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!

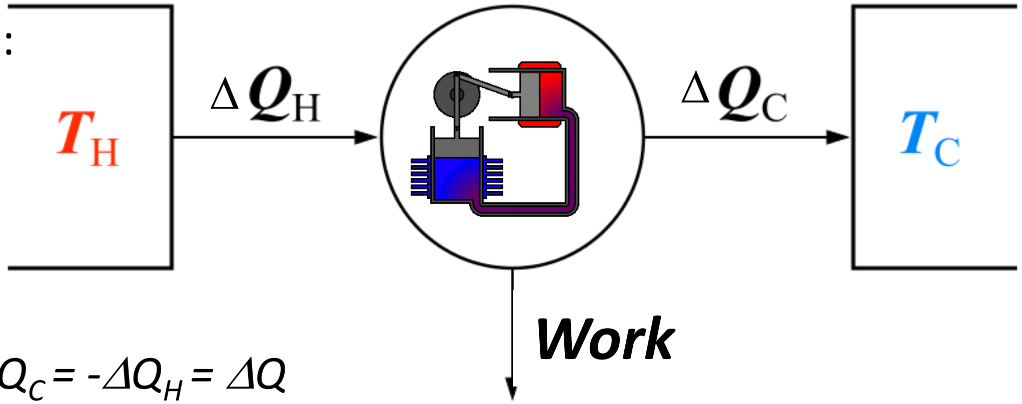
"It is impossible to derive mechanical effect from any portion of matter by cooling it below the temperature of the coldest of the surrounding objects."

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* , $\Delta Q_C = -\Delta Q_H = \Delta Q$

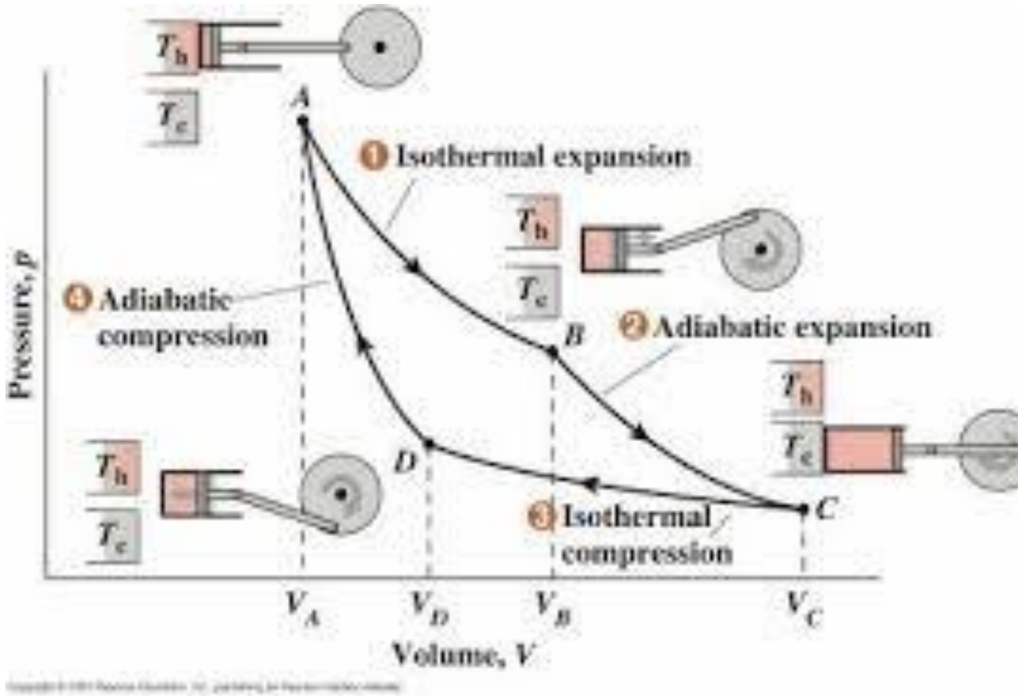
$$\Delta S_{total} = \frac{\Delta Q_C}{T_C} - \frac{\Delta Q_H}{T_H} = \Delta Q\left(\frac{1}{T_C} - \frac{1}{T_H}\right) \geq 0$$

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



In order to achieve the maximum efficiency of a steam engine, the gas would have to follow the so-called Carnot cycle (see its PV diagram above). It consists of two isothermal processes (T=const) ,and to adiabatic ones. Adiabatic process is a fast compression or expansion ***without heat exchange***. During the adiabatic process, pressure and temperature are related as $T = const \cdot P^{1/4}$. Based on this information, find the maximum efficiency of this steam engine. Assume that during adiabatic compression (process 4) the pressure goes up from 1 atm to the maximum that the engine can hold (16 atm). How your result would change if the maximum pressure is doubled?