Carnot engine [tln11]

Second law: Heat flows spontaneously from high to low temperatures.

Thermal contact: Temperature differences disappear without producing work.

Heat engine: Part of the heat flowing from high to low temperatures is converted into work via a cyclic process.

Carnot engine: All wasteful heat flows are eliminated (reversible processes).

The four steps of a Carnot process:

- $1 \to 2$: Isothermal absorption of heat: $\Delta Q_{12} > 0$ at Θ_H.
- $2 \to 3$: Adiabatic cooling: $\Theta_H \to \Theta_L$ with $\Delta Q_{23} = 0$ and $\Delta W_{23} < 0$.
- $3 \to 4$: Isothermal expulsion of heat: $\Delta Q_{34} < 0$ at Θ_L.
- $4 \to 1$: Adiabatic heating: $\Theta_L \to \Theta_H$ with $\Delta Q_{41} = 0$ and $\Delta W_{41} > 0$.

Total heat input: $\Delta Q_{in} = \Delta Q_{12}$.

Use first law: $\Delta U = \Delta Q_{12} + \Delta W_{12} + \Delta W_{23} + \Delta Q_{34} + \Delta W_{34} + \Delta W_{41} = 0$.

Net work output: $\Delta W_{out} \equiv -\Delta W_{12} - \Delta W_{23} - \Delta W_{34} - \Delta W_{41} = \Delta Q_{12} - |\Delta Q_{34}|$

Efficiency: $\eta \equiv \dfrac{\Delta W_{out}}{\Delta Q_{in}} = 1 - \dfrac{|\Delta Q_{34}|}{\Delta Q_{12}}$.