Lecture 18, Oct 20, 2022

Heat Transfer

- Thermodynamics typically only deals with equilibrium/quasi-equilibrium processes; in reality we care about kinetics (i.e. we need to worry about time), so the rate of heat transfer matters
- In heat transfer we deal with a lot of rates
- Various applications:
  - Insulating buildings, HVAC systems
  - Electronics cooling
  - Manufacturing/industry

Mechanisms of Heat Transfer

1. Conduction
   - Transfer of heat through a stationary medium, e.g. heat transfer through a metal, heat transfer through a window with an air gap
   - Driven by a temperature difference between two points in a stationary medium
2. Convection
   - Transfer of heat between a solid and surface and adjacent fluid that flows, e.g. moving air across a hot plate to cool it
   - Actually a combination of fluid mechanics and heat conduction
3. Radiation
   - Energy emitted by matter, e.g. the sun
   - Unlike the other forms, radiation can pass through a vacuum

Heat Flux

- Defined as the heat transfer rate per unit area
- Flux is defined as $\frac{\dot{Q}}{A}$, with units of heat transfer rate per unit area (W/cm^2)
- How do we reduce heat flux?
  - Reduce $\dot{Q}$ (less heat generation) – oftentimes not possible
  - Increase A (more area to dissipate heat)
- Size is important – due to the square-cube law, the specific surface area $\frac{A}{V}$ goes down as an object gets larger
  - If heat generation is proportional to volume, now we have less area to transfer heat per unit of heat generation
  - Larger systems are generally harder to cool if heat generation is proportional to volume
- Heat sinks are designed to maximally increase surface area
- We can also increase the amount of airflow (increasing the effects of convection)
- Some fluids are more effective at convection, e.g. water cooling