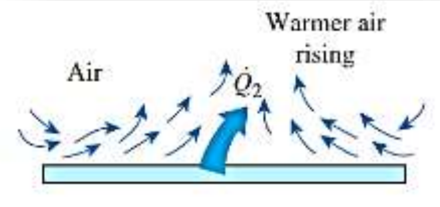
Convection Heat Transfer and Applications in Electronics Equipment

Mr.S.Arunkumar

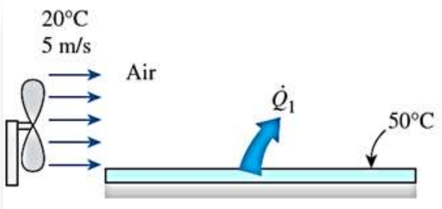
AP/Mech

CONVECTIVE HEAT TRANSFER

- HT through Fluid in the Presence of Bulk Fluid Motion
- Natural and Forced



- Fluid Motion Caused by Natural Means (by buoyancy)
- Cooling Down hot Coffee without a Fan . . .

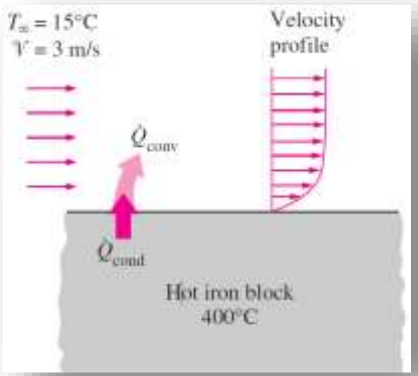


- Fluid Forced to Flow by External Means (by external Force)

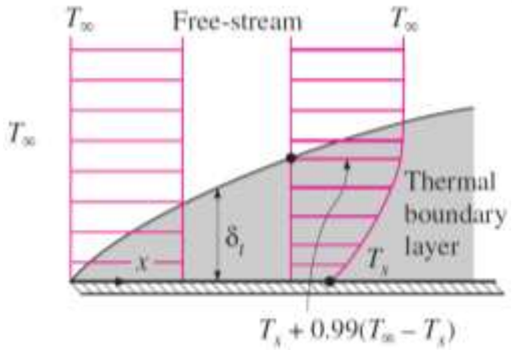
Governed by Newtons Law of Cooling $\ldots\ Q = hAdT$

COMPONENTS of CONVECTION

Conduction + Advection

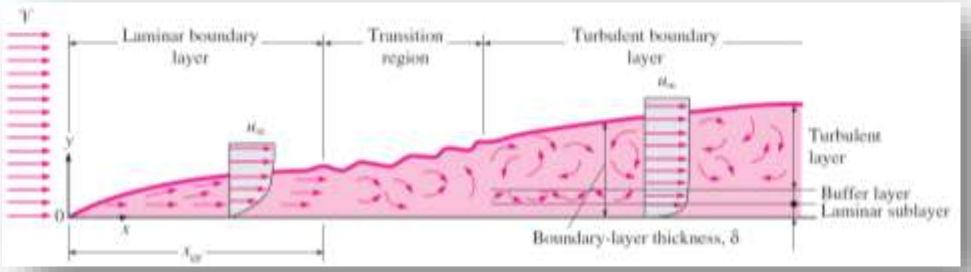


- Flow Properties Like v, ρ, μ, γ, and so on
- Thermal & Velocity Boundary Layers, and
- Flow Patterns like Laminar and Turbulent Flows



- Reynolds Number

$$Re = \frac{\rho v D}{\mu}$$



- Prandtl Number and,

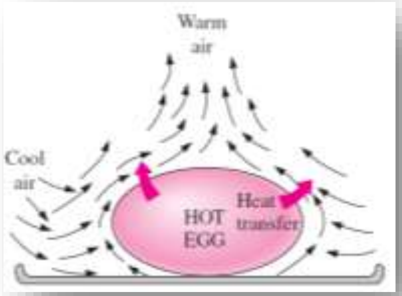
$$Pr = \frac{\mu C_p}{k}$$

- Nusselt numbers

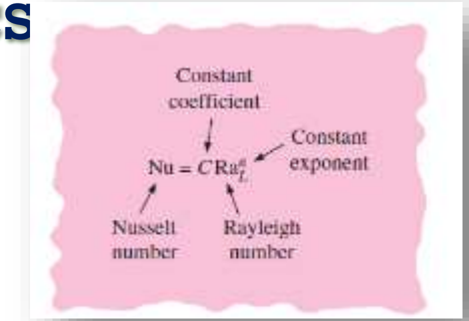
$$Nu = \frac{hL_c}{k}$$

$$Q = hAdT$$

HEAT TRANSFER COEFFICIENTS

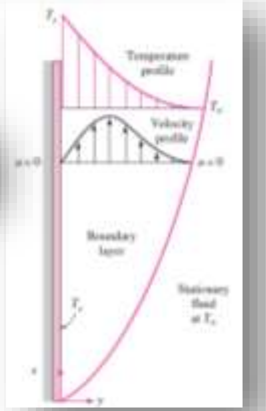


- Quantitative Characteristic between Wall & Fluid
- Depends on Thermal & Hydrodynamic Characteristics
- Hydrodynamic and Thermal Boundary Conditions
- Nusselt Correlations for General Estimation
- Enthalpy Difference for Varying Heat Capacity
- Overall HTC for Liquid to Liquid HT

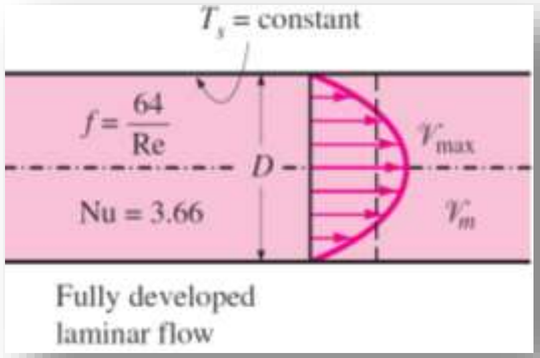


$$Nu = \frac{hL_c}{k} = C(Gr_L\,Pr)^n = C\,Ra_L^n$$

$$Ra_L = Gr_L\,Pr = \frac{g\beta(T_s - T_\infty)L_c^3}{\nu^2}\,Pr$$

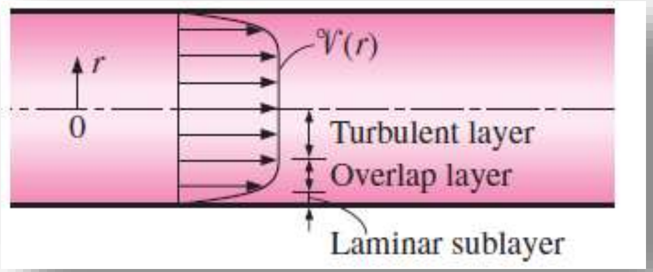


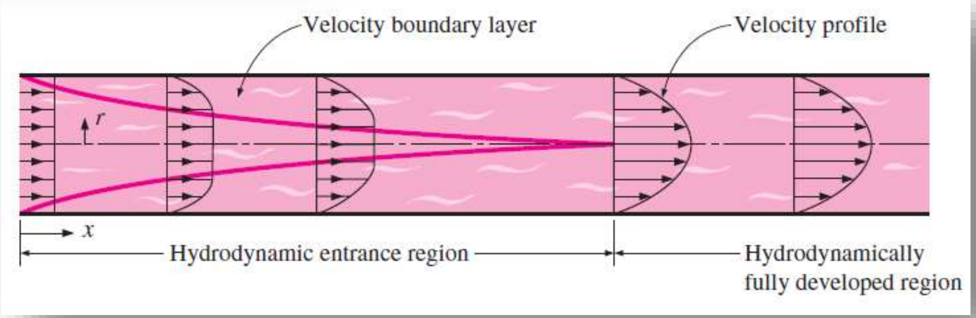
CONVECTIVE HEAT TRANSFER - ESTIMATION

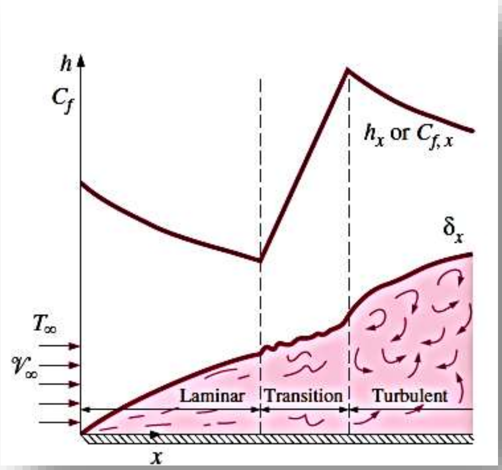


Laminar: $$Nu_x = \frac{h_x x}{k} = 0.332\, Re_x^{0.5}\, Pr^{1/3} \qquad Pr > 0.60$$

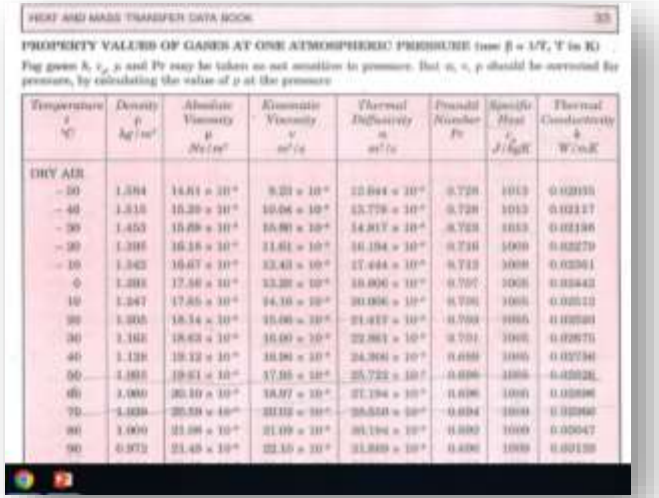
Turbulent: $$Nu_x = \frac{h_x x}{k} = 0.0296\, Re_x^{0.8}\, Pr^{1/3} \qquad \begin{matrix} 0.6 \le Pr \le 60 \\ 5 \times 10^5 \le Re_x \le 10^7 \end{matrix}$$





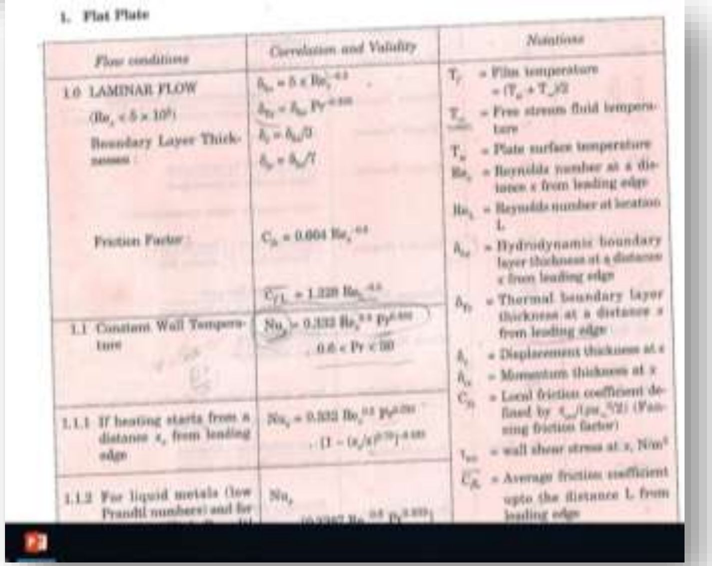


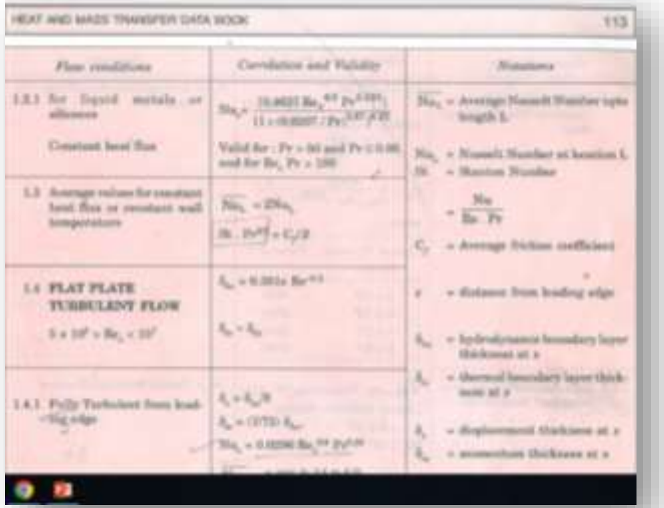
CONVECTIVE HEAT TRANSFER - ESTIMATION



Laminar: $$\mathrm{Nu}_x = \frac{h_x x}{k} = 0.332\,\mathrm{Re}_x^{0.5}\,\mathrm{Pr}^{1/3} \qquad \mathrm{Pr} > 0.60$$

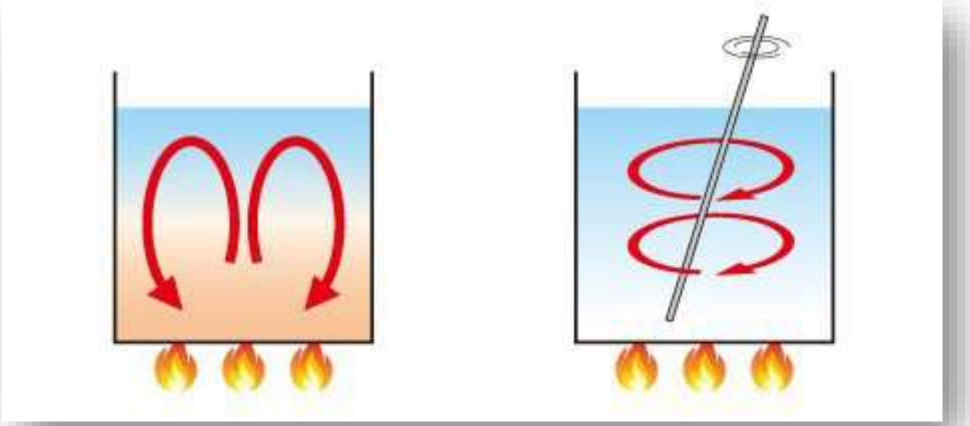
Turbulent: $$\mathrm{Nu}_x = \frac{h_x x}{k} = 0.0296\,\mathrm{Re}_x^{0.8}\,\mathrm{Pr}^{1/3} \qquad 0.6 \le \mathrm{Pr} \le 60, \quad 5 \times 10^5 \le \mathrm{Re}_x \le 10^7$$





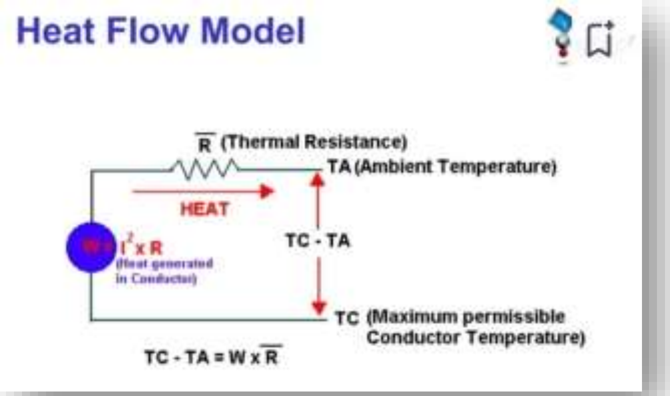
CONVECTIVE VS NATURAL HEAT TRANSFER

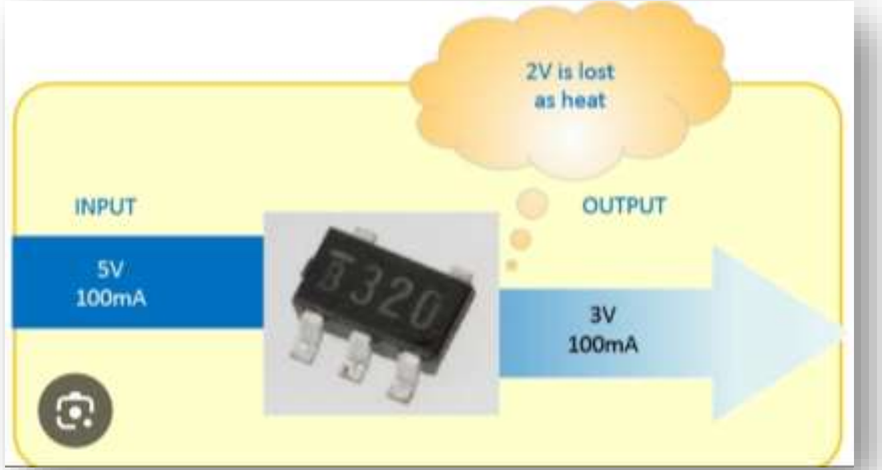
- Motion within Fluid – Density Difference
- Motion Caused by External Agent like **ower**



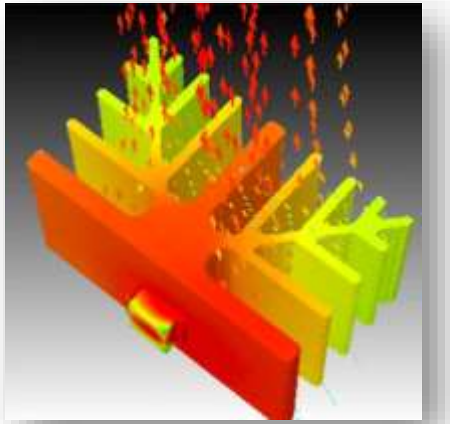
CONVECTION HT IN ELECTRONICS

- Need of Cooling Electronic Components
- Flow of Electron generates Heat
- Evacuation Needed to Maintain below BDT
- Increased Area Enhances Better HT
- Cooling Inevitable

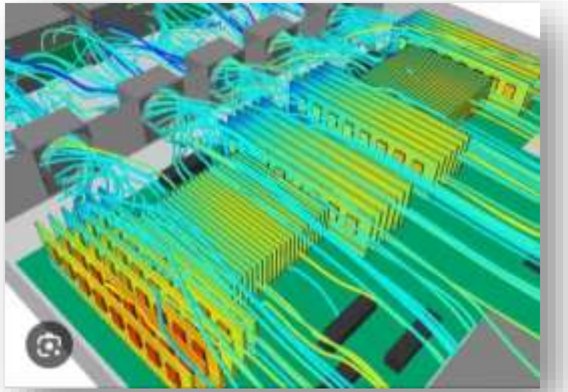


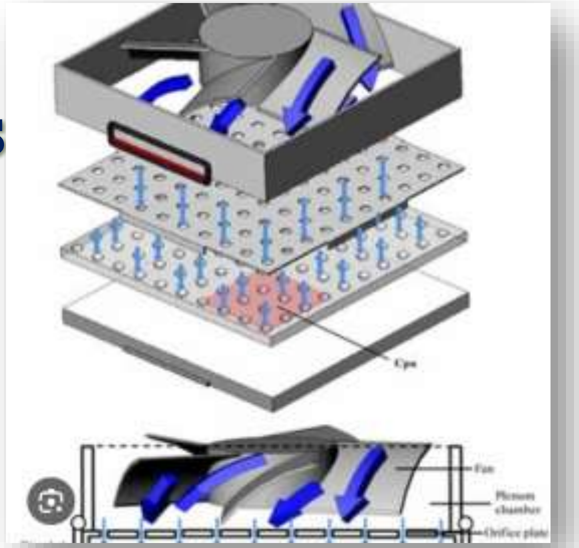


FORCED HT in COMPONENT COOLING



- Evacuation of Heat - Continuous
- Failing to Evacuate Breaks Down Component
- Stagnation Possible in Natural Convection
- Mostly Turbulent Pattern Exists
- Fans Adopted for Cooling

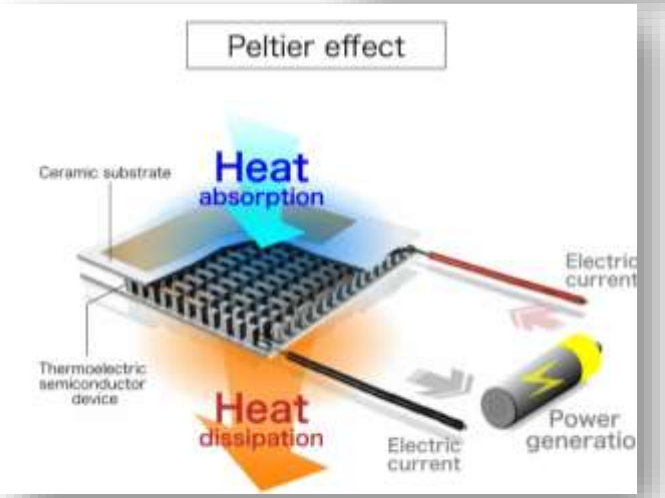




FORCED HT Efficient with FINS

- Increased Area Obtained through Fins

- Enhances Better Evacuation Rate
- Heat Transfer Area Exposes Well
- Miniaturization Balanced by Fins
- Great Scope for Cooling



RECAP . . .

- Heat Transfer By Convection – Property Oriented
- Natural and Forced Convection – Flow Pattern Dependent
- Miniaturization Makes Cooling Inevitable
- Cooling Module Design – Never Ending
- Fins – Vital in Cooling Modules
- Complexity Minimized with Numerical Modelling