{R}$$

$$i_H = \frac{T_1 - T_2}{R}$$

Thermal Resistance $R = \frac{L}{KA}$

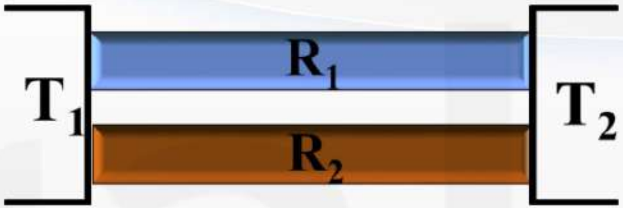
Series Combination



$$R_1 = \frac{\ell_1}{K_1 A_1} \qquad R_2 = \frac{\ell_2}{K_2 A_2}$$

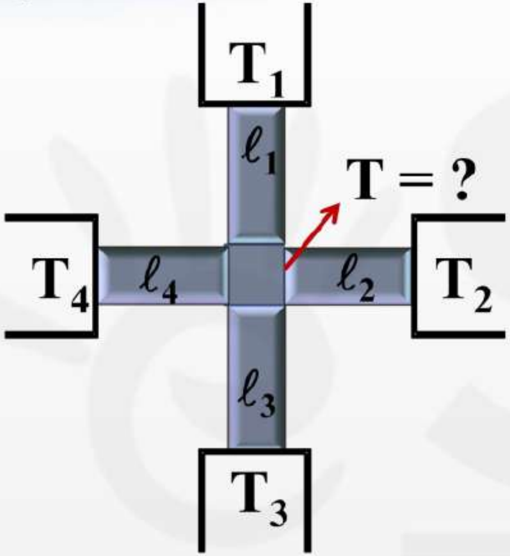
$$R_{eq} = R_1 + R_2$$

Parallel Combination



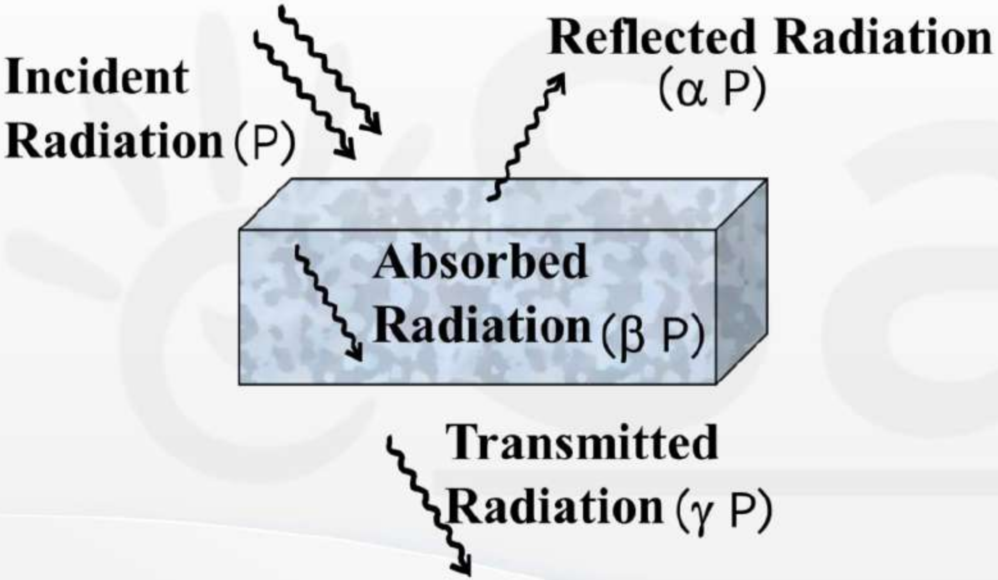
$$\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2}$$

Q) Find the value of T.



JUNCTION RULE

Sol. $$\frac{T - T_1}{R_1} + \frac{T - T_2}{R_2} + \frac{T - T_3}{R_3} + \frac{T - T_4}{R_4} = 0$$



Reflectivity

Transmittivity

$$\alpha + \beta + \gamma = 1$$

Absorptivity

Opaque body : $\gamma = 0$

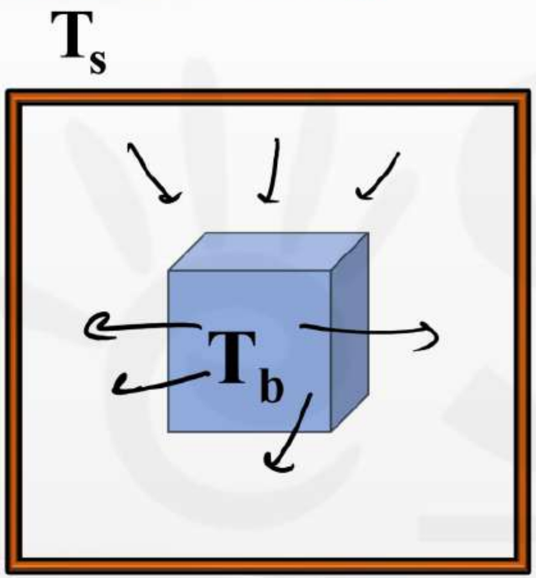
$$\alpha + \beta = 1$$

Black body : $\alpha = 0$

$$\beta = 1$$

$$\gamma = 0$$

Prevost Theory



$T_b > T_s$:Rate of emission > Rate of absorbing $\Rightarrow T_b \downarrow$

$T_b < T_s$:Rate of emission < Rate of absorbing $\Rightarrow T_b \uparrow$

$T_b = T_s$:Rate of emission = Rate of absorbing

$\Rightarrow T_b$ no change

Absorptive Power

Absorptive power of a body is defined as the fraction of incident radiation absorbed by the surface.

$$0 \leq a \leq 1$$

For a Black body : $a = 1$

Emissive Power (E)

Amount of radiation energy emitted by a surface per unit time per unit area is called its Emissive Power.

$$E = \frac{\Delta Q}{A\,\Delta t}$$

Unit : W/m^2

Stefan-boltzmann Law

$E = e\,\sigma\,T^4$ (T in Kelwin)

└→ Stefan-Boltzmann constant

$= 5.67\times10^{-8}\ W\ m^{-2}\ K^{-4}$

TRICK

$P = eA\sigma T^4$

P – Power emitted

A – Surface Area of the body

T – Temperature in Kelvin

σ – Stefan-Boltzmann constant

e – Emissivity of the surface

$0 \le e \le 1$

e = 1 for a Black body

Kirchhoff's Law of Thermal Radiation

Emissivity of a body is equal to the Absorptivity of the body at a given temperature.

$$e = a$$

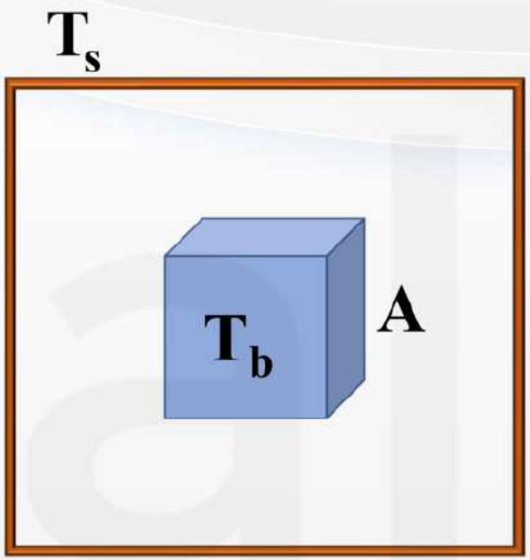
"Good absorbers are good emitters."

Net Rate of Heat Loss Through Radiation

Rate of heat emission $R_e = eA\sigma T_b^4$

Rate of heat absorption $R_a = eA\sigma T_s^4$

Net rate of heat loss $\frac{dQ}{dt} = eA\sigma(T_b^4 - T_s^4)$



Rate of Cooling

$$\frac{dQ}{dt} = eA\sigma(T_b^4 - T_s^4)$$

$$\frac{dQ}{dt} = -ms\frac{dT_b}{dt}$$

$$\frac{dT_b}{dt} = -\frac{eA\sigma}{ms}(T_b^4 - T_s^4)$$

→ Rate of cooling i.e. Rate of Loss of Temperature

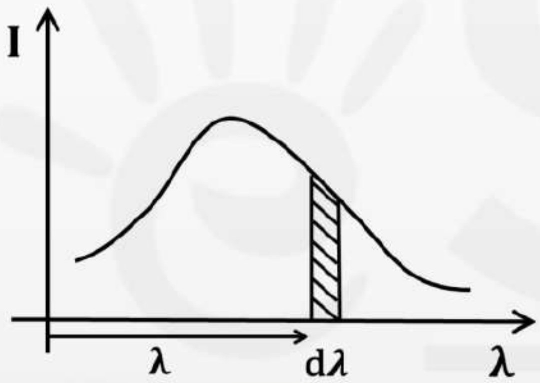
Newton's Law of Cooling

for $\Delta T = T_b - T_s \ll T_s$

$$\frac{dT_b}{dt} = -\frac{k}{ms}(T_b - T_s)$$

Spectral Emissive Power

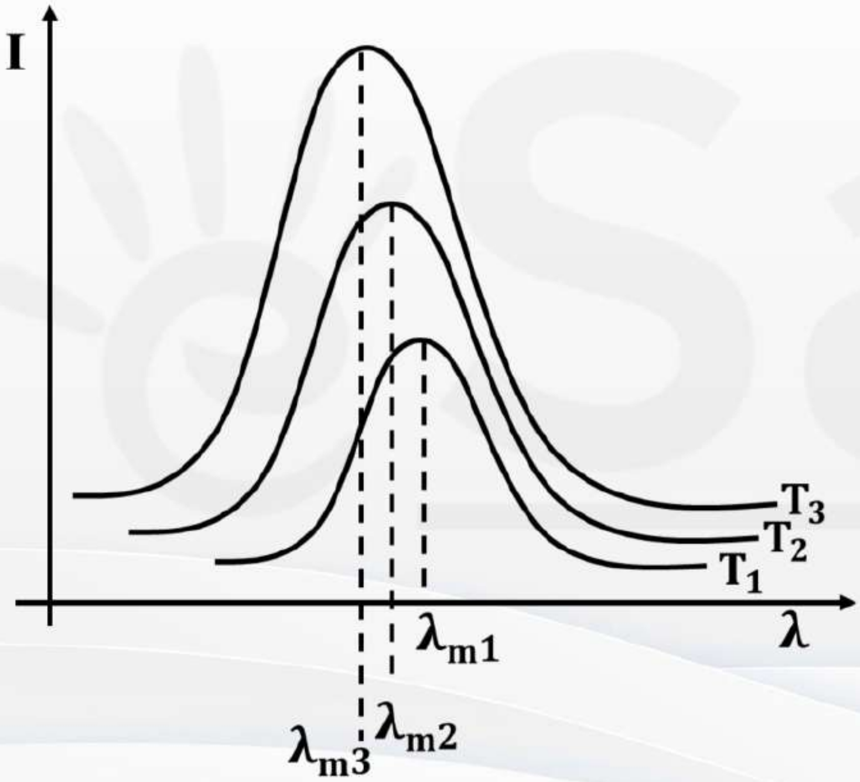
I is emissive power per unit wavelength near a given wavelength (λ).



$$\int_0^\infty I\,d\lambda = \text{total emissive power}$$

Total area of graph = Total emissive power = σT^4 → for a black body

Wien's Displacement Law



$$\lambda_m T = \text{constant}$$

$T_3 > T_2 > T_1$

Wein's constant

$$\lambda_{m_3} T_3 = \lambda_{m_2} T_2 = \lambda_{m_1} T_1 = b$$

b = 0.0029 m-K for a black body

Lets Meditate !!

Kinetic Theory of Gases

Superfast Revision

Average Speed

$$V_{avg} = \sqrt{\frac{8RT}{\pi M}}$$

R → Universal gas const.

M → mol. mass

V_{avg} ↓ average speed

Average velocity $= 0$

Root Mean Square Speed

$$V_{rms} = \sqrt{\frac{3P}{\rho}} = \sqrt{\frac{3RT}{M}}$$

V_{rms} → Root mean square speed

M → Molecular mass

$$V_{rms} = \sqrt{\frac{v_1^2 + v_2^2 + \ldots\ldots + v_N^2}{N}}$$

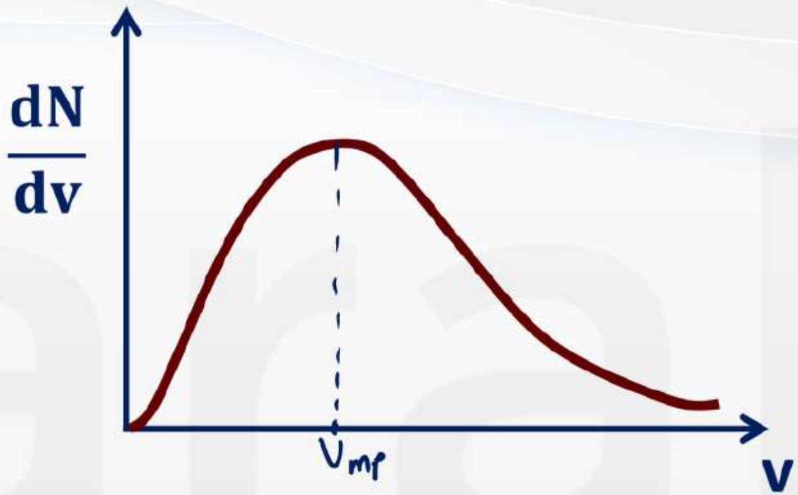
Most Probable Speed

$$V_{mp} = \sqrt{\frac{2RT}{M}}$$

↓

most probable speed

By Maxwell speed distribution



Ideal Gas Equation

$PV = nRT$

R is universal gas constant $= 8.314$

$$= \frac{25}{3} \frac{J}{Mol - K}$$

Graham's Law of Diffusion

$$\text{Q` sd ne c heet rhnm} \propto \frac{1}{\sqrt{\text{Molecular Mass}}}$$

$$\frac{r_1}{r_2} = \frac{\sqrt{M_2}}{\sqrt{M_1}}$$

Degree of Freedom (f)

It refers to the minimum numbers of independent means by which a molecule can possess energy.

Here we are not considering vibrational modes of energy. They should be considered at high temperatures.

Atomicity of gas	f
Monoatomic	3
Diatomic and other linear molecules	5
Non-linear	6

Equivalent DOF (f_{eq})

$$n_1 f_1 R T + n_2 f_2 R T = (n_1 + n_2) f_{eq} R T$$

$$f_{eq} = \frac{n_1 f_1 + n_2 f_2}{n_1 + n_2}$$

Law of Equipartition of Energy

Each degree of freedom contributes $\frac{1}{2}kT$ of energy per molecule.

k is Boltzmann constant

$$k = \frac{R}{N_A}$$

R → Universal Gas Constant

N_A → Avogadro number

k → Boltzmann constant

$k = 1.38 \times 10^{-23}$ J/K

Internal energy(U) of ‘n’ moles of gas $= \frac{f}{2}nRT$

Translational kinetic energy of ‘n’ moles $= \frac{3}{2}nRT = \frac{3}{2}PV$

Mean Free Path

The average distance between two successive collisions is called mean free path.

mean free path 'λ' $= \dfrac{1}{\sqrt{2}n\pi d^2}$

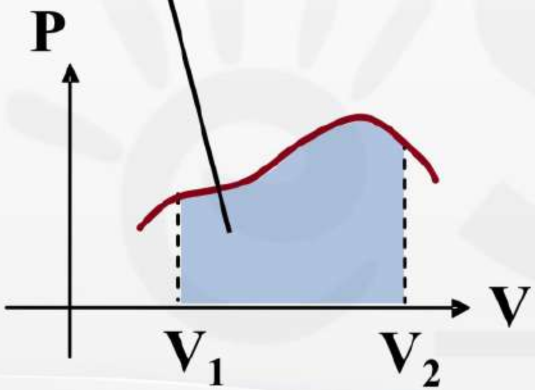
n → no of mol/vol

d → diameter of molecule

Thermodynamics
Superfast Revision

Work Done By Gas

$$W_{gas} = \int P\,dV$$



W can be +, − or 0

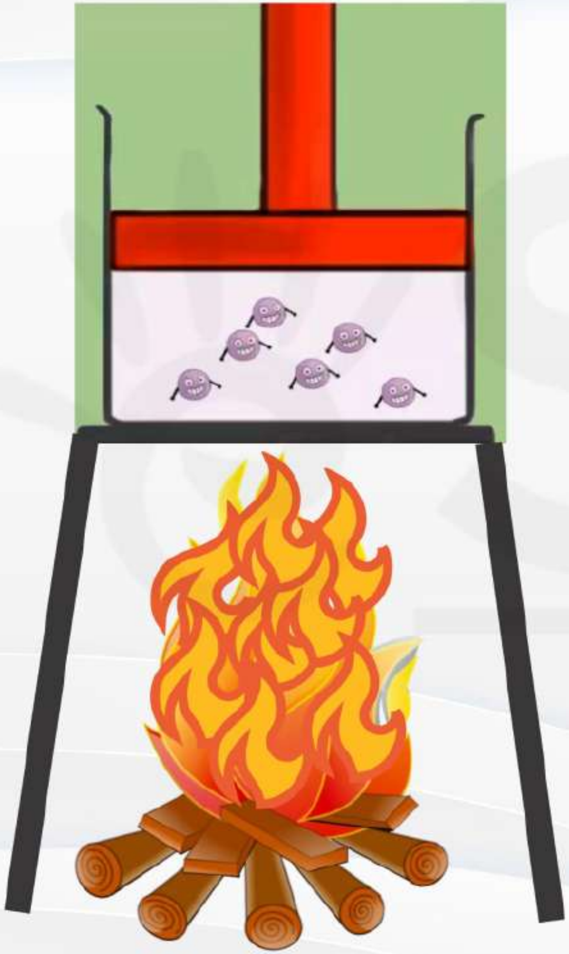
Internal Energy (U)

f → Degree of freedom

$$U = \frac{f}{2} nRT$$

$$\Delta U = \frac{f}{2} nR\Delta T$$

$$\Delta U = \frac{f}{2}(P_f V_f - P_i V_i)$$



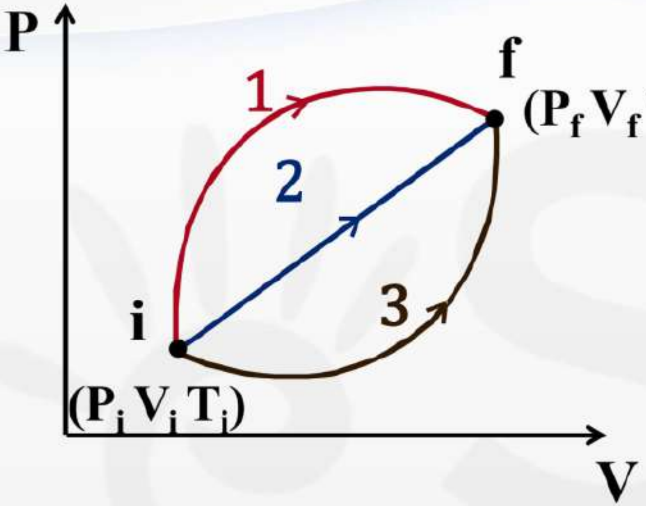
$$\Delta Q = \Delta U + W$$

First Law of thermodynamics

Based on Conservation of Energy

$\Delta Q = \Delta U + W$

	Definition	+ve	−ve
ΔQ	Heat supplied to gas	If heat is supplied to gas.	If heat is taken from gas
ΔU	Change in U	If $U \uparrow \Delta U = +ve$	If $U \downarrow \Delta U = -ve$
W	Work done BY gas	If work is done by gas i. e. $V \uparrow$	If work is done on gas i. e. $V \downarrow$



$W_1 > W_2 > W_3$

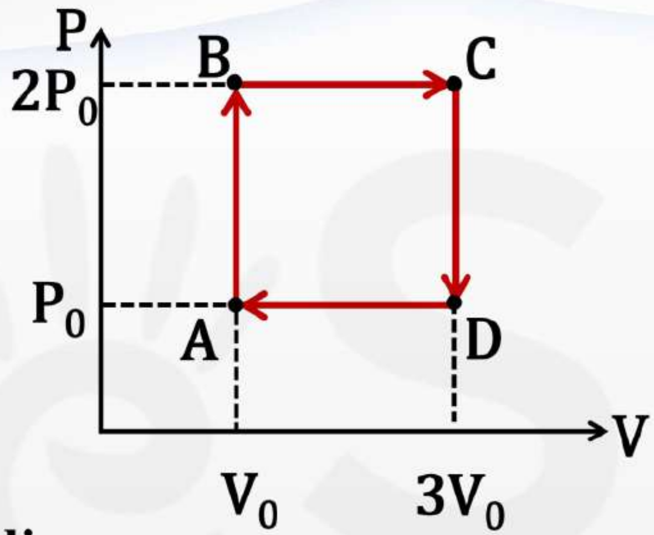
$\Delta U_1 = \Delta U_2 = \Delta U_3$

$\Delta Q_1 > \Delta Q_2 > \Delta Q_3$

(because $\Delta Q = \Delta U + W$)

- **ΔU is the state variable i.e. it's value depends only on the initial and final state and not on the path or process.**

- **Δ Q and W are the path variables (or transfer variables) i.e. their value depends on the process connecting initial and final states.**



in cyclic process

$\Delta U_{net} = 0$ $\Delta Q = W =$ area under PV cycle

Efficiency of cyclic process $= \dfrac{\text{Net work done by gas}}{\text{Total heat supplied to gas}}$

Molar Heat Capacity of Gas (C)

$$\Delta Q = n\,C\,\Delta T$$

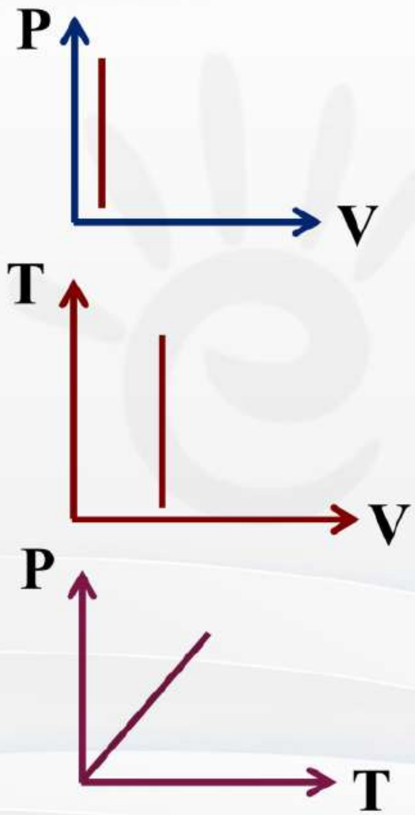
$$C = \frac{\Delta Q}{n\Delta T}$$

ΔQ depends on process

C also depends on process

Thermodynamic Processes

Isochoric Process



$V = \text{Constant}$

$W_{gas} = 0$

$$\Delta Q = n\frac{f}{2}R\,\Delta T \qquad \Delta Q = n\,C_V\,\Delta T$$

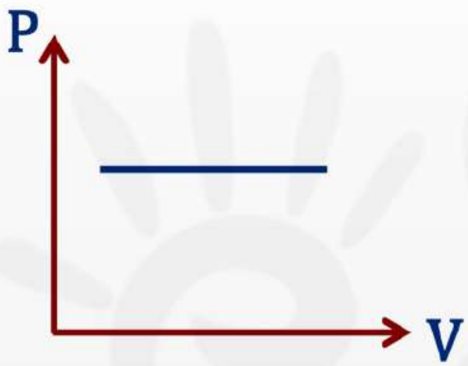
$$C_V = \frac{f}{2}R$$

Molar heat capacity at constant Volume

Bulk Modulus $B = -\dfrac{\Delta P}{\Delta V / V}$

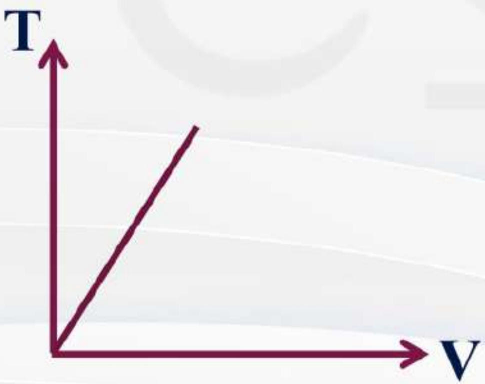
B is not defined (volume constant)

Isochoric Process



$P = \text{constant}$

$W_{gas} = n\,R\,\Delta T$



$$\Delta Q = n\left(\frac{f}{2}R + R\right)\Delta T$$

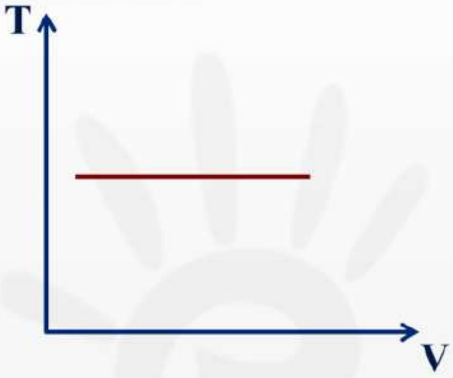
$$C_p = \frac{f}{2}R + R$$

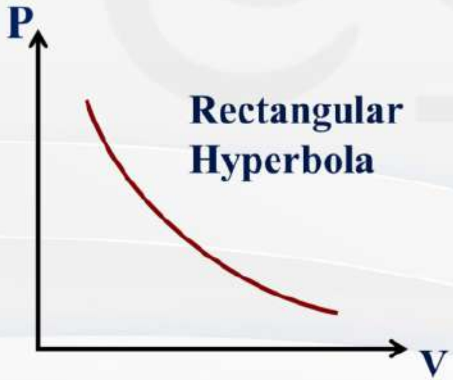
Molar heat capacity at constant Pressure

Bulk Modulus B $= \dfrac{-\Delta P}{\Delta V/V}$

Pressure Constant $B = 0$

Isothermal Process





$PV = \text{Constant}$

$p \propto \frac{1}{V}$

$T = \text{Constant} \quad PV = \text{constant}$

$P_1V_1 = P_2V_2$

$W_{gas} = nRT\,\ell n\left(\frac{V_f}{V_i}\right)$

$T = \text{Constant} \quad (\Delta T = 0)$

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

C of this process is not defined

Two isothermal curves for a particular gas do not intersect.

$$C_p = \frac{f}{2}R + R \qquad C_V = \frac{f}{2}R$$

$C_P - C_V = R$ **Mayor's equation**

$\frac{C_P}{C_V} = \gamma$ **Adiabatic constant**

$$f = \frac{2}{\gamma - 1} \quad C_V = \frac{R}{\gamma - 1} \quad C_P = \frac{R\gamma}{\gamma - 1}$$

$$C_V = \frac{f}{2}R \quad C_P = \frac{f}{2}R + R \quad \frac{C_P}{C_V} = \gamma$$

Atomicity of gas	f	C_v	C_P	γ
Monoatomic	3	$\frac{3}{2}R$	$\frac{5}{2}R$	$\frac{5}{3} = 1.67$
Diatomic or Triatomic linear	5	$\frac{5}{2}R$	$\frac{7}{2}R$	$\frac{7}{5} = 1.40$
Polyatomic or Triatomic Non- linear	6	$\frac{6}{2}R = 3R$	$\frac{8}{2}R = 4R$	$\frac{4}{3} = 1.33$

Q) If n_1 moles of gas 1 having γ_1 is mixed with n_2 moles of gas 2 having γ_2. Find $\gamma_{mixture}$ in terms of n_1, γ_1, n_2 and γ_2.

Sol. $n_1 f_1 R T + n_2 f_2 R T = (n_1 + n_2) f_{mix} R T$

$$f_{mix} = \frac{n_1 f_1 + n_2 f_2}{n_1 + n_2}$$

$$\frac{(n_1 + n_2)}{\gamma_{mix} - 1} = \frac{n_1}{\gamma_1 - 1} + \frac{n_2}{\gamma_2 - 1}$$

Adiabatic Process

$dQ = 0 \quad \Rightarrow \Delta Q = 0$

$W = -\Delta U$

Adiabatic constant (γ)

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

$P_1 V_1^{\gamma} = P_2 V_2^{\gamma}$

$W_{gas} = -\Delta U$

$$= -\frac{f}{2} n R \Delta T = \frac{n R \Delta T}{1-\gamma} = \frac{P_f V_f - P_i V_i}{1-\gamma}$$

Molar heat capacity

$C = \frac{\Delta Q}{n \Delta T} = 0 \quad (\text{as } \Delta Q = 0)$

Bulk Modulus

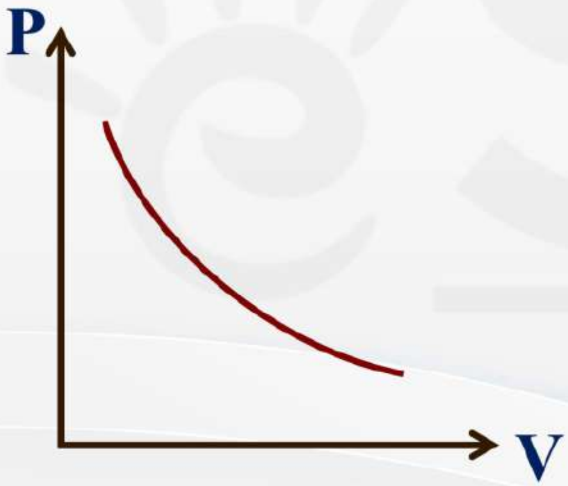
$B = \gamma P$

Two adiabatic curves for a particular gas do not intersect.

Adiabatic Process Graphs

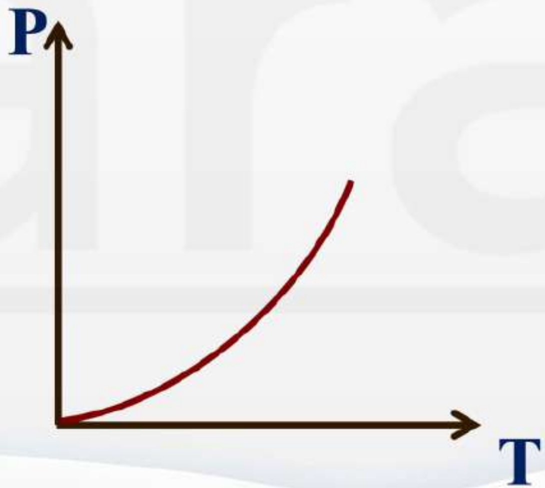
$PV^{\gamma} = C$

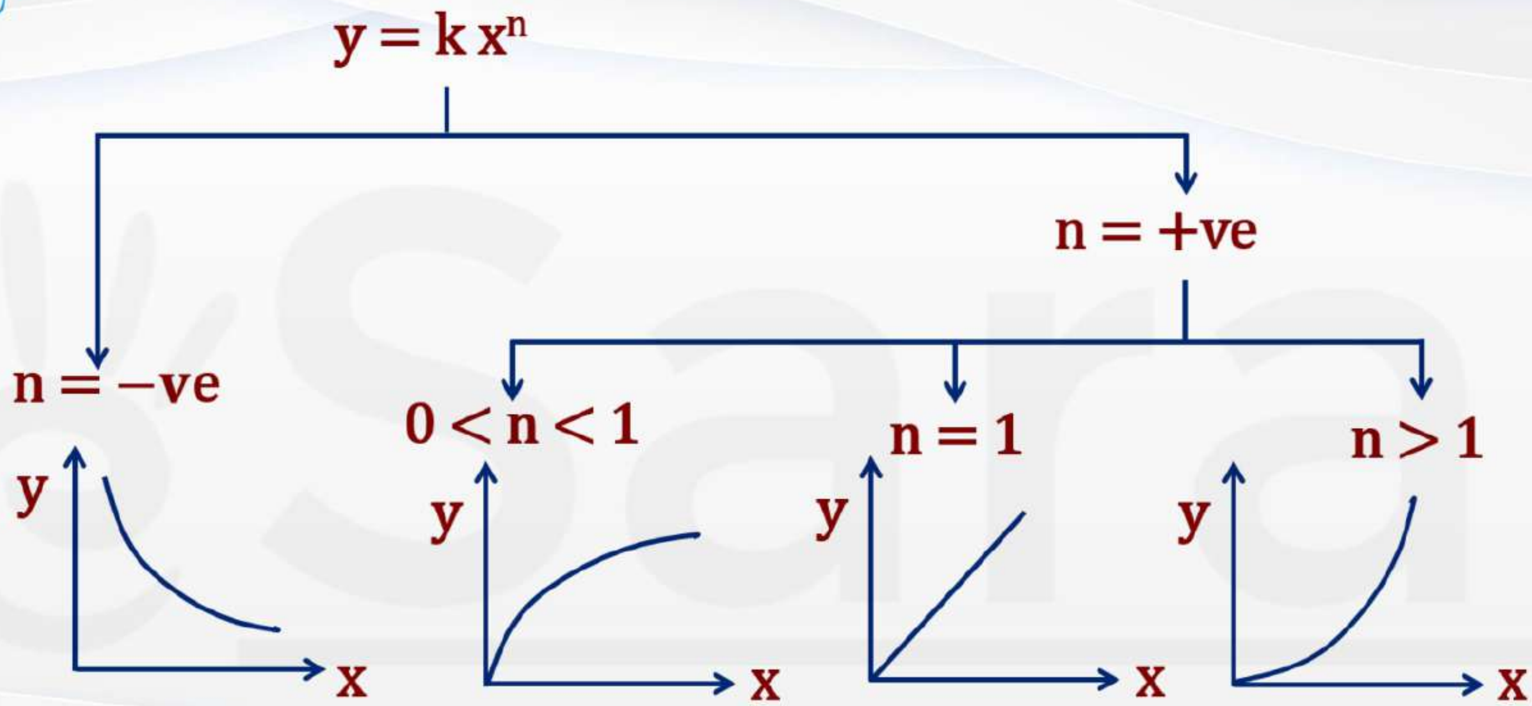
$P \propto V^{-\gamma}$



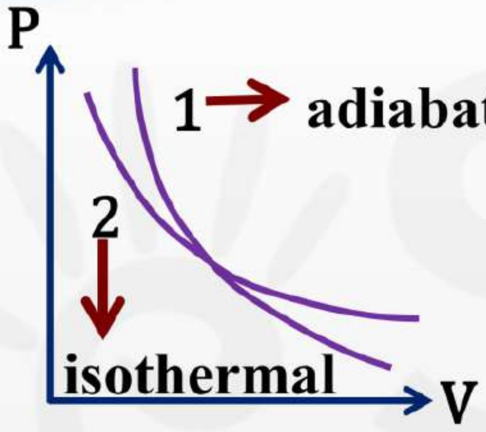
$PT^{\left(\frac{\gamma}{1-\gamma}\right)} = \text{constant}$

$P \propto T^{\left(\frac{\gamma}{\gamma-1}\right)}$




$y = kx^n$
$n = +ve$
$n = -ve$
$0 < n < 1$
$n = 1$
$n > 1$
y
x
y
x
y
x
y
x

Q) Which of the following curves represent isothermal and adiabatic process.



Sol.

$$\text{Adiabatic slope} = -\gamma\left(\frac{P_A}{V_A}\right)$$

$$\gamma > 1$$

$$\text{Isothermal slope} = -\left(\frac{P_A}{V_A}\right) \quad |\text{slope}|_{\text{adiabatic}} > |\text{slope}|_{\text{isothermal}}$$

Polytropic Process

$$P\,V^{x} = \text{Constant}$$

$$W_{gas} = \frac{n\,R\,\Delta T}{1-x}$$

$$= \frac{P_f V_f - P_i V_i}{1-x}$$

$$P\,V^{\gamma} = \text{constant}$$

$$W_{gas} = \frac{n\,R\,\Delta T}{1-\gamma}$$

$$= \frac{P_f V_f - P_i V_i}{1-\gamma}$$

Polytropic Process

Slope of P–V curve

$$P\,V^{x} = \text{Constant}$$

$$\text{Slope of P–V curve} = -\frac{xP}{V}$$

$$B = \frac{-dP}{\frac{dV}{V}} = x\,P$$

$$P\,V^{\gamma} = \text{constant}$$

$$\text{Slope of P – V curve} = -\frac{\gamma P}{V}$$

$$B = \frac{-dP}{\frac{dV}{V}} = \gamma P$$

Polytropic Process

Molar heat capacity

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

$$= \frac{\Delta U + W}{n\Delta T}$$

$$= \frac{R}{\gamma - 1} + \frac{R}{1 - x} \qquad C = R\left(\frac{1}{\gamma - 1} - \frac{1}{x - 1}\right)$$

Free Expansion of Gas

$W_g = 0$

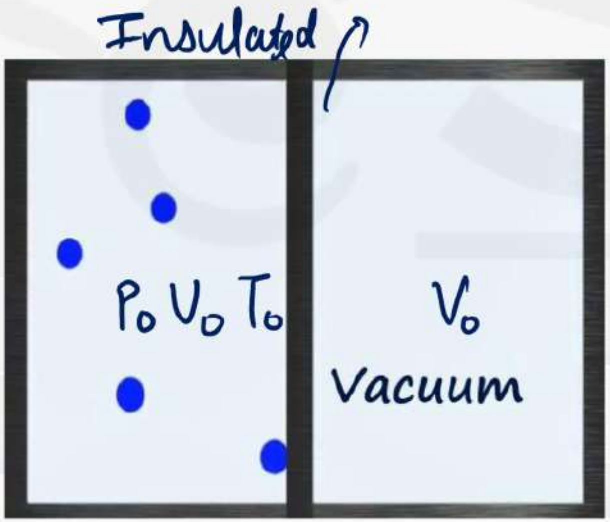
$\Delta Q = 0$

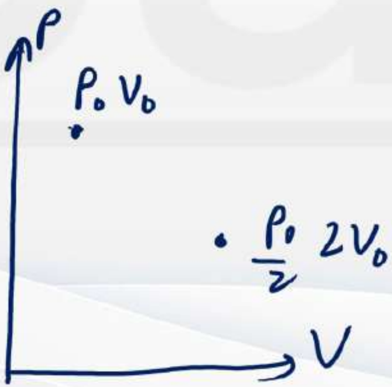
$\Rightarrow \Delta U = 0$

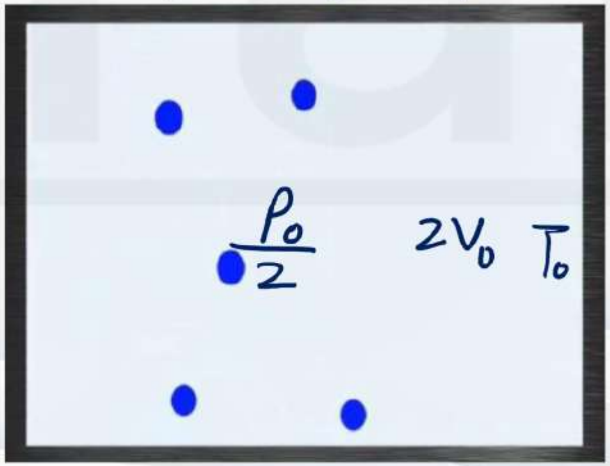
$\Rightarrow$ T will not change

$P_0 V_0 = nRT_0$

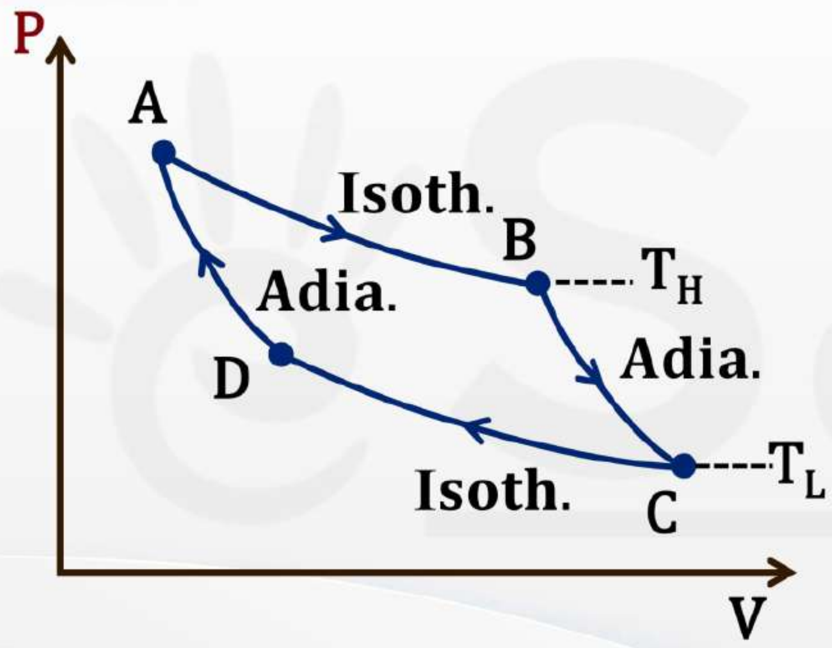
$P_f \, 2V_0 = nRT_0 \Rightarrow P_f = P_0/2$







Carnot Cycle



$$\text{efficiency } '\eta' = \frac{W_{net}}{Q_{in}}$$

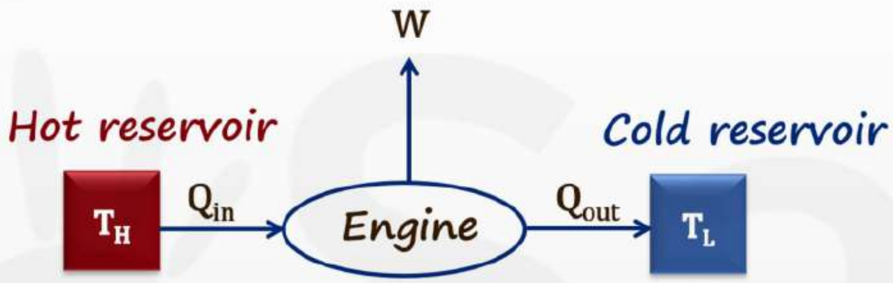
$$= 1 - \frac{|Q_{out}|}{|Q_{in}|}$$

$$= 1 - \frac{T_L}{T_H}$$

TRICK

(T_H & T_L are in kelvin)

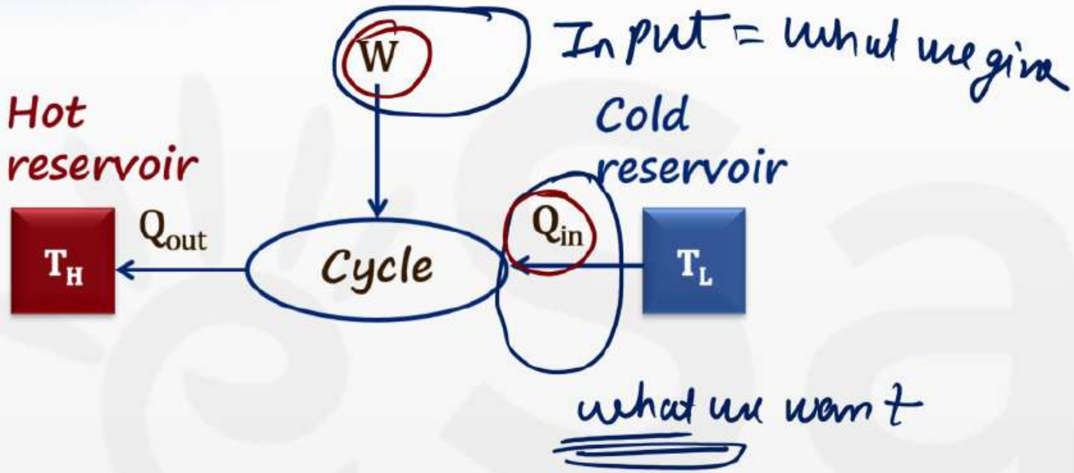
Second Law of Thermodynamics



No process is possible whose sole result is the absorption of heat from a reservoir and the complete conversion of heat to work.

Efficiency of Cyclic process must be less than 1.

Refrigerator



$$W + |Q_{in}| = |Q_{out}|$$

TRICK

$$\text{Coefficient of performance } (\alpha) = \frac{Q_{in}}{W} = \frac{|Q_{in}|}{|Q_{out}| - |Q_{in}|} = \frac{T_L}{T_H - T_L}$$

for reverse Carnot

Entropy(S)

Related to disorder in system.

$$dS = \frac{dQ}{T}$$

$$\Delta S = \int dS = \int \frac{dQ}{T}$$

Temp → Kelvin

For adiabatic process $\Delta S = 0$

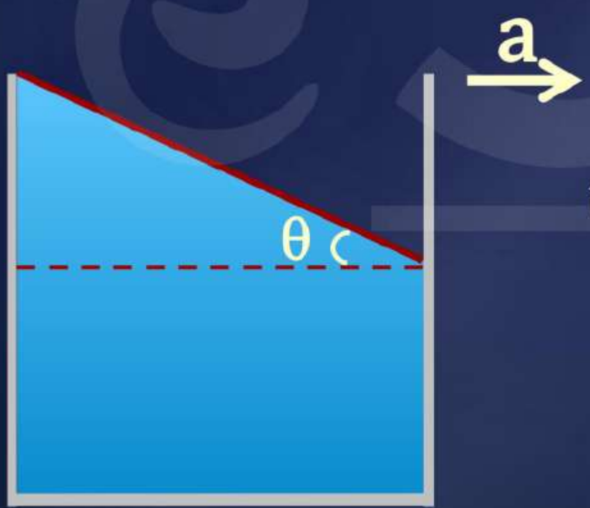
Lets Meditate !!

Fluid Mechanics
Superfast Revision

Pressure (Force/ Area) SI unit is N/m^2 = Pascal (Pa)

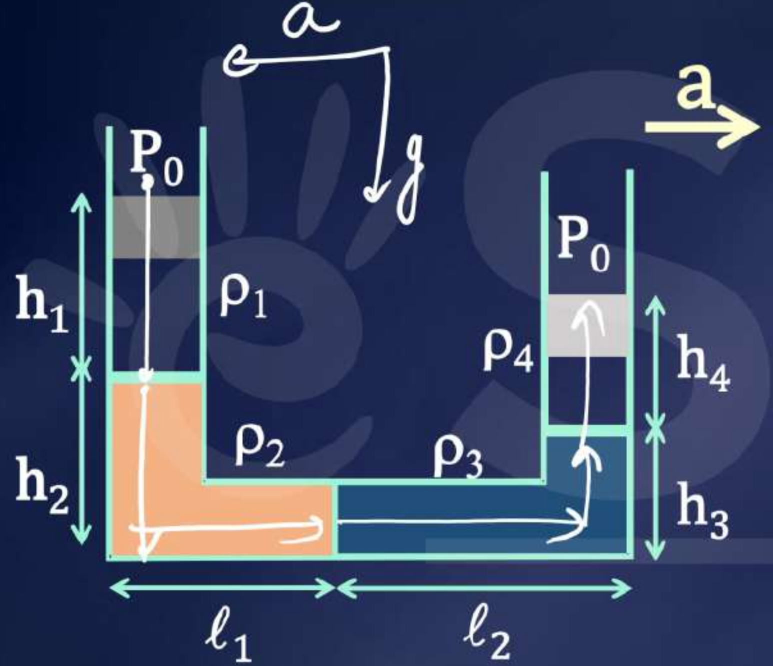
$1 \text{ bar} = 10^5 \text{ Pa}$

$1 \text{ atm} = 1.01325 \text{ bar} \approx 1 \text{ bar}$



$$\tan\theta = \frac{a}{g}$$

Variation of Pressure



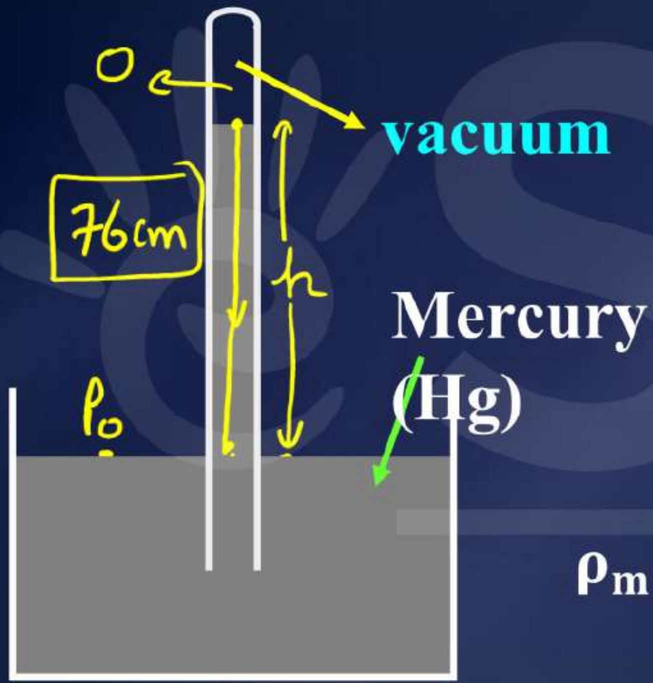
$$P_0 + \rho_1 g h_1 + \rho_2 g h_2 - \rho_2 a \ell_1 - \rho_3 a \ell_2 - \rho_3 g h_3 - \rho_4 g h_4 = P_0$$

Q) Find pressure at other end of the rotating tube as shown.

Sol.

$$P_0 + \rho\ \omega^2 \frac{\ell}{2}\ell = P_1$$

Barometer



$$\rho_m \, g(76cm) = P_0$$

Buoyant Force

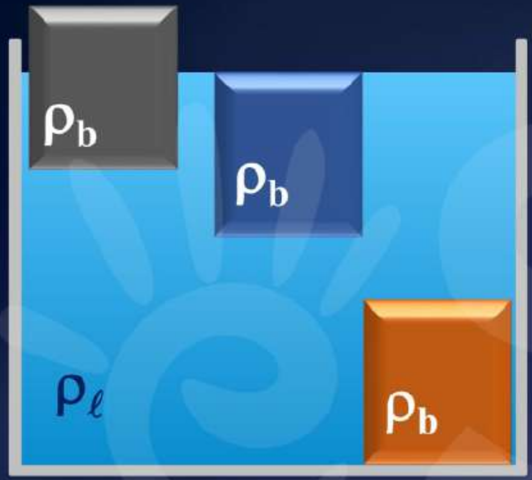
Buoyant force is equal to weight of the fluid displaced.

Buoyant force depends on g_{eff}

Buoyant force acts opposite to g_{eff}

$BF = \rho_f gh A$

Loss of weight of a body submerged (partially or completely) in a fluid is equal to the weight of the fluid displaced.



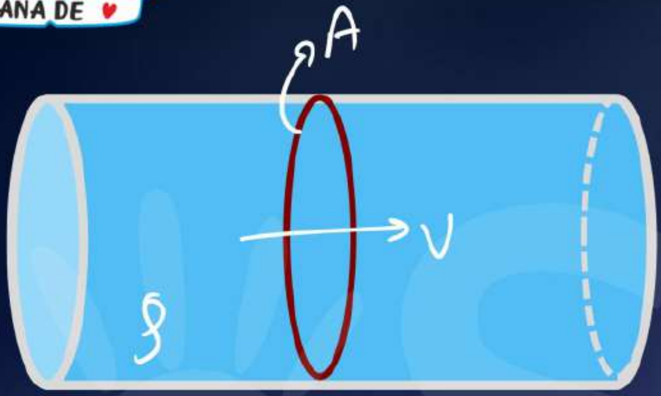
If $\rho_b < \rho_\ell$ then body will float

If $\rho_b = \rho_\ell$ then body will just float with fully submerged

If $\rho_b > \rho_\ell$ then body will sink

fraction submerged ↑

For Floating objects: $\frac{V_S}{V_b} = \frac{\rho_b}{\rho_\ell}$



Volume flow rate

Volume flowing through per unit time.

$$\frac{dV}{dt} = Av$$

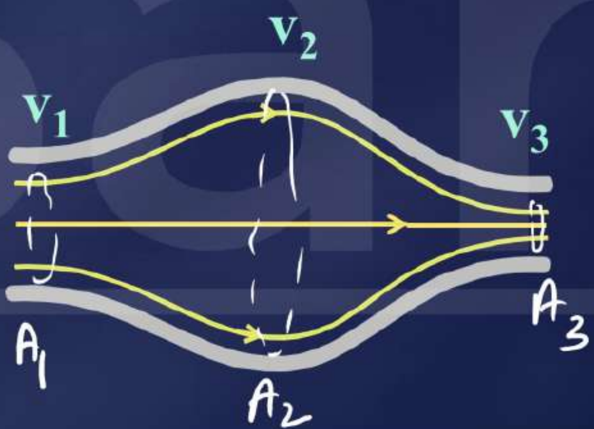
Mass flow rate

Mass flowing through per unit time.

$$\frac{dm}{dt} = \rho Av$$

Equation of Continuity

More crowded the streamlines in a region more is the velocity in that region.

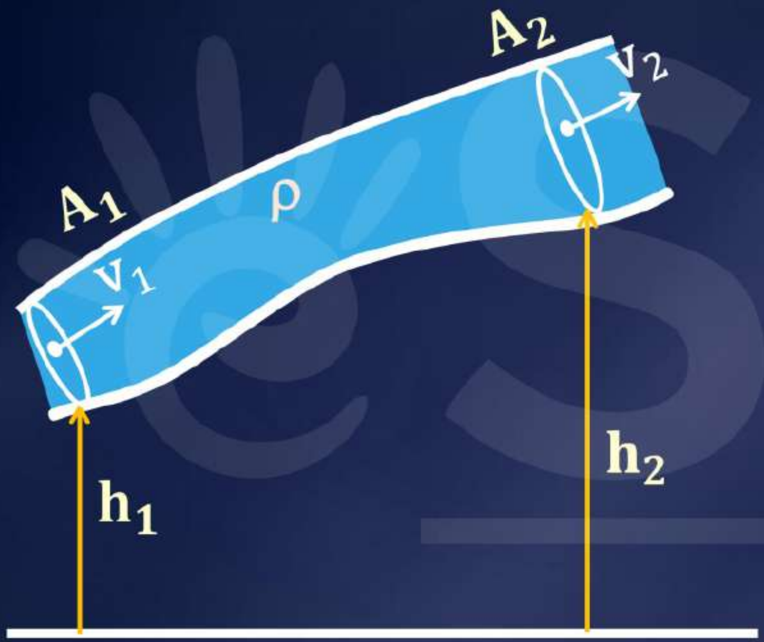


$$A_1v_1 = A_2v_2$$

It is based on law of conservation of mass

$v_3 > v_1 > v_2$

Bernoulli's Principle

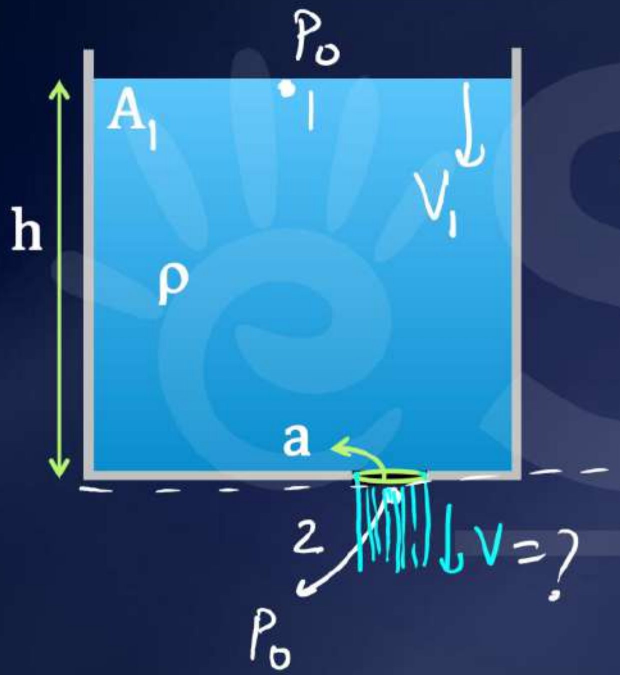


$$P_1 + \rho g h_1 + \frac{1}{2}\rho v_1^2 = P_2 + \rho g h_2 + \frac{1}{2}\rho v_2^2$$

$$P + \rho g h + \frac{1}{2}\rho v^2 = \text{Constant}$$

It is based on law of conservation of energy

Speed of Efflux: Torricelli's Law



$$v = \sqrt{\frac{2gh}{1 - \frac{a^2}{A_1^2}}}$$

$$a \ll A_1$$

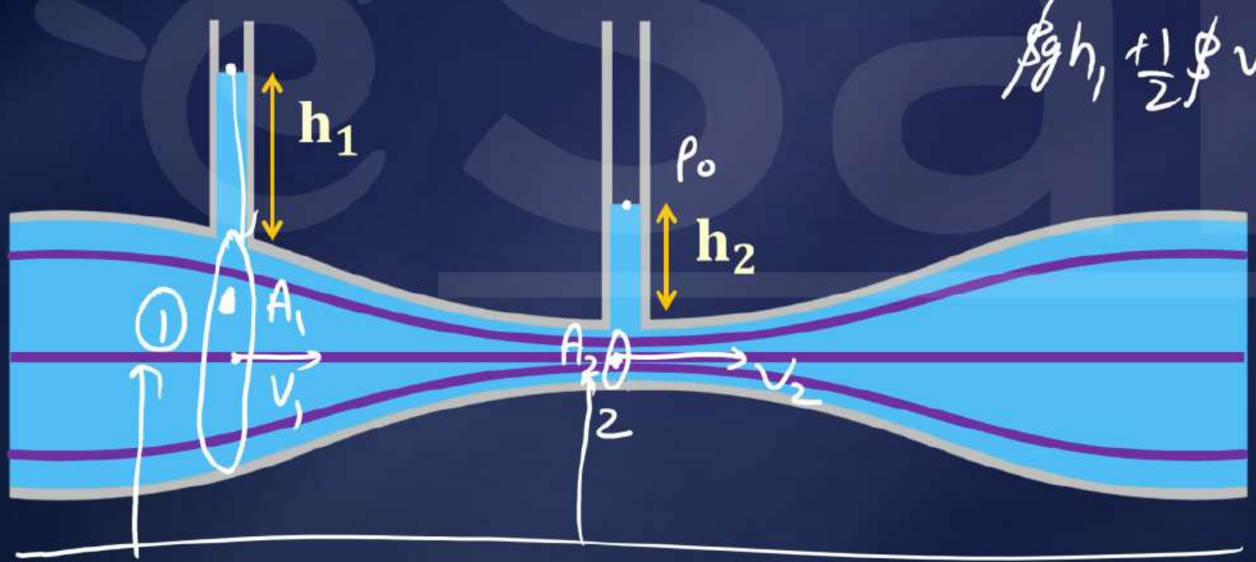
$$\sqrt{2gh} = v$$

Venturi Tube

$$P_1 = P_0 + \rho g h_1$$

$$P_2 = P_0 + \rho g h_2$$

$$A_1 V_1 = A_2 V_2 \quad \text{—} \ (1)$$

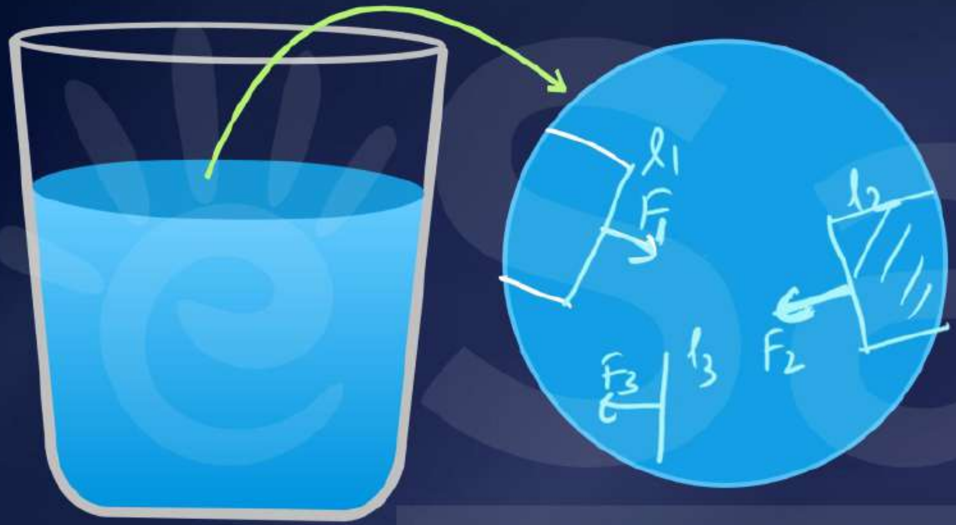


$$\rho g h_1 + \frac{1}{2}\rho v_1^2 = \rho g h_2 + \frac{1}{2}\rho v_2^2 \quad \text{—} \ (2)$$

$$2g(h_1 - h_2) = v_2^2 - v_1^2$$

$$2g(h_1 - h_2) = \left(\frac{A_1^2}{A_2^2} - 1\right) v_1^2$$

Surface Tension



$$S = \frac{F_1}{\ell_1} = \frac{F_2}{\ell_2} = \frac{F_3}{\ell_3}$$

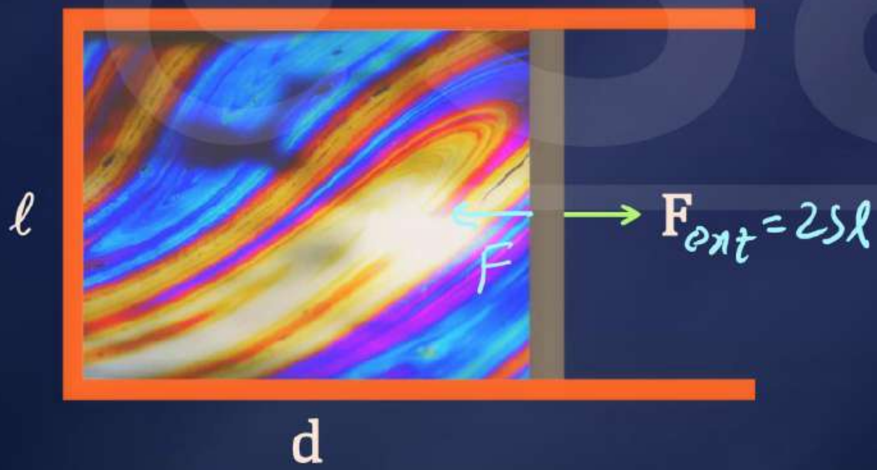
$$\text{Surface Tension (S)} = \frac{\text{Force}}{\text{Length}} = \frac{F}{L}$$

It acts away from the system.

Surface Energy

Surface Energy = Surface Tension × Surface Area

$$U = S \times (\ell d) \times 2$$



Q) A water drop of radius R is broken into 27 small drops. Find work done or increase in surface energy in this process. Given surface tension of water is 'S'.

Sol.

$$\Delta U = U_f - U_i = 8S\pi R^2$$

$$U_i = S \times 4\pi R^2 \;;\; U_f = S \times 4\pi r^2 \times 27$$

$$= 4S\pi R^2 \qquad = S \times 4\pi \frac{R^2}{9} \times 27$$

$$= 12 S\pi R^2$$

$$V_i = V_f$$

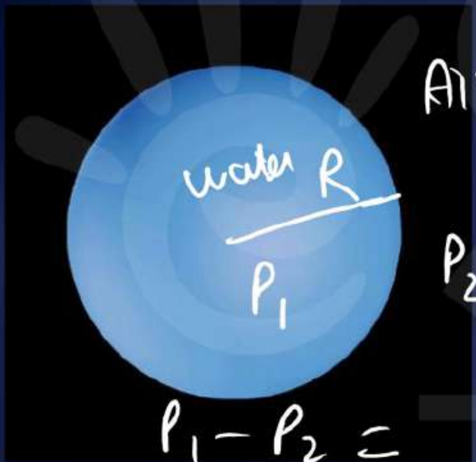
$$\frac{4}{3}\pi R^3 = 27 \times \frac{4}{3}\pi r^3$$

$$R = 3r$$

$$r = R/3$$

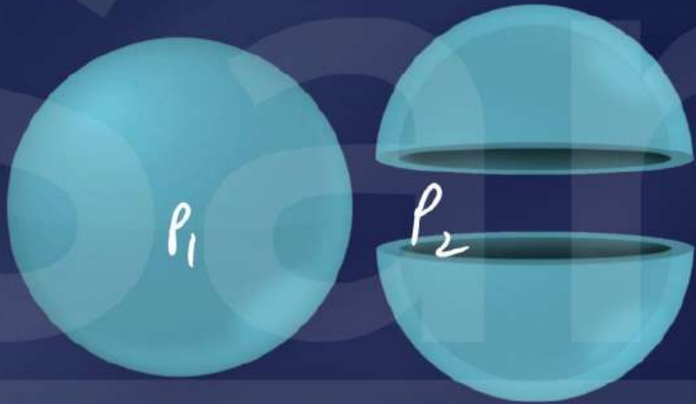
Excess Pressure

Inside a Drop in Air



$$\frac{2S}{R}$$

Thin Soap Bubble in Air

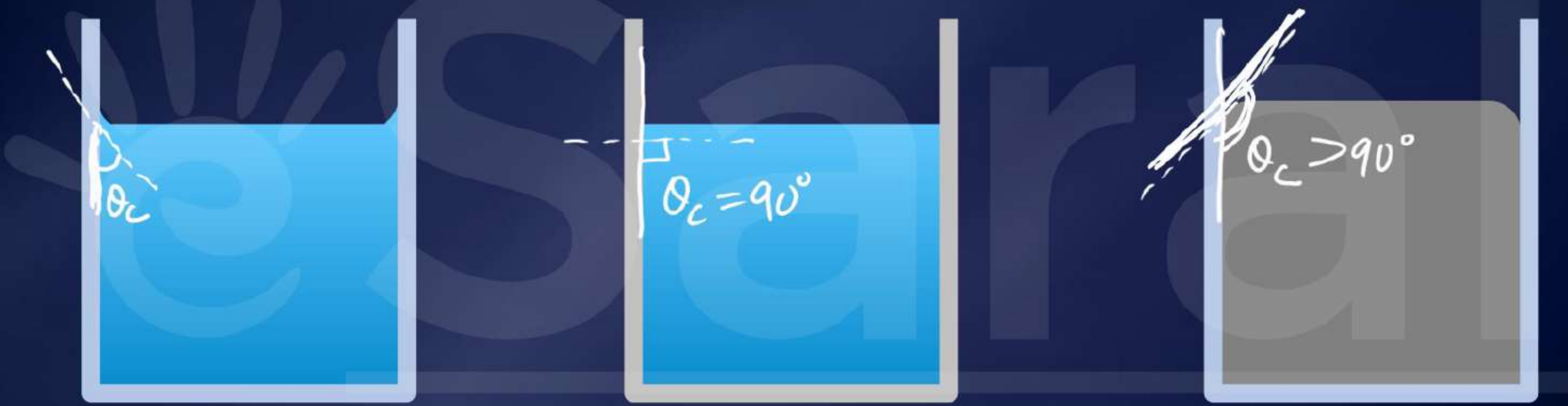


$$P_1 - P_2 \quad \frac{4S}{R}$$

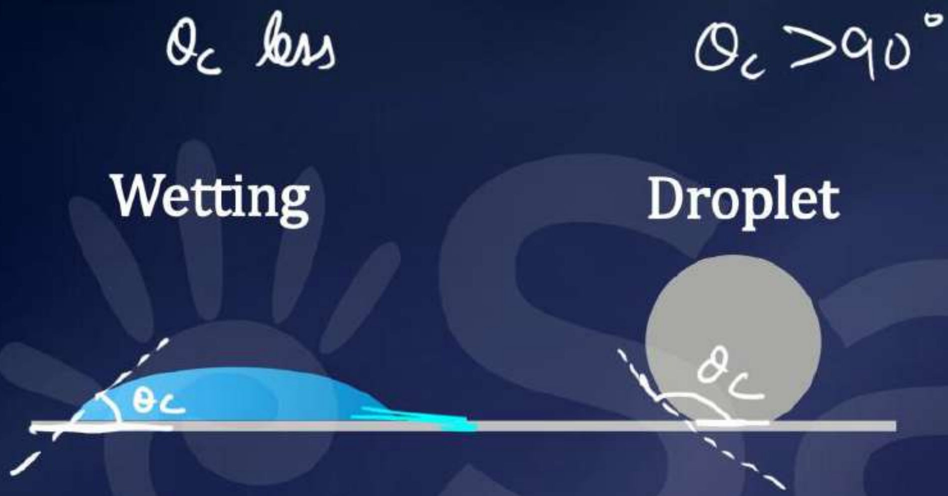
Air Bubble in Water

$$P_1 - P_2 = \frac{2S}{R}$$

Contact Angle (θ_c)



Glass Vessel – Water	Silver Vessel – Water	Glass Vessel – Mercury
$\theta_C < 90°$	$\theta_C = 90°$	$\theta_C > 90°$



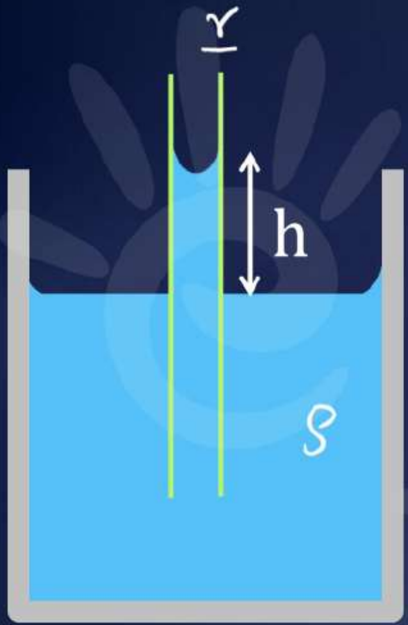
The value of θ_C determines whether a liquid will spread on the surface (wetting) or it will form droplets.

Soaps, detergents and dying substances are wetting agents.

When they are added the angle of contact becomes small so that these may penetrate well and become effective.

Water proofing agents on the other hand are added to create a large angle of contact between the water and fibres.

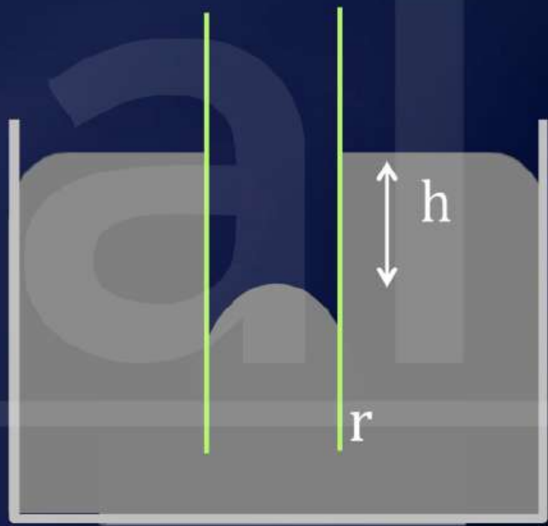
Rise of Liquid in Capillary Tube



$$R = \frac{r}{\cos\theta_c}$$

$$h = \frac{2S}{\rho g R} = \frac{2S}{\rho g r}\cos\theta_c$$

↓ (R) Rad of curv

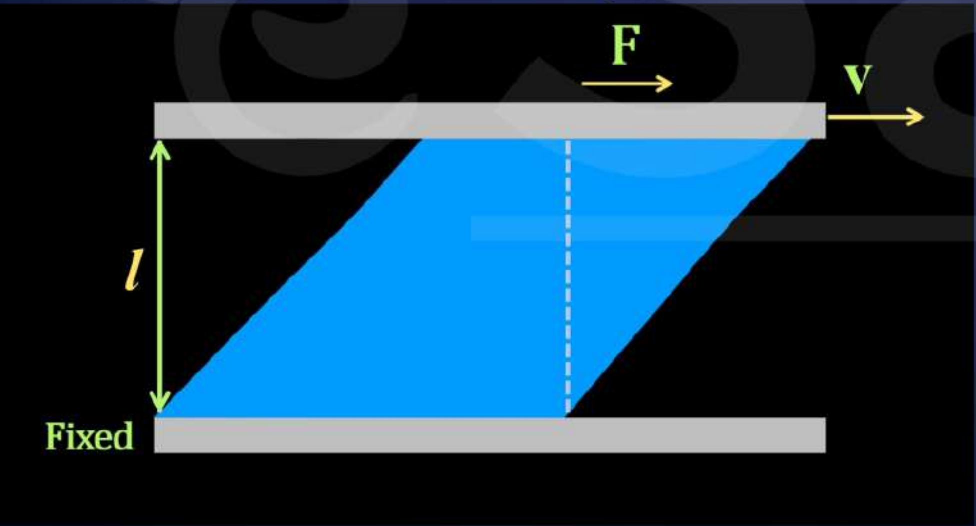


Viscosity

Viscous force exists when there is relative motion between layers of the liquid.

$$F = \eta A \left(\frac{v}{\ell}\right) \longrightarrow \text{Velocity gradient}$$

$\eta \downarrow$ Coefficient of viscosity



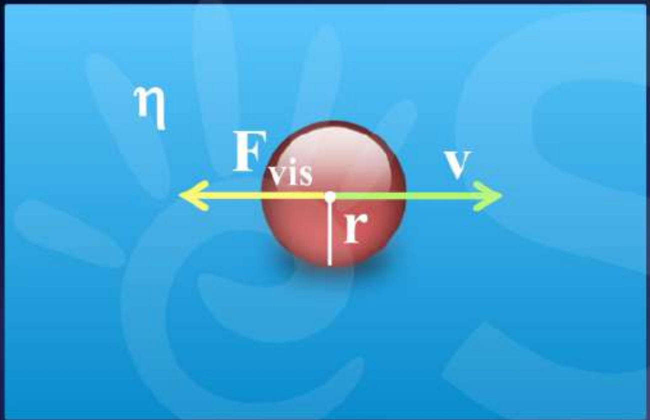
Viscosity

SI unit of η is Poiseuille (Pl)

CGS unit is Poise

1 Poise = 0.1 Poiseuille

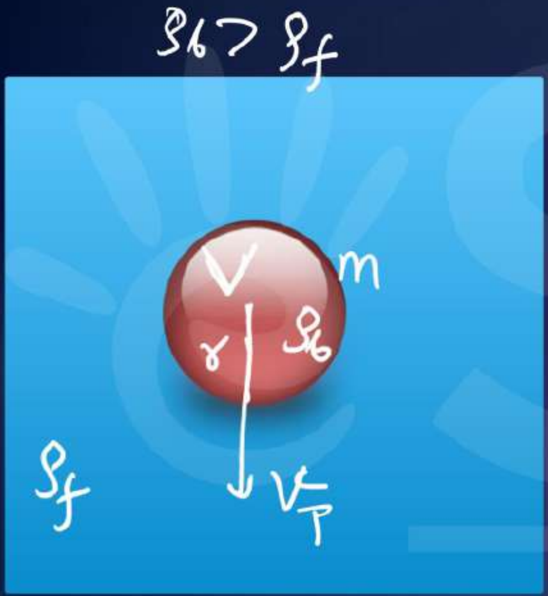
Stokes' Law

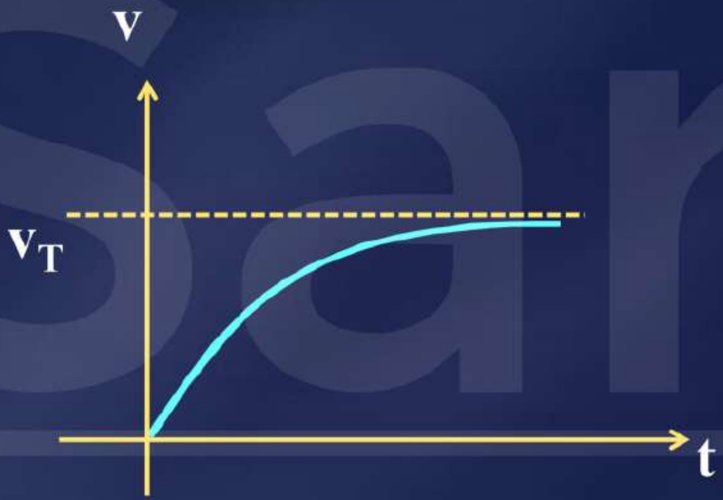


$$F_{vis} = 6\pi\eta rv$$

$\vec{F}_{vis}$ is opp. to $\vec{v}$

Terminal Velocity





$$V_T = \frac{2}{9}\frac{(\rho_b - \rho_f)r^2 g}{\eta}$$

Reynolds Number (R_e)

$$R_e = \frac{\rho v d}{\eta}$$

Density of fluid (ρ)

Velocity of fluid (v)

Diameter of tube (d)

Coefficient of viscosity (η)

If $R_e < 1000$	Flow is steady
If $1000 < R_e < 2000$	Flow is unstable
If $R_e > 2000$	Flow is turbulent

Largest velocity till which flow is steady is called Critical Velocity.

Lets Meditate !!

Complete Physics Mega Revision Timetable

15 Feb
- Electrostatics
- Current electricity
- Capacitor
- 🎁 **Surprise Gift** 🎁

16 Feb
- Calorimetry
- Elasticity
- Thermal Expansion
- Heat Transfer
- KTG
- Thermodynamics
- Fluid Mechanics

17 Feb
- Magnetic effect of current
- Manetism and matter
- Emi
- AC

18 Feb
- UD
- Vector
- Kinematics 1D
- Kinematics 2D
- NLM
- Friction
- Circular motion
- Work power energy
- COM
- Rotation motion

19 Feb
- Ray optics
- Optical Instruments
- Wave optics
- EM Waves
- Errors in measurement

20 Feb
- Gravitation
- SHM
- Wave on string
- Sound wave

21 Feb
- Dual nature of radiation
- X-rays
- Nuclear physics
- Radioactivity
- Semi conductor
- Communication system

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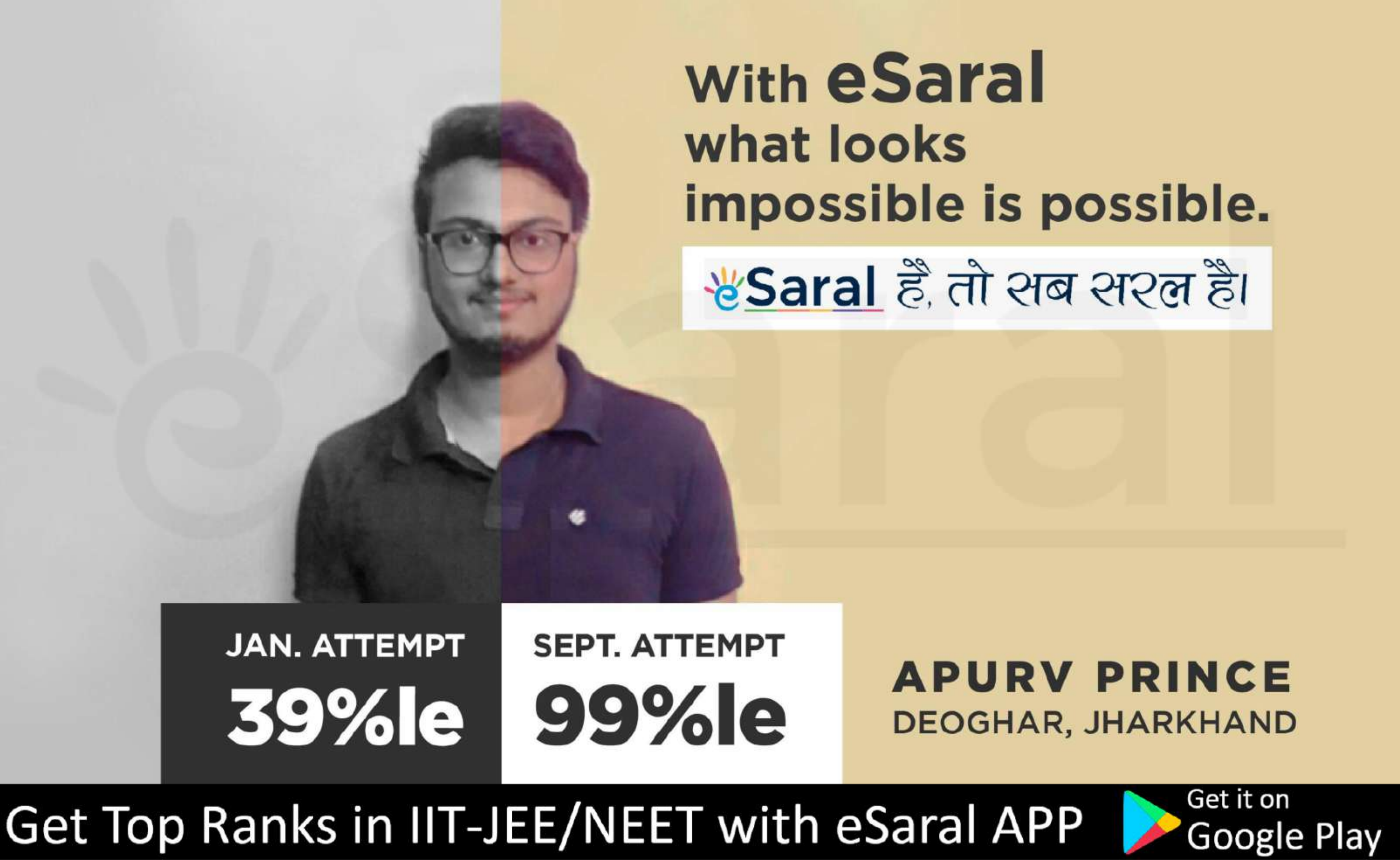
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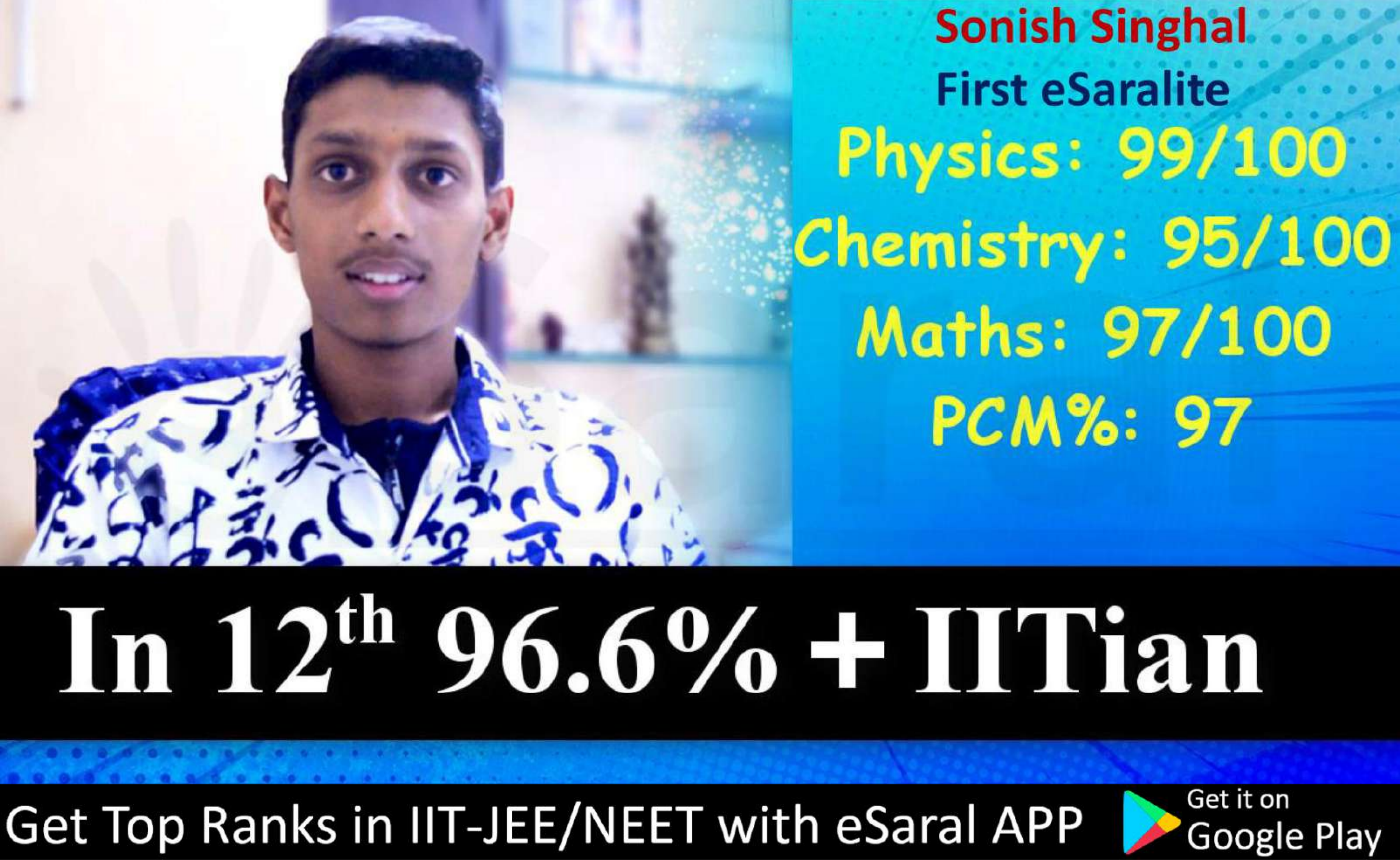
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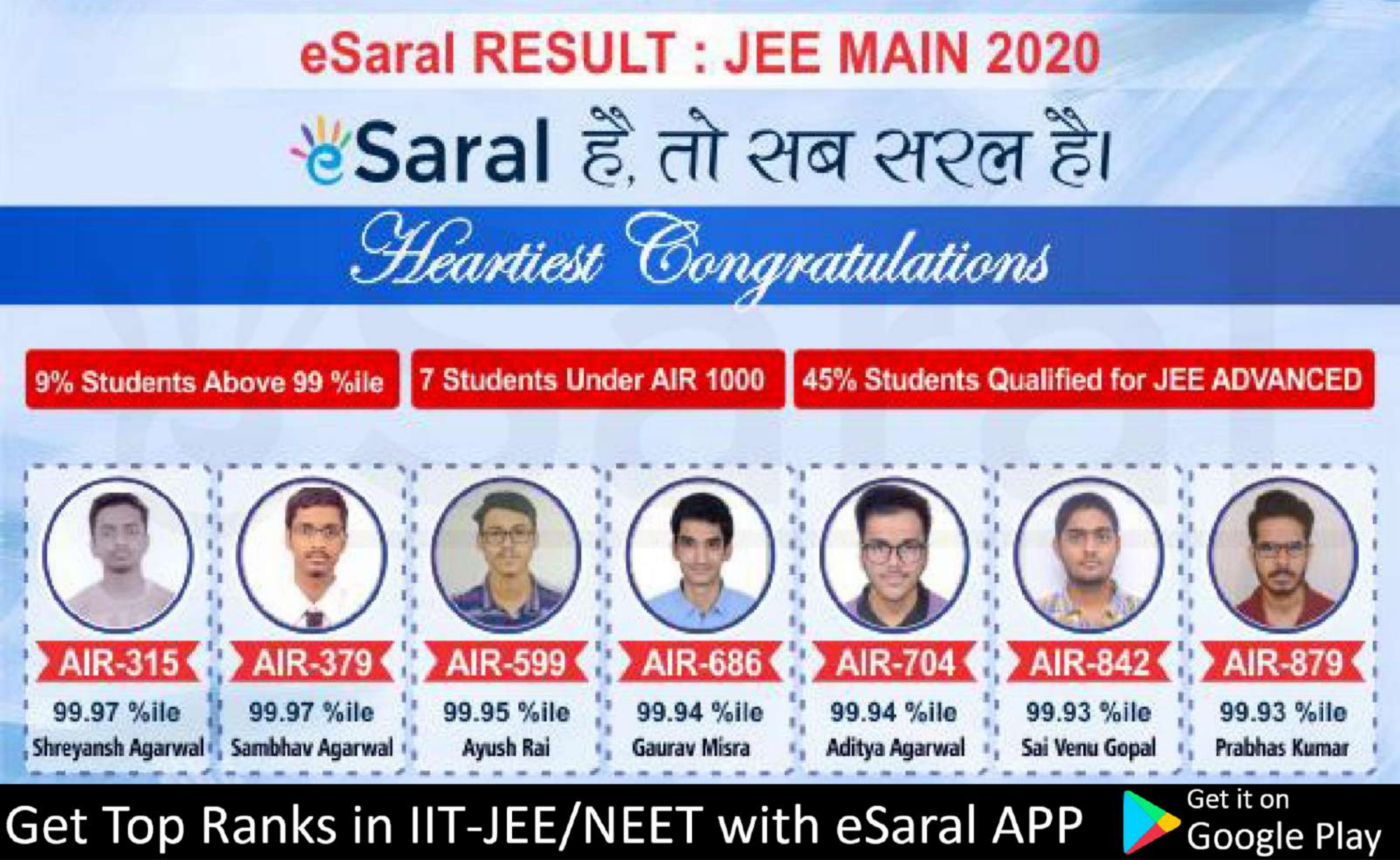
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