Internal Energy

When mechanical energy is “lost”, due to friction or air drag, it does not disappear. It changes into “Internal Energy”: kinetic and potential energies of molecules that make up stuff around us. We can “feel” the increase of internal energy of an object since its temperature is rising. The internal energy can be changed either by doing mechanical work, or by adding Heat:

$$\Delta E_{\text{int}} = Q + W$$

E_{int} – Internal (Thermal) Energy of an object.

Q – Heat adsorbed by the object

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

Conservation of Energy Revisited: First Law of Thermodynamics

$$\Delta E_{\text{int}} = Q + W$$

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

Thus, mechanical energy (kinetic K + potential U) can be converted to thermal (internal), and back

$$K + U + E_{\text{int}} = const$$

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^{o}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^{o}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:

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

Homework

Problem

A cyclist is moving at speed v=5m/s. He applies breaks and comes to a complete stop. Assuming that all the heat generated during the breaking is concentrated in rubber blocks that "squeeze" the wheel, find the change in temperature of the rubber after the breaking, ΔT. Mass of the cyclist with the bicycle is M=100kg, total mass of all rubber blocks is m=50g. Specific heat capacity of rubber is C=2 kJ/kg/K.