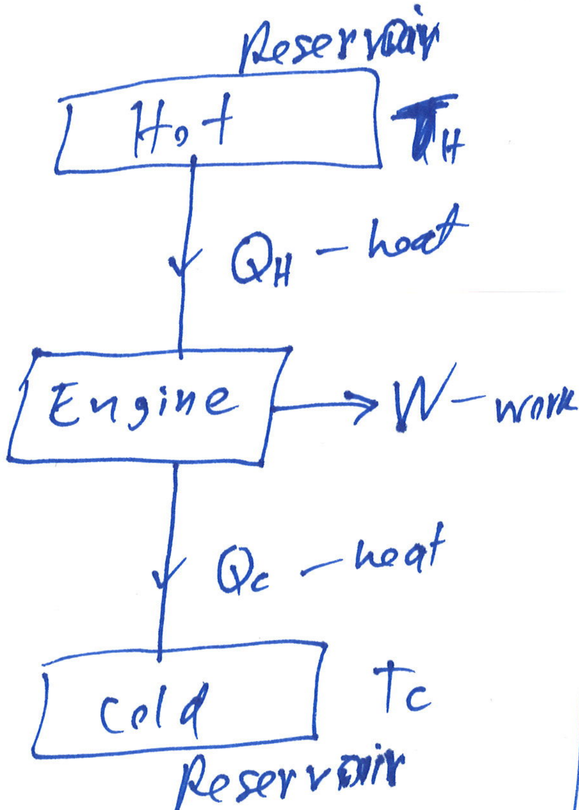
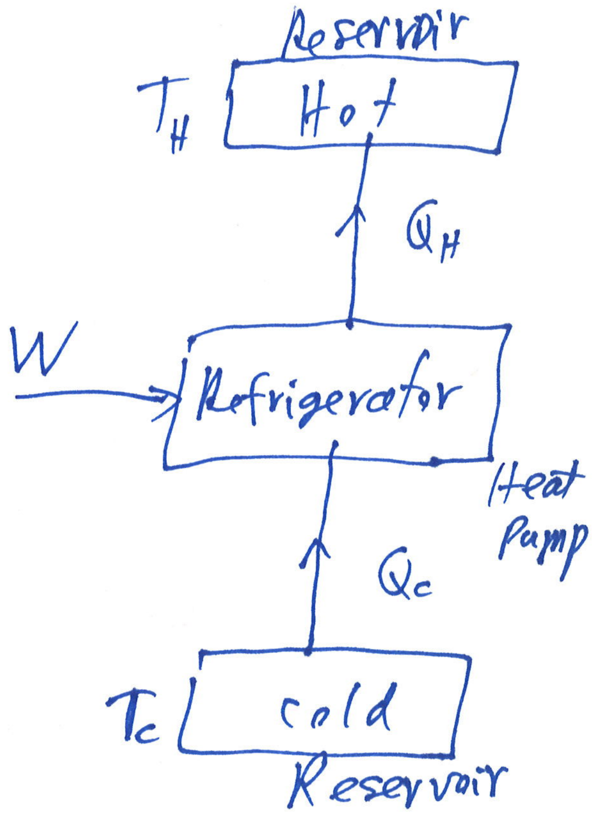
Second Law of thermodynamics

Sadi Carnot 1824

maximize theoretical efficiency of engines





efficiency

(eta) $\eta \equiv \dfrac{\text{"out"}}{\text{"in"}} = \dfrac{W}{Q_H}$

$= \dfrac{Q_H - Q_C}{Q_H} = 1 - \dfrac{Q_C}{Q_H} < 1$

$0 < \eta < 1$

Coefficient of performance

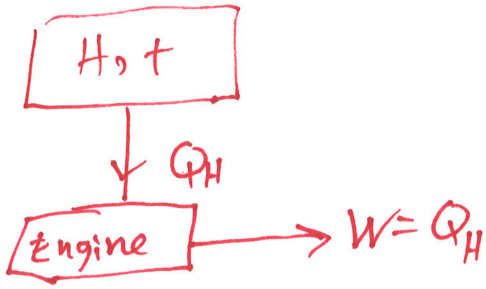
$COP = \dfrac{\text{"out"}}{\text{"in"}} = \dfrac{Q_C}{W} = \dfrac{Q_C}{Q_H - Q_C}$

COP could be > 1
< 1

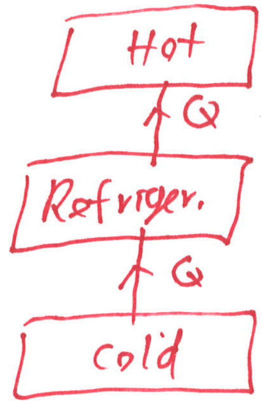
Kelvin (K) of 2nd Law:

There is no perfect heat engine.

$\bar{K}$



anti-Kelvin machine $\eta = 1$

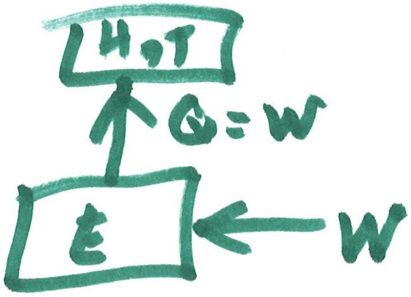


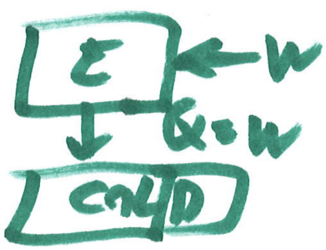
$\bar{C}$ anti-clausius machine

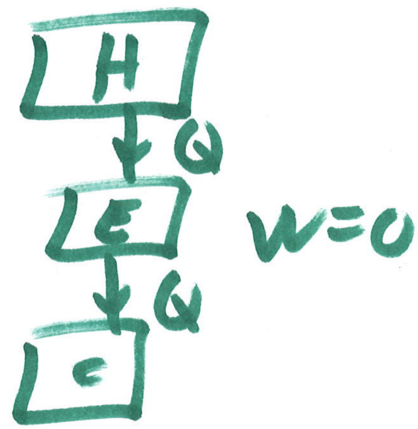
Clausius (C) of 2nd Law:

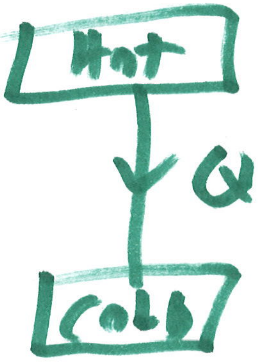
There is no perfect refrigerator.

These are possible.



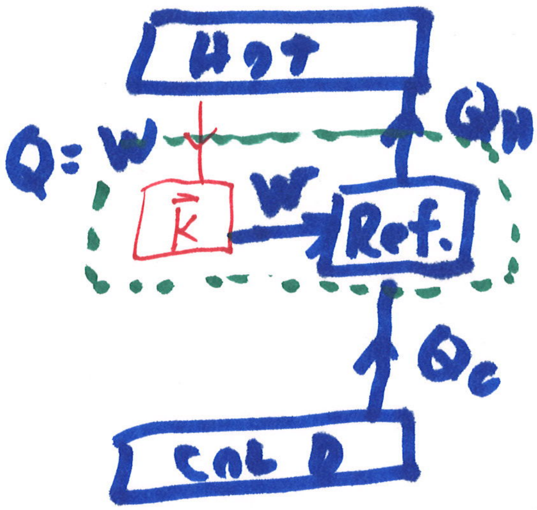


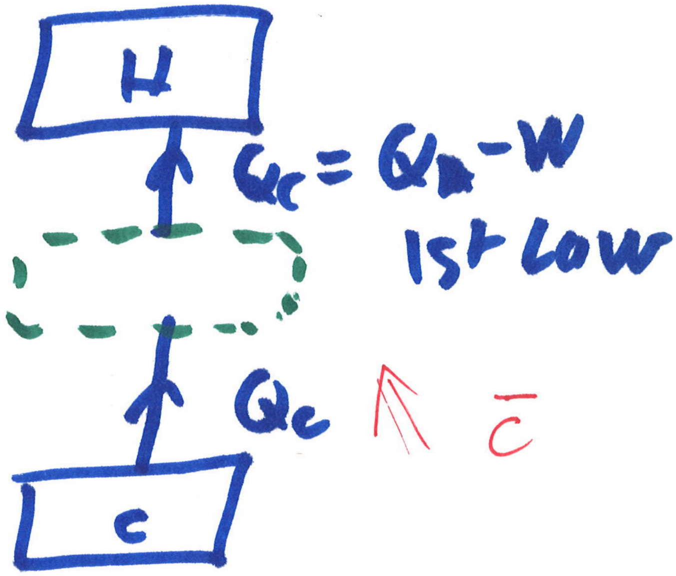




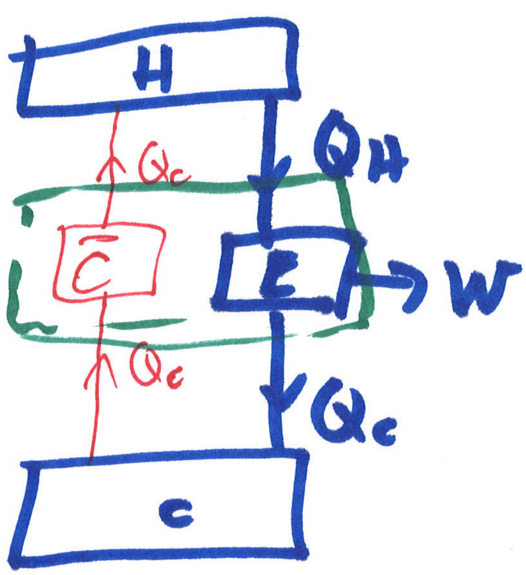
$K \Leftrightarrow C$: $\bar{K} \Rightarrow \bar{C}$ and $\bar{C} \Rightarrow \bar{K}$

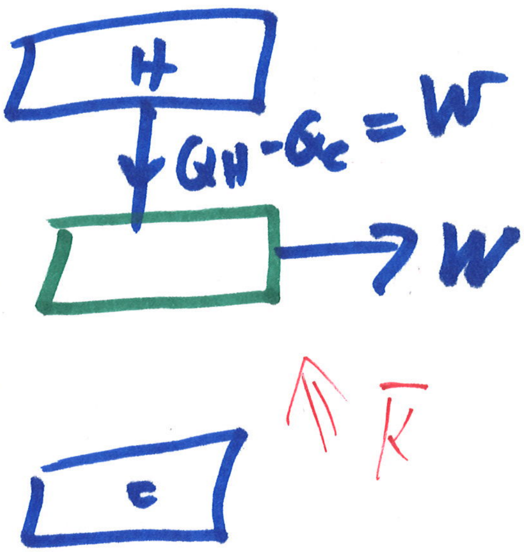
$\bar{K} \Rightarrow \bar{C}$





$\bar{C} \Rightarrow \bar{K}$

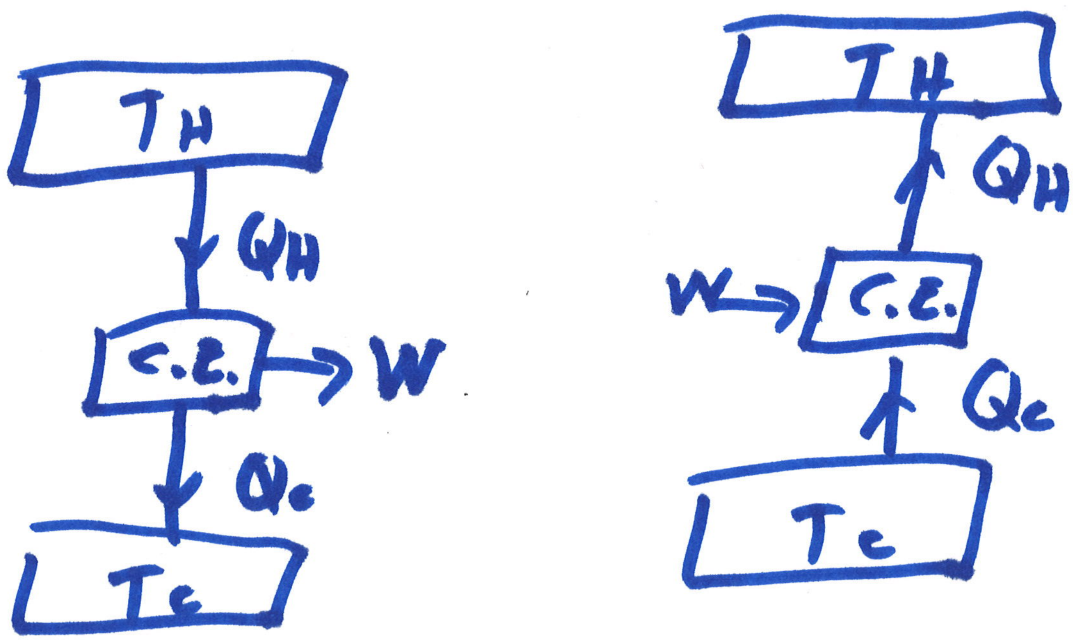




Carnot Engine (C.E.)

<u>Reversible</u>, cyclic, operates between two reservoir temperatures T_H + T_c.

↑ change the direction of inputs and outputs but not their values.



Carnot Engine concept is independent of the working substance, but look at an ideal gas.

Equation of state: $PV = Nk_B T = \nu RT$

$$\nu = \frac{N}{N_A} \Rightarrow k_B = \frac{R}{N_A}$$

↑ # moles