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)

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^oC.
- 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^oC.
- 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:

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

Homework

Problem 1

How much energy, in Joules, do you consume with each standard serving of your favorite food (check the nutrition label)? Assuming that you need about 70,000 J to run 1 mile, what distance can you run on one serving?

Problem 2

A droplet of water with a mass of m=10mg falls from a height of h=1,000m in complete vacuum, so there is no air resistance or energy loss of any type. At the end of the fall, the droplet lands on a perfectly insulating surface, so no energy is transferred and all the energy becomes internal energy of the droplet. The acquired energy is given by:

$$\Delta E_{\text{int}} = m\ g\ h = (0.01g) \times \left(9.81\, {}^{m}/_{s^2}\right) \times (1{,}000m) = 0.0981\, J$$

This energy will increase the temperature of the droplet. Find the change in its temperature ΔT, and show your work.