Welcome to ME516: Macroscale Heat Transfer

- Open Website & Read intro
- Open Syllabus & Read

* So what is Heat Transfer besides redundant?

Heat: is the transfer of energy due to a temperature gradient.

- Conduction: occurs due to the interaction of micro-scale energy carriers.
- Convection: occurs when conduction happens to a medium that is flowing or free to move.
- Radiation: occurs when electromagnetic waves (e.g., light) transfer energy.

Principle Microscale Energy Carriers

**Solid**
- Mechanisms
  1. Electron/Hole transport (Thermoelectric generators)
  2. Phonon (Lattice Vibrations)
  3. Radiation (EM waves/photons)
  4. Fluid particle translation, vibration, rotation
  5. Random Collisions

**Liquid**

**Gas**

* When the distance between microscale carrier interaction (\(L_{\text{mfp}}\)) is much less than the length scale (\(L\)) that matters.

\[ k_n = \frac{L_{\text{mfp}}}{L} \ll 1 \text{ then we can lump these interactions into 1 property.} \]
Thermal Conductivity $k \left( \frac{W}{m \cdot K} \right)$ is used to calculate heat transfer via Fourier's Law: $q'' = -k \frac{dT}{dx}$ where $q''$ is heat flux in direction $\hat{n}_x$.

$\frac{dT}{dx}$ is the temperature gradient in $x$.

$m_s = \# \text{density of the energy carriers (} \frac{\#}{m^2})$

$v_m = \text{velocity of the energy carriers (} m/s)$

$k_p\frac{v_m}{m_s} = \text{average distance between interactions (} m)$

$c_m = \text{ratio of the energy of its carrier to its temperature}$

- Left to right:
  
  $q'' \approx n_m v_m c_m T_x - l_m \frac{dT}{dx} \left( \frac{2l_m}{2l_m} \right) =
  
  \Rightarrow q'' \approx n_m v_m c_m 2l_m (T_x + \text{temp}) - T_x - h_m =
  
  \Rightarrow q'' = -k \frac{dT}{dx}$

- Show Plot from Ekin
What causes the features & trends observed in this graph?
List as many mechanisms as you can think of.
It is often more convenient to calculate the total heat transfer $Q$ instead of the heat flux. This allows us to transform thermal conductivity into a convenient resistance value:

\[ R \left( \frac{k}{W} \right) = \frac{\text{temperature differential}}{\text{heat transfer rate}} \]

\[ \frac{\Delta T}{Q} \Rightarrow R = \frac{\Delta T}{Q} \]

However, the thermal resistance not only depends on thermal conductivity but on the particular geometry of the problem. See Table 12 pg. 17.

By quickly estimating the size of thermal resistances, you can quickly determine what physical features are relevant to an analysis. This is similar to a type of comparison known as a sensitivity study. If convective and radiative resistances are orders of magnitude less than conduction, you can often assume these terms are negligible in your analysis.

Next time we'll begin to create a process that will help us focus our efforts on 1-D conduction problems.