First Law of Thermodynamics

$$\Delta U = Q + W$$

U – Internal (Thermal) Energy

Q – Heat adsorbed by the System

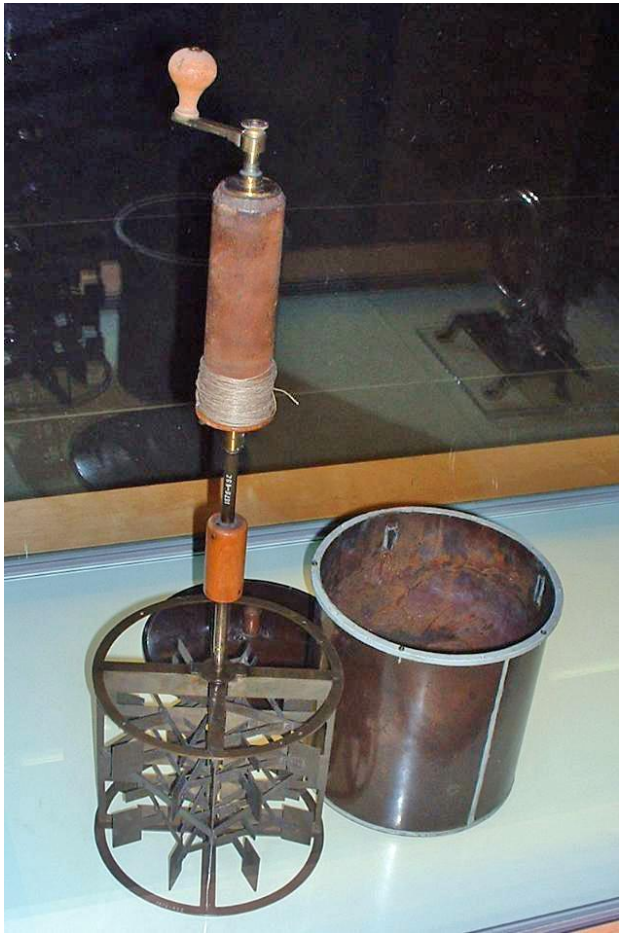
W=Fd – Work done by external forces (Force * Displacement)

Conservation of Energy Revisited:

$$E_{kin} + E_{pot} + U = const$$

"In thermally isolated system (Q=0), Total Energy (Mechanical+Internal) is conserved"

James Joule: mechanical equivalent of heat



1 cal = 4.184 J

Calories and Joules

Traditionally, Heat was measured in calories (cal):

- **1 calorie** is an amount of heat needed to increase the temperature of 1g of water by 1°C.
- For nutritional/dietary purposes people use "big Calories" (Cal, with capital "C"). **1 Cal=1000cal** (or simply kilocalorie). By definition, this is an amount of heat needed to increase the temperature of 1 kg (1 liter) of water by 1°C.
- Since Heat is a form or energy, calories can be converted to Joules:

1 cal = 4.184 J

1 Cal = 1000cal = 4184 J (used for dietary purposes)

Specific Heat

In order to know how much energy is needed to heat up an object by certain temperature, you need to know the specific heat capacity (aka specific heat) of the material, C:

$$Q=m\,C\,\Delta T$$

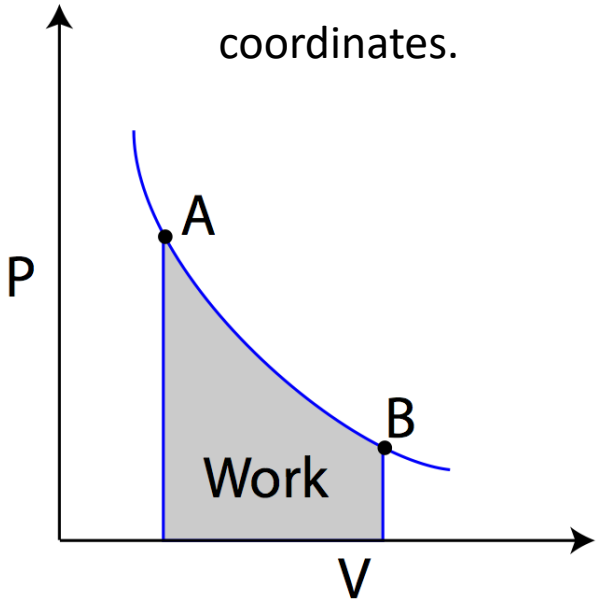
Here m is mass of the object, ΔT is change of its temperature, C is specific heat of its material. For instance, specific heat of liquid water is:

$$C_{water} = 1000\,\frac{cal}{kg\cdot\,^0C} = 4184\,\frac{J}{kg\cdot\,^0C}$$

Applying the 1st Law of Thermodynamics to ideal gas

$$\Delta Q = \Delta U + \Delta W$$

- ΔQ - total heat adsorbed by gas
- ΔU – change in internal energy, $\Delta U = \mathrm{n} C_V \Delta T$. Here C_V is specific heat per mole at constant volume.
- Work ΔW can be found as an integral $\int P dV$, or area under P(V) plot in (V,P) coordinates.



Homework

A heat engine is using 1 mole of gas that undergoes the process shown on PV diagram. Find the change in internal energy , work done by the gas, and total heat adsorbed during each segment (a->b, b->c, and c->d).
Specific heat of the gas at constant volume is C_V =20 J/K/mol. Note that PV=RT for n=1 mole. Universal gas vconstant is R= 8.3 J/K/mol

	Δ E, J	Δ W, J	Δ Q,J
a->b			
b->c			
c->a