Perpetual motion

- **<u>First kind:</u> Motion with no energy source.** Impossible because of energy conservation (***The First Law of Thermodynamics***).

- **<u>Second kind:</u> converting the heat of an environment to work.**

NOPE!

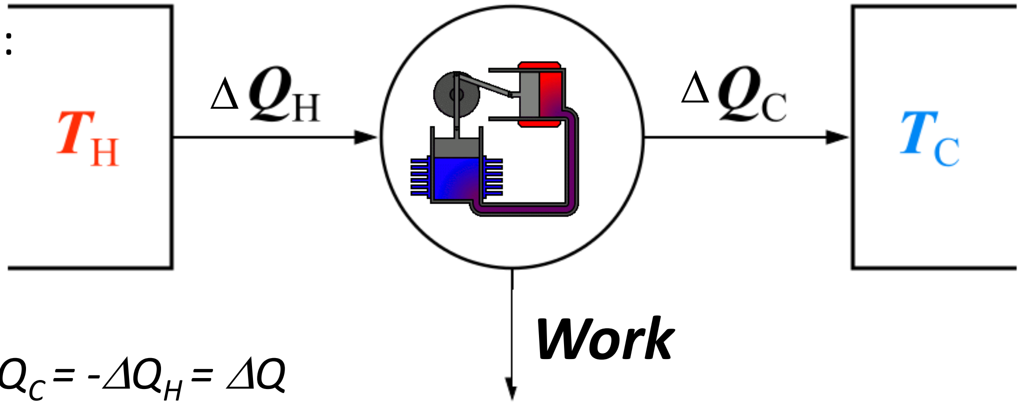
"It is impossible to derive mechanical effect from any portion of matter by cooling it below the temperature of the coldest of the surrounding objects."

Lord Kelvin's version of *the Second Law of Thermodynamics*

Second Law of Thermodynamics and Entropy

Change in entropy (Clausius definition):

$$\Delta S = \frac{\Delta Q}{T}$$



If *Work=0* , $\Delta Q_C = -\Delta Q_H = \Delta Q$

$$\Delta S_{total} = \frac{\Delta Q_C}{T_C} - \frac{\Delta Q_H}{T_H} = \Delta Q\left(\frac{1}{T_C} - \frac{1}{T_H}\right) \geq 0$$

Clausius version of ***the Second Law :***
"In an isolated system, the total **entropy** cannot decrease over time"

$$\Delta S_{total} = \Delta Q_H\left(\frac{1}{T_C} - \frac{1}{T_H}\right) - \frac{Work}{T_C} \geq 0$$

$Work \leq \Delta Q_H\left(\frac{T_H - T_C}{T_H}\right)$, so the maximum efficiency of a heat engine is $\frac{\Delta T}{T_{max}}$

Homework

As you know, when it is really hot, people start sweating. This is our way of cooling ourselves. When the sweat evaporates, it takes a lot of energy (google the "latent heat of evaporation of water"). Typically, a human consumes about 100 Watts of energy from food, most of which ends up in the form of heat that has to be removed.

Calculate, how much sweat needs to be evaporated per hour to remove all the heat generated by a person.