Dr. Supriya Kumari
Asstt. Prof. of Physics

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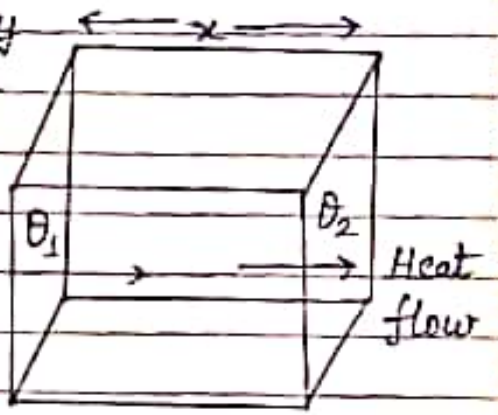
Conduction of Heat

Conduction is the process of transference of heat in a medium without involving the actual motion of the particles of the medium. In solids, the transmission of heat is mainly by the process of conduction and this takes place through free electrons. Free electrons carry energy readily from the hotter to the colder region.

Coefficient of Thermal Conductivity (K):

Let us consider two isothermal surfaces seperated by a distance x, each of area A at temperature θ_1 and θ_2 respectively $(\theta_1 > \theta_2)$.

Experiments shows that in steady state the amount of heat energy that flows from one surface to other is



(i) directly proportional to the area A.

(ii) directly proportional to $(\theta_1 - \theta_2)$.

(iii) directly proportional to time of flow t, and

(iv) inversly proportional to the distance x, i.e

$$\theta \propto \frac{A(\theta_1 - \theta_2)t}{x}$$

$$\text{or, } \theta = \frac{KA(\theta_1 - \theta_2)t}{x} \quad \text{---} \quad (1)$$

Here, K is a constant of proportionality and depends

on the material of the rod and is called the coefficient of thermal conductivity or simply the thermal conductivity. If $A = 1$, $(\theta_1 - \theta_2) = 1$, $t = 1$ and $x = 1$ then $Q = K$. This enables the coefficient of thermal conductivity to be defined as — The quantity of heat flowing per second through unit area of cross section of an element of the material, of unit thickness when the difference of temperature between its faces is unity.

The quantity $\frac{\theta_1 - \theta_2}{x}$, which represents the rate of fall of temperature with distance in the direction of heat flow, is known as temperature gradient. When the temperature gradient is not uniform, it becomes necessary to reduce the quantity $\frac{\theta_1 - \theta_2}{x}$ to the limiting value $\frac{d\theta}{dx}$, and rewrite the relation (1) as

$$Q = -KA \cdot \frac{d\theta}{dx} t \quad \text{—— (2)}$$

The -ve sign on RHS indicates that $\frac{d\theta}{dx}$ is negative, since it represents ~~that~~ the rate of fall of temperature with distance.

The value of K depends on temperature. It increases slightly with increase of temperature.

Thermal diffusivity or thermometric conductivity (h):

It is defined as the ratio of coefficient of thermal conductivity to the heat capacity per unit volume, i.e.

$$h = \frac{K}{\rho S}$$

, where ρ = density of material
S = specific heat of material.