Homework 13

Electrical power.

Last class we learned how to calculate power consumed by an electrical device. To do that we have to remember what is the voltage (or potential difference) between two points A and B. This is the work we have to perform to move a unit positive charge from point A to point B. If our charge is not unit, then, to calculate the work W we have to multiply the charge magnitude Q to the voltage *U*.

$$W = Q \cdot U \quad (1)$$

So for any electrical device, as long as the voltage at the device terminals is U and total charge we "pushed" through the device is Q, the total energy we "pumped" into the device can be calculated using formula (1). I have written "we pumped" but, more exactly, this energy came from the battery or power plant – the electrical energy source we are using. Our device, in turn, spends this energy as it designed to - produce light, sound etc. Unfortunately, a considerable part of this energy is converted to heat. It is good for a heater, but not that good for a computer or lamp.

Power is work produced per unit time. To calculate electrical power consumed by the device we have to calculate the charge, passing through the device per unit time. The latter is, by definition, electrical current *I*. So the power, consumed by the device can be calculated as

$$P = I \cdot U \quad (2)$$

In case of a simple resistor we can use Ohm's law: $U = I \cdot R$, so the power is

$$P = I^2 \cdot R \quad (3)$$

When we put current through the resistor we just heat it up, so in this case our work is mostly converted to heat.

1. Current flows through the filament of a bulb. Voltage on the bulb is maintained constant. Will the bulb glow brighter if you somehow decrease the resistance of the filament?

2. Return to the problem 1. Now we maintain constant current through the bulb. Will the bulb glow brighter if you somehow decrease the resistance of the filament?

3. A water pump needs 10 A of current at a voltage of 12V. How much time does it take to pump 100 liters of water to the second floor which is 5 m over the ground? (Assume that only 20% of the total power consumed by the pump is useful, or, the *efficiency* is 20%).

   To solve problem 3 you have to understand what happens to the gravitational potential energy of water which is being lifted.