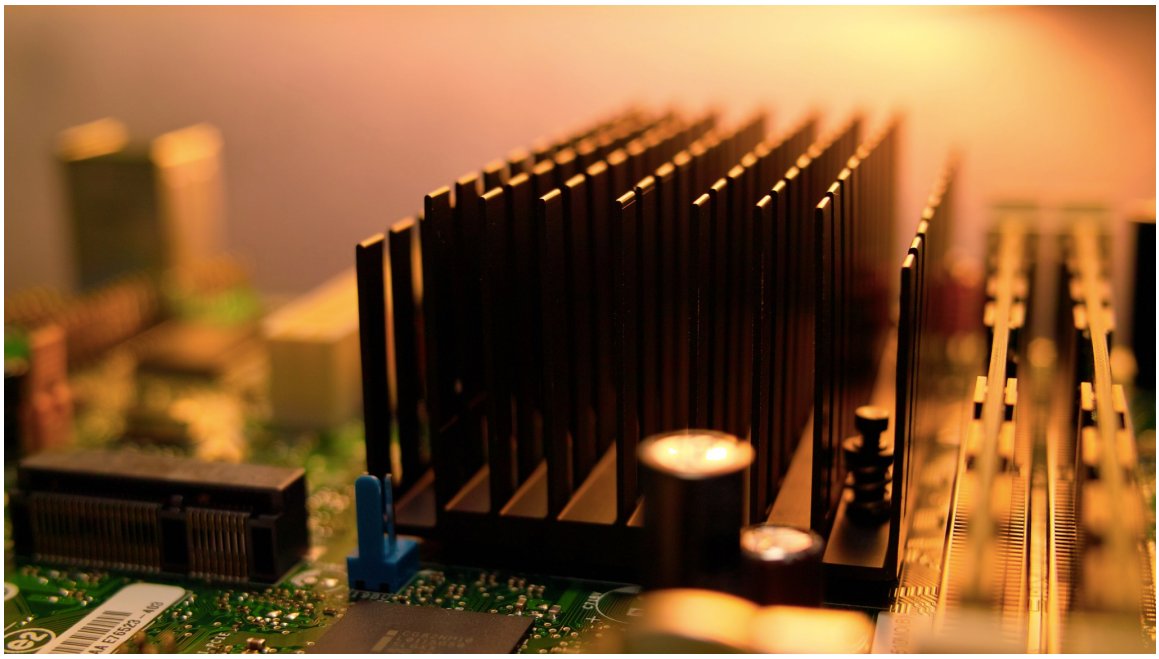


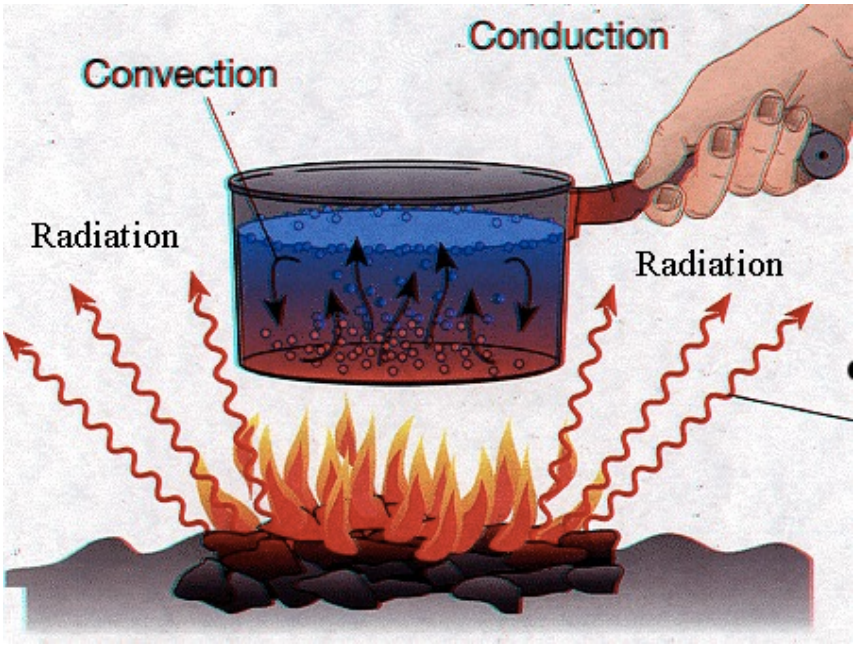
Types of Heat Transfer
First Law of Thermodynamics without Mass Flow

Heat Transfer

Conduction: transfer of energy from more energetic particles of a substance to the adjacent, less energetic ones due to the interaction between particles

Convection: energy transfer between and a solid surface and an adjacent fluid that is in motion; it involves the combined effects of conduction and relative fluid motion (also known as *advection*)

Radiation: energy emitted by matter in the form of electromagnetic waves as a result of changes in the electronic configurations of the atoms or molecules



Notes:

1. The convention is $Q > 0$ means energy goes into the system via heat transfer and $Q < 0$ means that energy leaves the system via heat transfer. Include a subscript Q_{into} or $Q_{\text{out of}}$ to avoid confusion.
2. Like work, heat is not a property. It's an energy exchange and is path dependent.
3. $\dot{Q}$ is the rate at which energy is transferred via heat transfer, i.e., $[\dot{Q}] = \frac{E}{T}$.
4. Adiabatic means that there is no heat transfer, i.e., $\dot{Q} = 0$.

First Law of Thermodynamics without Mass Transfer

$$\Delta E_{sys} = Q_{into\ sys} - W_{by\ sys}$$

or

$$\frac{dE_{CV}}{dt} = \dot{Q}_{into\ CV} - \dot{W}_{by\ CV} + \sum_{into\ CV} (\dot{m}e) - \sum_{out\ of\ CV} (\dot{m}e)$$

Notes:

1. $\Delta E_{sys} = \Delta U_{sys} + \Delta KE_{sys} + \Delta PE_{sys}$

2. $W_{by\ sys} = W_{by\ sys,pressure} + W_{by\ sys,shaft} + W_{by\ sys,spring} + W_{by\ sys,elec} + \ldots$

3. Common modeling assumptions:
   a. adiabatic process => $Q_{into\ sys} = 0$, e.g., a well-insulated container
   b. no pressure work => $W_{by\ sys,pressure} = 0$, e.g., a rigid container
   c. negligible change in kinetic energy/potential energy => $\Delta KE_{sys} = \Delta PE_{sys} = 0$
   d. steady state => $d/dt(\ldots) = 0$, e.g., $dE_{CV}/dt = 0$.