$$\Delta E = \Delta KE + \Delta PE + \Delta U$$

Energy Transfer by Heat

System => Gas in a container

Heat it up with a hot plate

Energy in the gas increases, but no mechanical work is done

Heat Transfer: Q

If $Q > 0$, Heat transfer to the system from the surroundings

If $Q < 0$, Heat transfer from the system to the surroundings

Can be shown with an arrow on a sketch

Heat Transfer is <u>not</u> a property

Rate of Heat Transfer $\Rightarrow \dot{Q}$

$$Q = \int_{t_1}^{t_2} \dot{Q}\, dt \qquad t \Rightarrow \text{time}$$

<u>Heat Flux</u> $\dot{q} \Rightarrow$ Rate of heat transfer per unit area

$$\dot{Q} = \int_{Area} \dot{q}\, dA$$

Units for Heat Transfer = Same as work

<u>Modes of Heat Transfer</u>

Conduction

- Transfer of Energy from more energic particles to adjacent particles that are less energic
- Due to interaction between particles
- An intervening medium is required

Example: Exterior wall of a house

Time rate of energy transfer by conduction

=> Fourier's Law

$$\dot{Q}_x = -K A \frac{dT}{dx}$$

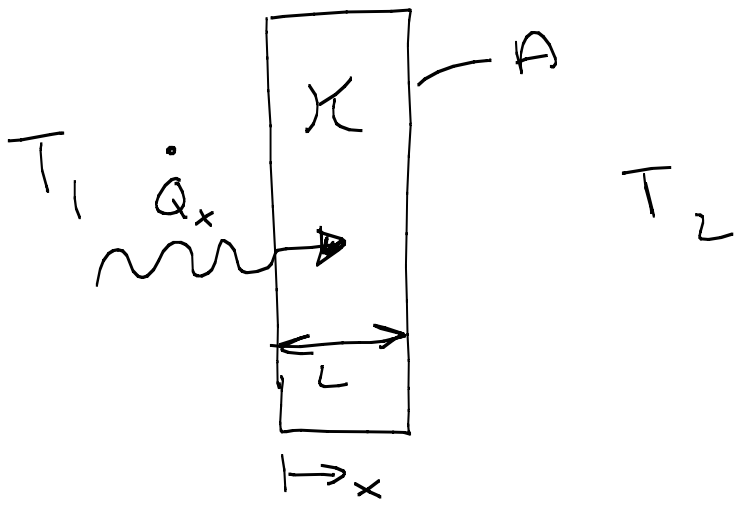
K = Thermal Conductivity

A = Area of the medium

$\frac{dT}{dx}$ = Temperature Gradient

If temperature varies linearly along the thickness of the wall

$$\frac{dT}{dx} = \frac{T_2 - T_1}{L}$$ thickness



Radiation

- Changes in the electron configuration of atoms
- Energy is transported by electromagnetics or photons
- No medium is required

Stefan - Boltzmann Law

$$\dot{Q}_e = \varepsilon \sigma A T_b^4$$

T_b = Absolute Temperature

ε = Emissivity (How effective the surface radiates)

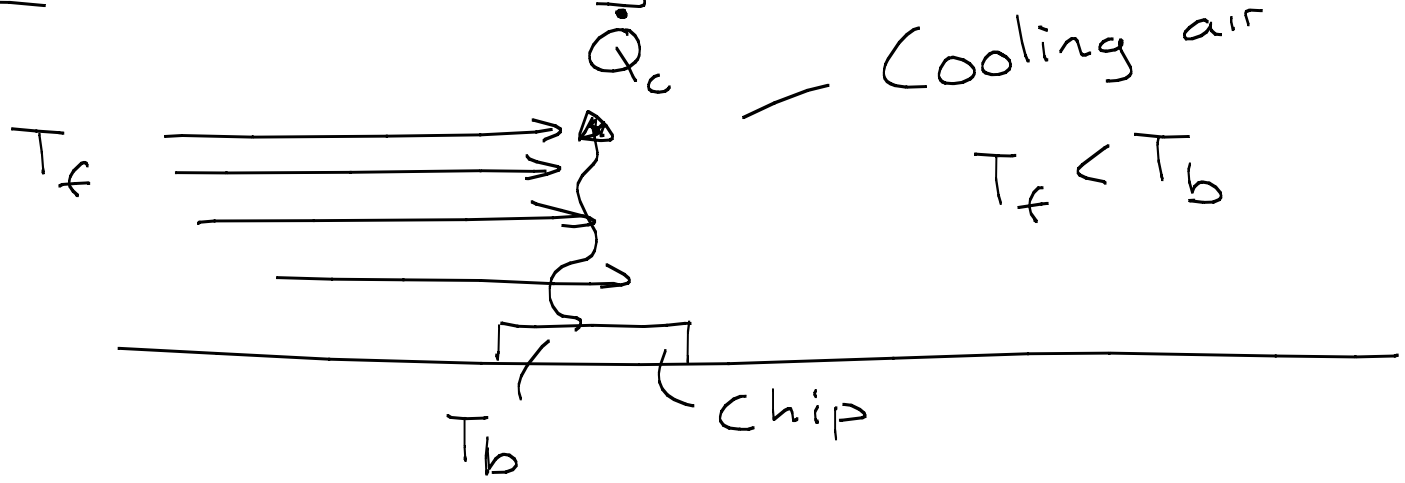
σ = Stefan - Boltzmann Constant = 5.67×10^{-8} $W/m^2 \cdot K^4$

A = Area of the surface

Convection

- Energy transfer between a solid surface at one temperature and an adjacent moving gas or liquid at a different temperature

Example Chip Cooling



Newton's Law of Cooling

$$\dot{Q}_c = h A (T_b - T_f)$$

h = Heat Transfer Coefficient (Table 2.1)

A = Area of the solid surface

T_b = Temperature of the solid

T_f = Temperature of the gas