Mechanisms of Heat Transfer

- We want to know the rate at which energy is transferred
- There are various mechanisms responsible for the transfer:
  - **Conduction**
  - **Convection**
  - **Radiation**

Conduction

- The transfer can be viewed on an atomic scale
  - It is an exchange of energy between microscopic particles by collisions
    - The microscopic particles can be atoms, molecules or free electrons
  - Less energetic particles gain energy during collisions with more energetic particles
- Rate of conduction depends upon the characteristics of the substance

Conduction example

- The molecules vibrate about their equilibrium positions
- Particles near the heat source vibrate with larger amplitudes
- These collide with adjacent molecules and transfer some energy
- Eventually, the energy travels entirely through the pan

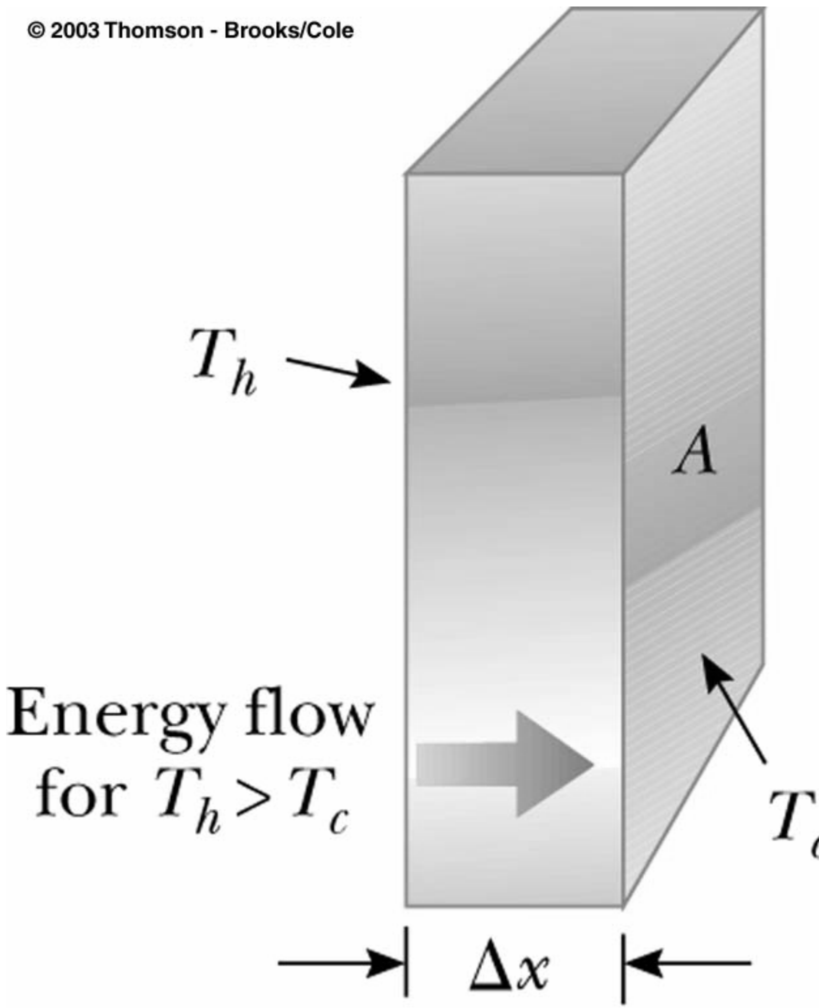
Conduction

- **Metals are good conductors**
  - They contain **large numbers of electrons** that are relatively free to move through the metal
  - They can transport energy from one region to another
- Poor conductors include asbestos, paper, and gases
- **Conduction can occur only if there is a difference in temperature between two parts of the conducting medium**

Conduction equation

- The slab at right allows energy to transfer from the region of higher temperature to the region of lower temperature
- The rate of transfer is given by:

$$\wp = \frac{Q}{\Delta t} = kA\left|\frac{dT}{dx}\right|$$

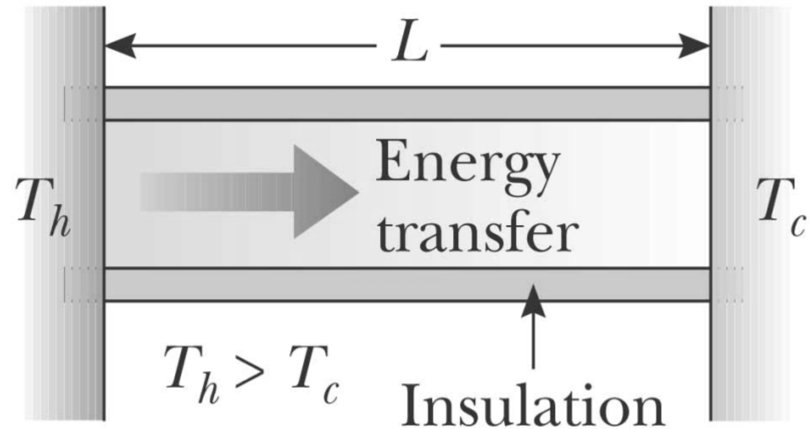


Conduction equation: explanation

- *A* is the cross-sectional area
- ?*x* is the thickness of the slab
  - Or the length of a rod
- *P* is in Watts when *Q* is in Joules and *t* is in seconds
- *k* is the *thermal conductivity* of the material
  - Good conductors have high *k* values and good insulators have low *k* values

Temperature Gradient

- The quantity $|dT / dx|$ is called the **temperature gradient** of the material
  - It measures the rate at which temperature varies with position



- For a rod, the temperature gradient can be expressed as:

$$\left|\frac{dT}{dx}\right| = \frac{T_h - T_c}{L}$$

Rate of Energy Transfer in a Rod

- Using the temperature gradient for the rod, the rate of energy transfer becomes:

$$\wp = kA\left(\frac{T_h - T_c}{L}\right)$$