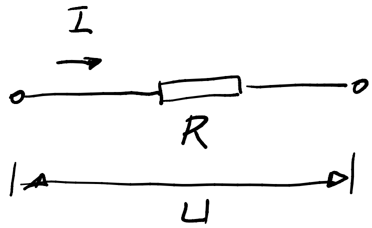
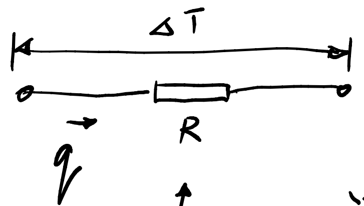
Thermal Circuits

Chapter 1 & 2.

Chapter 3.



Current $I = \frac{U}{R}$ voltage, resistance



thermal resistance

$$\boxed{q = \frac{\Delta T}{R}}$$

$$q = \frac{\Delta T}{R} \quad [°C \text{ or } K]$$

[W]

$$\Rightarrow R = \frac{\Delta T}{q} \quad [°C/W \text{ or } K/W]$$

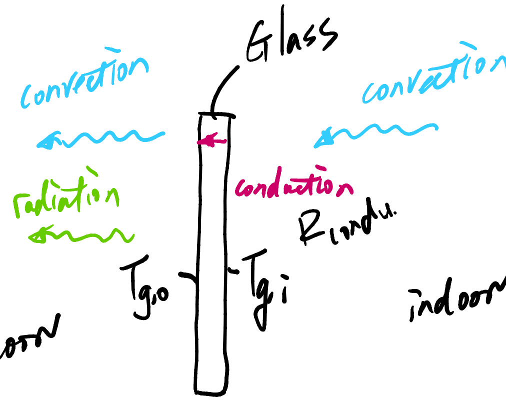
Winter in Columbia $T_1 = 0°C$

sky at 4K $-269.15°C$

T_{sky}

outdoor

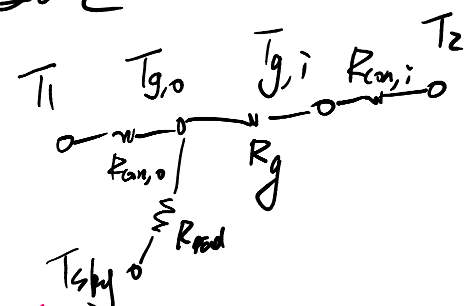
R_{rad}



$R_{condu.}$

$R_{conv.}$ $T_2 = 20°C$

indoor

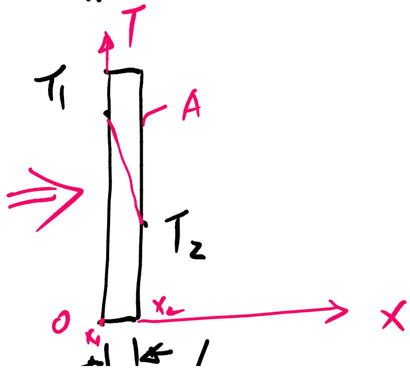


← q heat loss ?

i) 1-D conduction across a flat plate in steady state.

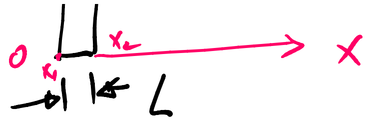
$$q = -k \cdot A \cdot \frac{dT}{dx} \xrightarrow{\text{simplified}} q = k \cdot A \cdot \frac{\Delta T}{L} \text{ — positive}$$

$\frac{y_2 - y_1}{x_2 - x_1}$



$T_1 > T_2$

positive



$$= \frac{T_2 - T_1}{x_2 - x_1}$$

$T_1 > T_2$

$$q = -K \cdot A \cdot \frac{dT}{dx} = -K \cdot A \cdot \frac{T_2 - T_1}{x_2 - x_1} = K \cdot A \cdot \frac{T_1 - T_2}{L}$$

$$q = KA \frac{\Delta T}{L} \Rightarrow \frac{\Delta T}{q} = \boxed{\frac{L}{K \cdot A} = R_{plate}}$$

$$\left(R = \frac{\Delta T}{q} \right)$$

thickness

$$R_{plate} = \frac{L}{K \cdot A}$$

area

thermal conductivity

$[°C/W \text{ or } K/W]$

$$q = \frac{\Delta T}{R_{plate}}$$

or °C/W

ii> convection

$$q = h_c \cdot A \cdot \Delta T \Rightarrow \frac{\Delta T}{q} = R_{conv.} = \frac{1}{h_c \cdot A} \left[\frac{K}{W}\right]$$

iii> Radiation

$$q = \varepsilon \cdot \sigma \cdot A \cdot (T_1^4 - T_2^4)$$

$$= \varepsilon \cdot \sigma \cdot A \cdot (T_2^2 + T_1^2)(T_1 + T_2)\underbrace{(T_1 - T_2)}_{\Delta T}$$

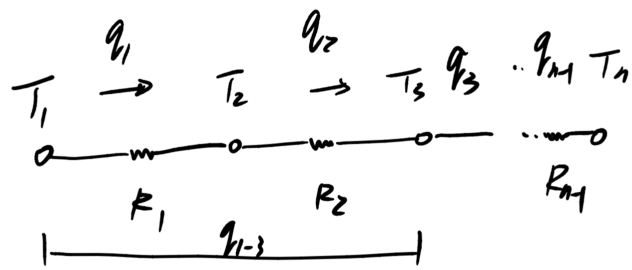
$$= \underbrace{\varepsilon \cdot \sigma \cdot (T_1^2 + T_2^2)(T_1 + T_2)}_{h_r} \cdot A \cdot \Delta T$$

$$q = h_r \cdot A \cdot \Delta T$$

$$\Rightarrow \frac{\Delta T}{q} = \frac{1}{h_r \cdot A} = R_{rad}.$$

— R arrangements

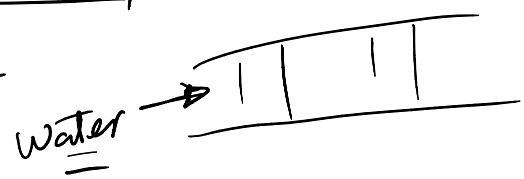
i> In series



$q_1 = q_2 = q_3 = \cdots = q_{n-1} = q$ ✓

$= q_{1-3}$

$T_1 > T_2$



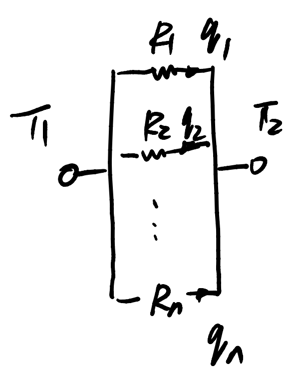
$$q = \frac{\Delta T}{R}$$

R: Rtotal between T_1 & T_n

$$R_{total} = R_1 + R_2 + \cdots + R_{n-1} = \sum_{i=1}^{n-1} R_i$$

ii> In parallel

$\Delta T_1 = \Delta T_2 = \cdots = \Delta T_n$

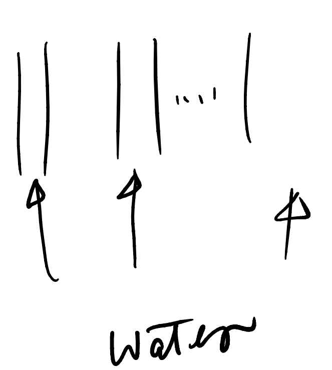


$T_1 > T_2$

$q = q_1 + q_2 + \cdots + q_n$

$$R_{total} = \left(\frac{1}{R_1} + \frac{1}{R_2} + \cdots + \frac{1}{R_n}\right)^{-1}$$

$$q = \frac{\Delta T}{R_{total}}$$



$$\Rightarrow q = q_1 + q_2 + \cdots + q_n$$

$$\frac{\cancel{\Delta T}}{R} = \frac{\cancel{\Delta T_1}}{R_1} + \frac{\cancel{\Delta T_2}}{R_2} + \cdots + \frac{\cancel{\Delta T_n}}{R_n}$$

$$\frac{\cancel{\Delta T}}{R_{total}} = \frac{\cancel{\Delta T_1}}{R_1} + \frac{\cancel{\Delta T_2}}{R_2} + \cdots + \frac{\cancel{\Delta T_n}}{R_n}$$

$$\frac{1}{R_{total}} = \frac{1}{R_1} + \frac{1}{R_2} + \cdots + \frac{1}{R_n}$$