Lecture 4, Sep 15, 2022

The First Law of Thermodynamics

- For a control mass, energy transfer due to a temperature difference is defined as heat Q, and all other forms of energy transfer are defined as work W
  - $Q + W = \Delta E$

Important

Energy transfer to a system is positive; energy transfer from a system is negative

- As a rate equation: $\dot{Q} + \dot{W} = \dfrac{\mathrm{d}E}{\mathrm{d}t}$
- Modes of work:
  - Boundary work: force acts on the boundary of the system, e.g. expansion and compression of a gas
    - Assuming a quasi-equilibrium process and no friction, then $W = -PV$
    - $\delta W = -P\,\mathrm{d}V$
- Constant volume processes do no work
- For an isothermal process $W = -mRT \ln\left(\dfrac{V_2}{V_1}\right)$
  - If the gas is expanding, $V_2 > V_1$ and the work is negative, so it does work on the surroundings

Polytropic Processes

- Assume $PV^n = c$, where n, c are constants
- $n = 1$ is an isothermal process (since $PV = mRT$ is constant, so T is constant)
- $n = 0$ is an isobaric process (since then $PV^0 = P = c$)
- $W_{12} = \displaystyle\int_{V_1}^{V_2} \frac{c}{V^n}\,\mathrm{d}V = -c\left[\frac{V^{1-n}}{1-n}\right]_{V_1}^{V_2} = c\left(\frac{V_2^{1-n} - V_1^{1-n}}{1-n}\right)$
- $W_{12} = \dfrac{P_2V_2 - P_1V_1}{n-1}$ assuming $n \neq 1$