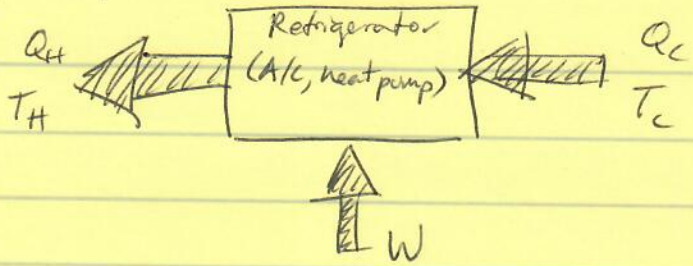
Refrigerator:



$$Q_H = Q_C + W \qquad (1^{ST}\ Law)$$

$$0 \leq \Delta S_{total} = \Delta S_H + \Delta S_C$$

$$= + \frac{Q_H}{T_H} - \frac{Q_C}{T_C} \qquad (Quasistatic)$$

$$= \frac{W + Q_C}{T_H} - \frac{Q_C}{T_C}$$

$$\Rightarrow \left(T_H/T_C - 1\right) Q_C \leq W$$

lower bound on the work required to move Q_C from the cold bath.

Analogously to the efficiency of the engine, we can define a "coefficient of performance" for an A/C

$$C.O.P. = Q_C/W \qquad (\text{heat pumped out}/\text{electricity needed})$$

$$COP \leq \left(\frac{T_H}{T_C} - 1\right)^{-1} = \frac{T_C}{T_H - T_C}$$

HOT DAY A/C: $T_H = 40^\circ C\ (104^\circ F) = 313\,K$, $T_C = 20^\circ C\ (68^\circ F) = 293\,K$ $\Big\}$ $COP \leq \frac{293}{20} = 14.6$

(typical COP more like 3-4)