Nishant Jindal

Heat Transfer

Mode of heat transfer

Conduction (Jee Mains)

- Medium required but medium doesn't move.
- Heat flow due to drifting of free electrons
- Occur in metallic body

Convection

- Medium required
- Heat transfer takes place due to actual Movement of medium
- Two type
  - → Natural Convection
  - → Forced Convection

Radiation

- Medium not required for heat transfer.
- Heat transfer through E.M Wave.

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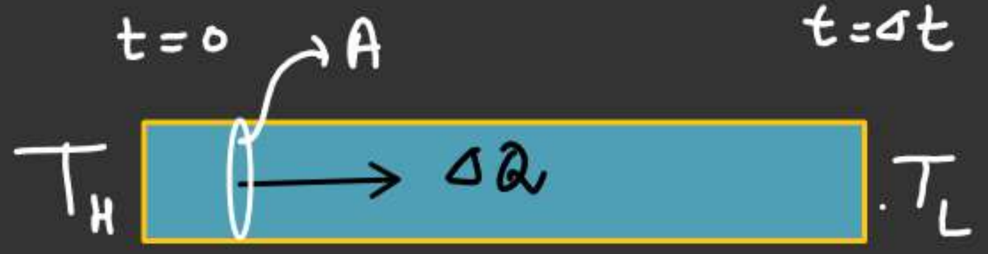
Heat Transfer

CONDUCTION

$$\frac{\Delta Q}{\Delta t} \propto \frac{A(T_L - T_H)}{L}$$

$T_L \rightarrow T_f$

$T_H \rightarrow T_i$



$T_H > T_L$

$$J/s \leftarrow \left(\frac{\Delta Q}{\Delta t}\right) = \ominus \frac{KA(T_L - T_H)}{L} \longrightarrow \boxed{\frac{\Delta Q}{\Delta t} = \frac{KA(T_H - T_L)}{L}}$$

$\downarrow$

P

ΔQ

Heat flow from higher to lower temp

K = thermal conductivity of material

A = crossection area

L = length of the rod.

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Heat Transfer

$$\frac{\Delta Q}{\delta t} = \frac{KA(T_H - T_L)}{L}$$

$$\Delta T = T_f - T_i = (T_L - T_H)$$

$$\frac{\Delta Q}{\Delta t} = -\frac{KA}{L}(\Delta T)$$

$$\boxed{\frac{dQ}{dt} = -KA\frac{dT}{dx}}$$

$L \rightarrow dx$

$\Delta T \rightarrow dT$

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Heat Transfer

Concept of Steady - state heat flow

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

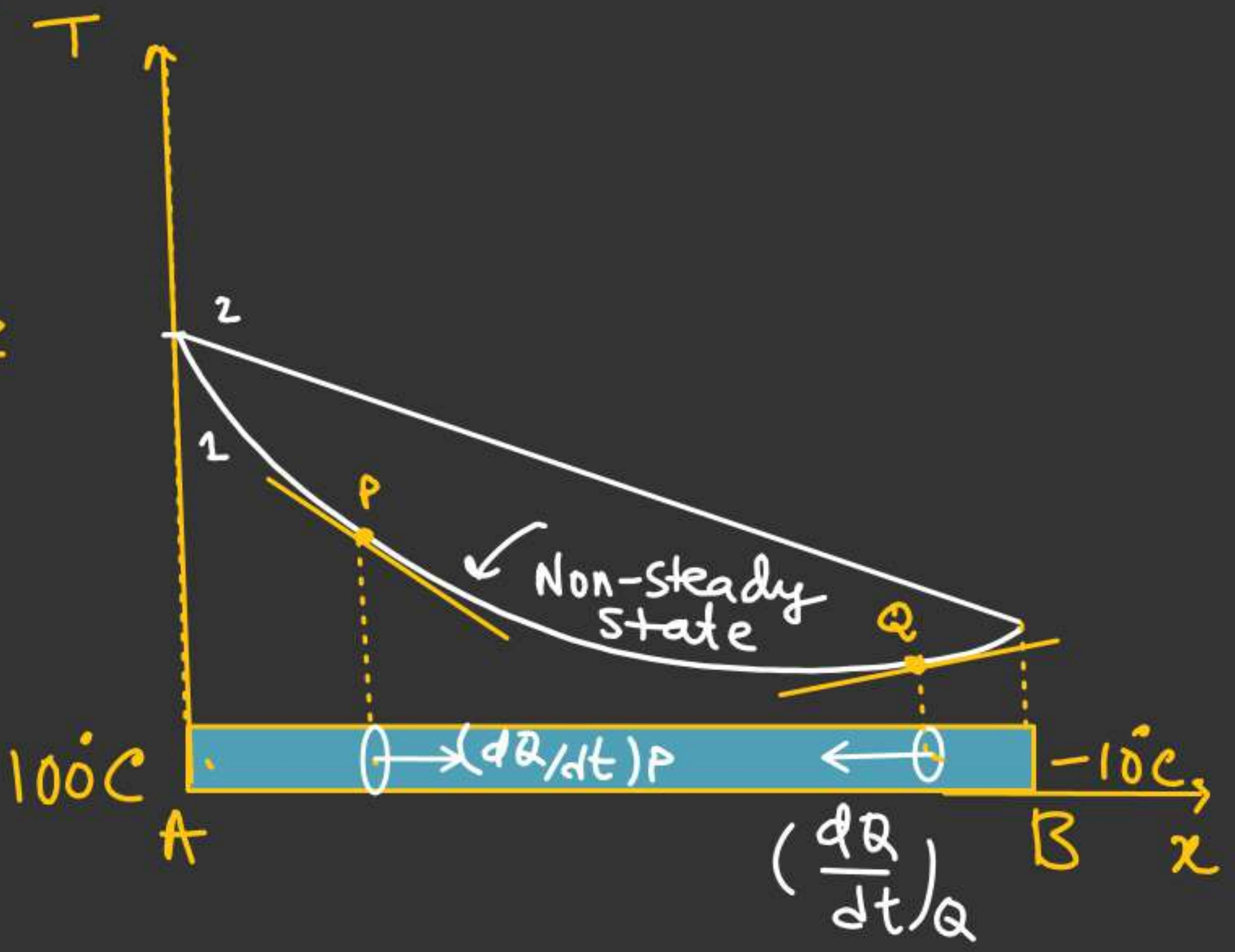
$\Downarrow$

Slope of tangent on T Vs x Curve

At P, $\frac{dT}{dx} < 0$, $\left(\frac{dQ}{dt}\right)_P > 0$

At Q, $\frac{dT}{dx} > 0$, $\left(\frac{dQ}{dt}\right)_Q < 0$

graph 1 $\rightarrow$ (Non - steady state heat flow.)



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Heat Transfer

Concept of Steady - state heat flow

$$\frac{dQ}{dt} = -KA\underbrace{\left(\frac{dT}{dx}\right)}_{\Downarrow}$$

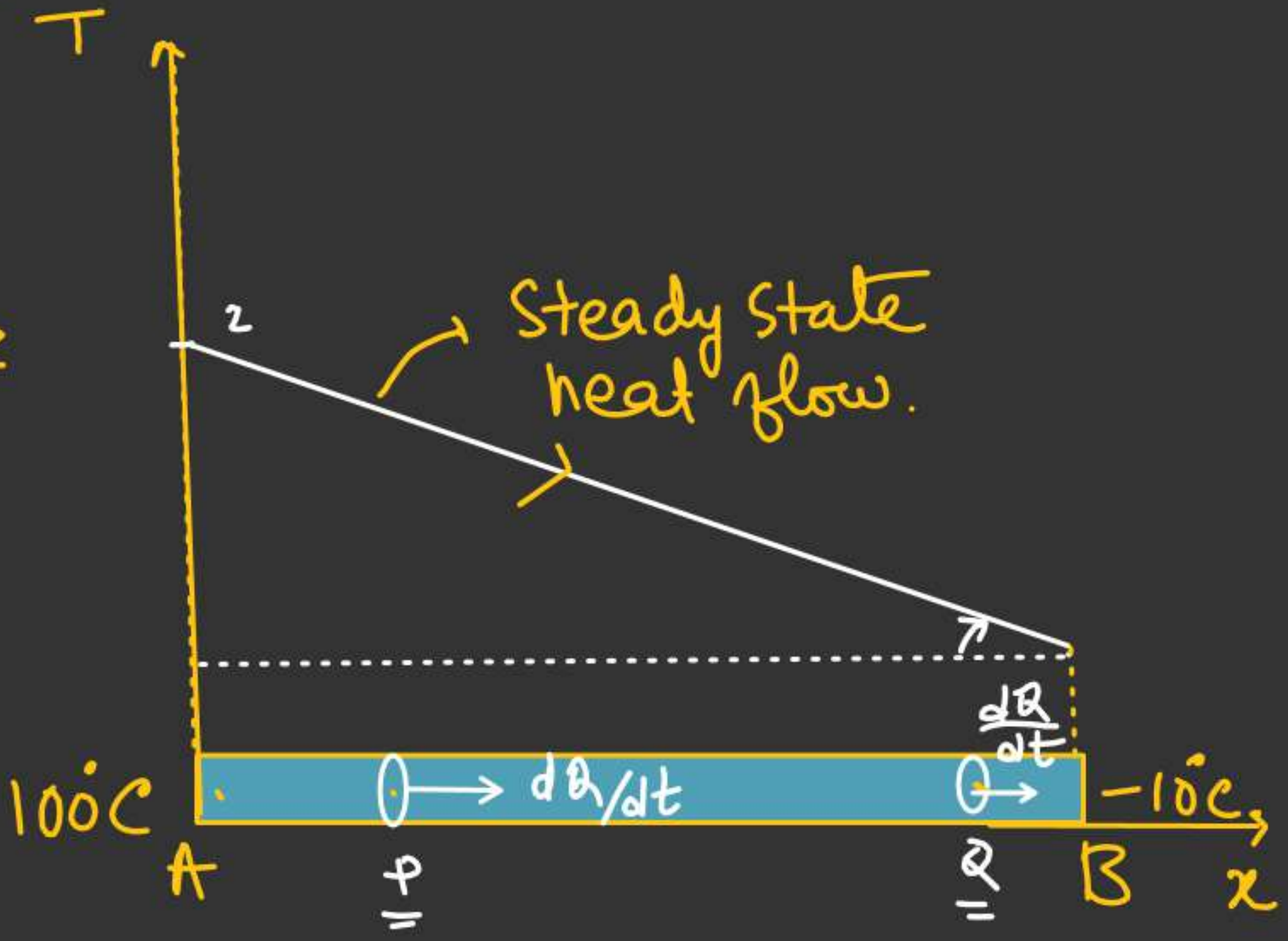
Slope of tangent on T Vs x Curve

For graph-2

$$\frac{dT}{dx} = \text{Constant} \ \& \ -\text{ve}.$$

$$\frac{dQ}{dt} = \text{Constant} \ \& \ +\text{ve}$$

ie from A to B

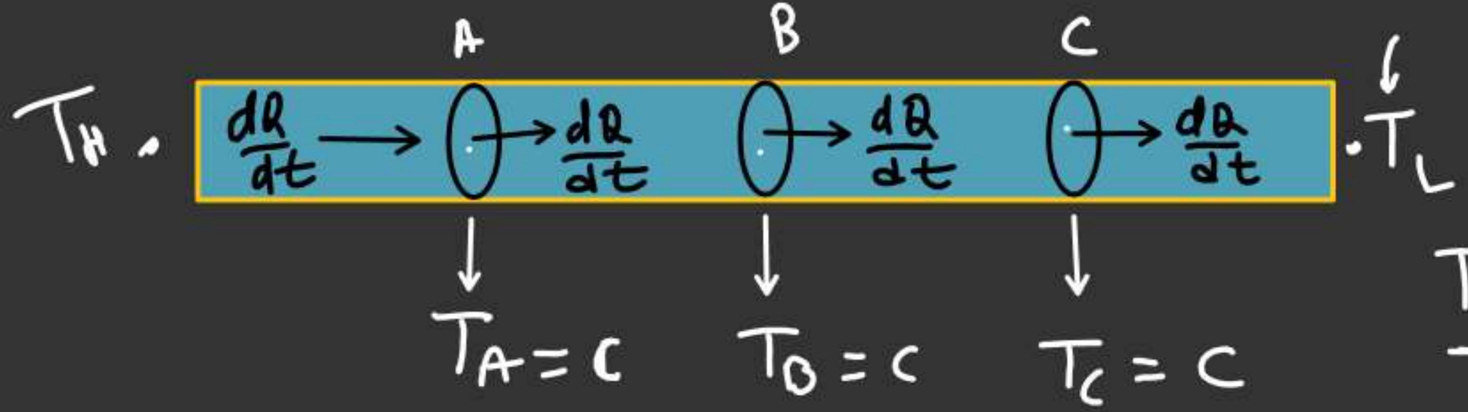


Graph-2 → steady state heat flow

→ Heat flow is constant through each crosssectional area

Heat Transfer

Steady State



$T_A > T_B > T_C$

At the time of steady state whatever be the temp assign by each part of the rod will remain Constant as $\frac{dQ}{dt}$ is constant

i.e neither any part of rod absorb any heat nor released any heat

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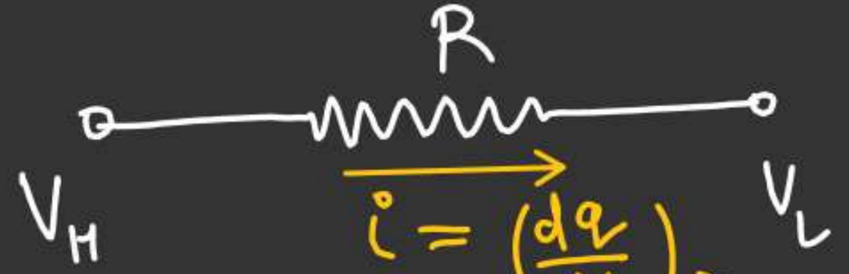
Eq Electrical Ckt



$i = \left(\dfrac{dq}{dt}\right)$ Rate of flow of charge

$$V_H - V_L = iR$$

$$i = \left(\frac{V_H - V_L}{R}\right)$$

$$\frac{\Delta Q}{\Delta t} = \frac{KA(T_H - T_L)}{L}$$

$$\left(\frac{\Delta Q}{\Delta t}\right) = \frac{T_H - T_L}{\left(L/KA\right)}$$

$\left(\dfrac{\Delta Q}{\Delta t}\right)$ ⇓ Rate of flow of heat w.r.t time

$\left(L/KA\right)$ ⇓ R_{th}

⇓

$$i_{th} = \left(\frac{T_H - T_L}{R_{th}}\right)$$

i_{th} ← thermal current

$$R_{th} = \frac{L}{KA}$$

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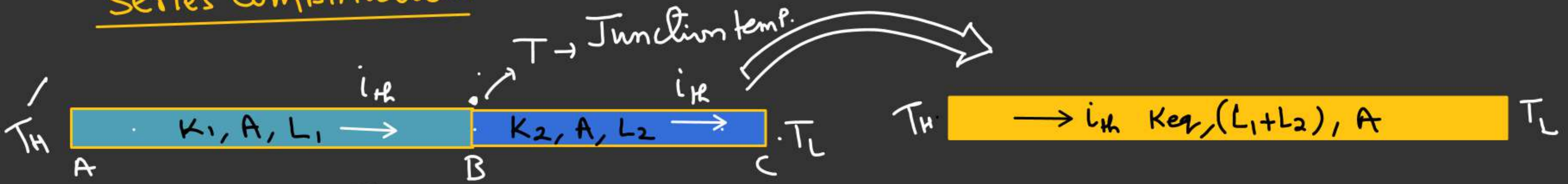
Heat Transfer

Equivalent thermal Conductivity

Equivalent rod

Series Combination



$R_{th_1} = \frac{L_1}{K_1 A}$ $\quad R_{th_2} = \frac{L_2}{K_2 A}$

Junction temp

For AB → $i_{th} = \frac{K_1 (T_H - T) A}{L_1}$

For BC → $i_{th} = \left(\frac{T - T_L}{L_2}\right) K_2 A$

$$\frac{K_1 \cancel{A}}{L_1}(T_H - T) = \frac{K_2 \cancel{A}}{L_2}(T - T_L)$$

$$\frac{K_1 T_H}{L_1} + \frac{K_2 T_L}{L_2} = \left(\frac{K_2}{L_2} + \frac{K_1}{L_1}\right) T$$

$$\left(\frac{K_1 L_2 T_H + K_2 L_1 T_L}{K_2 L_1 + K_1 L_2}\right) = T$$

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Equivalent thermal Conductivity

$$\left(\frac{K_1 L_2 T_H + K_2 L_1 T_L}{K_2 L_1 + K_1 L_2}\right) = T$$

$$\boxed{T = \left(\frac{T_H + T_L}{2}\right)}$$

If Rods are identical

$$L_1 = L_2 = L$$

$$K_1 = K_2 = K$$

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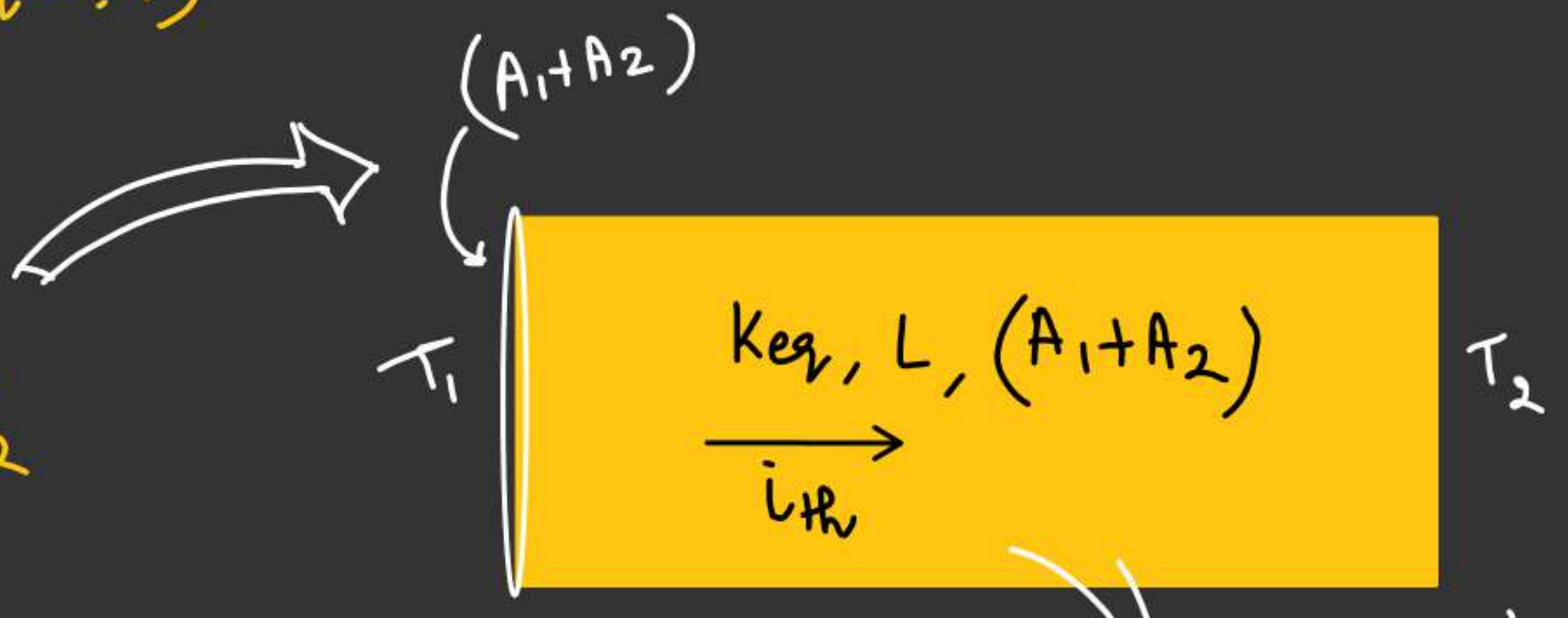
Heat Transfer

Parallel Combination ($K_{eq} = ??$)

$T_1 > T_2$



$$R_{eq} = \frac{L}{K_{eq}(A_1 + A_2)}$$

$$R_{th_1} = \frac{L}{K_1 A_1}$$

$$R_{th_2} = \frac{L}{K_2 A_2}$$

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Heat Transfer

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

$$\frac{1}{\frac{L}{K_{eq}(A_1+A_2)}} = \frac{1}{\left(\frac{L}{K_1A_1}\right)} + \frac{1}{\left(\frac{L}{K_2A_2}\right)}$$

$$\frac{K_{eq}(A_1+A_2)}{\cancel{L}} = \frac{K_1A_1}{\cancel{L}} + \frac{K_2A_2}{\cancel{L}}$$

$$K_{eq} = \left(\frac{K_1A_1+K_2A_2}{A_1+A_2}\right) ✓$$

if rods have same crossectional area

$$A_1 = A_2$$

$$K_{eq} = \left(\frac{K_1+K_2}{2}\right)$$

if Rods are identical also ie $K_1 = K_2 = K$ & $A_1 = A_2 = A$

$$\underline{K_{eq} = K}$$

Heat Transfer

Heat flow through Variable Crossectional area

Whatsapp-No → Only message for group formation

(Only for XIth batch JEE-2025)

Name → ??

Batch → ??

$\boxed{7080800241}$