PROBLEM-SOLVING TACTICS

1. Problems of conduction can be easily solved by making analogy with current electricity (Problems like calculation of net conductance of series and parallel connection. Actually, the way in which steady state is achieved in heat transfer and current electricity is very similar. At steady state considering a cylindrical rod, potential at each point becomes constant in current electricity and so does temperature in heat transfer. The amount of charge transferred per unit time is related in same way to potential as that of heat energy transferred relates to temperature difference and the constant of proportionality have similar properties.)

2. Most of the problems involve concepts of integration, so be careful with infinitesimal elements. Basically, try to be physically involved in the problem and understand it event by event so that you learn more. Toughness in most of the questions is involved only in its mathematical analysis.

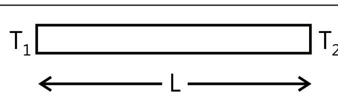
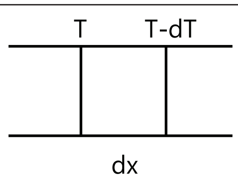
3. Problems from radiation and law of cooling also generally involve integration which becomes necessary to do at times. However an approximate approach is also available in case of law of cooling useful in solving problems without involving integration.

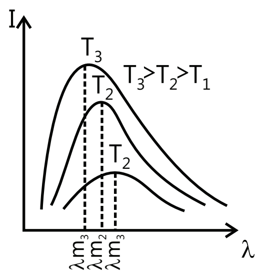
4. Laws must be carefully known because many questions directly focus on understanding of laws rather than involving calculations (Example - If temperature of a body is doubled, find the ratio of maximum wavelength for final and initial state.)

5. Noting down the known and asked quantities and thinking of a link between them will always prove to be a good way.

6. Questions from this topic usually come in a hybrid involving concepts of other topics like thermodynamics, gaseous state and calorimetry. So one must be strong in their concepts too!!

FORMULAE SHEET

S. No.	Term	Descriptions
1.	Conduction	Due to vibration and collision of medium particles.
2.	Steady state	In this state heat absorption stops and temperature gradient throughout the rod becomes constant i.e. $\frac{dT}{dx} = \text{constant}$.
3.	Before steady state	Temp of rod at any point changes. **Note:** If specific heat of any substance is zero, it can be considered always to be in steady state.
4.	Ohm's law for thermal Conduction in Steady state	Let the two ends of rod of length L is maintained At temp T_1 and $T_2 \left(T_1 > T_2\right)$ Thermal Current $\frac{dQ}{dT} = \frac{T_1 - T_2}{R_{Th}}$. Where $R_{Th} = \frac{L}{KA}$ (L is length of material, K is coefficient of thermal conductivity, A is area of cross- section) 
5.	Differential form of Ohm's law	$\frac{dQ}{dT} = KA\frac{dT}{dx}$ $\frac{dT}{dx}$ = Temperature gradient 
6.	Convection	Heat transfer due to movement of medium particles.

7.	Radiation	Every body radiates electromagnetic radiation of all possible wavelength at all temp>0 K
8.	Stefan's Law	Rate of heat emitted by a body at temp T K from per unit area $E = \sigma T^4 J/sec/m^2$ Radiation power $\frac{dQ}{dT} = P = \sigma A T^4 watt$ If body is placed in a surrounding of temperature T_s $\frac{dQ}{dT} = \sigma A(T^4 - T_s^{\ 4})$ valid only for black body Emissivity or emmisive power $e = \frac{\text{heat from general body}}{\text{heat from black body}}$ If temp of body falls by dT in time dt $\frac{dT}{dt} = \frac{eA\sigma}{ms}\left(T^4 - T_s^{\ 4}\right)$ (dT/dt=Rate of cooling)
9.	Newton's law of cooling	If temp difference of body with surrounding is small i.e. $T = T_s$ Then, $\frac{dT}{dt} = \frac{4eA\sigma}{ms}T_s^{\ 3}\left(T - T_s\right)$ So $\frac{dT}{dt} \propto \left(T - T_s\right)$
10.	Average form of Newton's law of cooling	If a body cools from T_1 to T_2 in time δt $\frac{T_1 - T_2}{\delta t} = \frac{K}{mS}\left(\frac{T_1 + T_2}{2} - T_S\right)$ (Used generally in objective questions) $\frac{dT}{dt} = \frac{K}{mS}(T - T_S)$ (For better results use this generally in subjective)
11.	Wien's black body radiation	At every temperature (>0K) a body radiates energy radiations of all wavelengths. According to Wien's displacement law if the wavelength corresponding to maximum energy is λ_m then λ_m T=b where b= is a constant(Wien's Constant) T=Temperature of body 

Solved Examples

JEE Main/Boards

Example 1: A copper rod 2 m long has a circular cross section of radius 1 cm. One end is kept at 100°C and other at 0°C, and the surface is insulated so that negligible heat is lost through the surface. Find

(a) The thermal resistance of bar

(b) The thermal current H

(c) The temperature gradient $\frac{dT}{dx}$

(d) The temperature 25 cm from hot end. Thermal conductivity of copper is 401 W/m-K

Sol: Recall the formula of heat transfer.

(a) Thermal resistance

$$R = \frac{1}{kA} = \frac{1}{k(\pi r^2)} \text{ or } R = \frac{2}{(401)(\pi)(10^{-2})^2} = 15.9K/W$$

(b) Thermal current, $H = \frac{\Delta T}{R} = \frac{\Delta\theta}{R} = \frac{100}{15.9}$ or

$H = 6.3W$

(c) Temperature gradient

$$= \frac{0-100}{2} = -50K/m = -50°C/m$$