***The Carnot Cycle:*** Sadi Carnot envisioned a perfect machine that would have the greatest possible efficiency that it could possibly have. We’ve already seen how the equation for this efficiency was developed. But what kind of machine could do that? Well, the machine that Carnot came up with is a simple piston/cylinder device. The operating sequence of the thing is called ***the Carnot cycle***.



Here is the device (the drawing above). The sides and top of the cylinder are insulated so heat cannot flow in or out of the system. The bottom is made of an ideal conductor so that heat can flow in or out of the system through the bottom of the cylinder. Three stands are available for cylinder placement; a hot stand, a cold stand, and a perfect insulator stand. Let’s see how the cycle works.

***Step1:*** ***Isothermal expansion***. The cylinder is placed on a high temperature heat sink that is at ***TH***. The heat is conducted through the bottom of the cylinder and the gas absorbs heat. We call this heat ***Qin*** . As a result of the added heat, the gas expands, pushing the piston upward. This step does some work. We call this step isothermal expansion because the temperature stays constant (isothermal means constant temperature) and the volume increases. The work done is equal to ***PΔV***. This step is represented as the curve ***AB*** on the PV diagram below.

***Step 2: Adiabatic expansion:*** The cylinder is immediately moved from the hot stand to the insulated stand. Once it is placed on the insulated stand, heat can no longer flow into the system (or out of it). The gas continues to expand, but since heat is no longer entering or leaving, this is an adiabatic expansion. The pressure in the cylinder drops to its lowest value. This is represented by the curve ***BC*** on the PV diagram. Work continues to be done by the system during this step.

***Step 3: Isothermal compression***: The cylinder is immediately place on the low temperature heat sink. Heat, which we call ***Qout***, flows from the cylinder into the heat sink. The system loses heat, the volume decreases, and the gas is compressed isothermally. This is represented by the curve ***CD*** on the PV diagram.

***Step 4: Adiabatic compression***: The cylinder is place on the insulated stand. Heat no longer can enter or leave, so the system undergoes adiabatic compression back to its original state along the curve ***AD***. The heat engine is now ready to undergo another cycle.



Here is the PV diagram for the Carnot cycle.

***A*** to ***B*** -- isothermal expansion.

## V increases and P decreases

***B*** to ***C*** -- adiabatic expansion.

***C*** to ***D --*** isothermal compression

***D*** to ***A --*** adiabatic compression

 Work is done along the curves ***AB*** and ***BC***.

The efficiency of the Carnot cycle, how well it operates, depends on the absorption of heat and the loss of heat in the respective steps of the cycle. One of the key factors that controls the flow of heat is the temperature difference. This would be the temperature of the hot stand and the cold stand. When placed on the hot stand, heat flows into the cylinder and it reaches (if left long enough) the same temperature as the hot stand. When placed on the cold stand, the temperature difference is equal to the hot temperature minus the cold temperature (of the cold stand).

If ***ΔT*** is increased, heat will flow faster and the machine will operate more efficiently.

So the higher the hot temperature reservoir (the hot stand), the greater the amount of heat absorbed by the system. Also, if we decrease the cold temperature reservoir, this too will increase the amount of heat that flows.

Increase the heat flow and you increase the efficiency of the system.