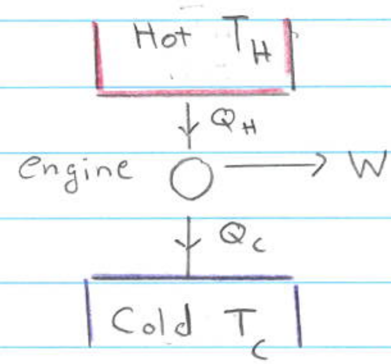
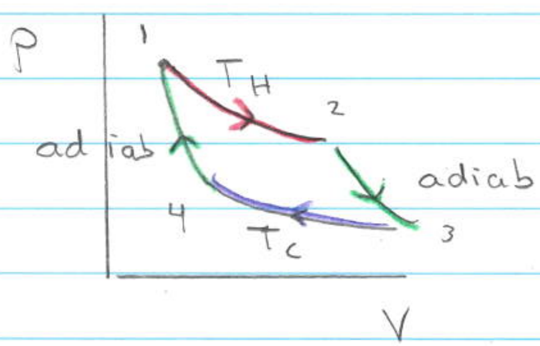
Carnot Efficiency



- Carnot and Clausius viewed the heat exchange as a kind of waterfall that can be used to do work.



- The steps consist of an isothermal expansion at T_H $(1 \to 2)$, followed by an adiab $(2 \to 3)$, followed by an isothermal compression $(3 \to 4)$ at T_c, followed by the adiab $(4 \to 1)$

- Then the change in entropy in parts are:

$$\Delta S_H = -\frac{Q_H}{T_c} = \text{change in entropy of Hot Reservoir}$$

$$\Delta S_c = +\frac{Q_c}{T_c} = \text{change in entropy of cold Reservoir}$$

$\Delta S_{system} = 0$ $\Leftarrow$ the working gas makes a closed loop. Since it starts and stops at the same place $\Delta S = 0$

So

$$\boxed{\Delta S_{univ} = -\frac{Q_H}{T_H} + \frac{Q_c}{T_c} \geq 0}$$

- Rearranging

$$\frac{Q_C}{Q_H} \geq \frac{T_C}{T_H}$$

Now the efficiency of the engine is $\cancel{\Delta U}^{0} = Q_{net} - W_{out}$ a closed cycle

$$\eta = \frac{W_{out}}{Q_H} = \frac{Q_H - Q_C}{Q_H} = 1 - \frac{Q_C}{Q_H}$$ ⇐ this is general using $Q_{net} = Q_H - Q_C$

So

$$\boxed{\eta \leq 1 - \frac{T_C}{T_H}}$$