Lecture 26

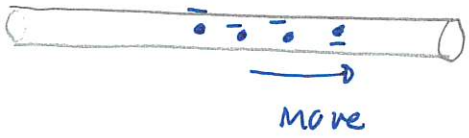
Weds: Read 8.6

Fri: Review

Mon: Test 2

Electric current

Any stream of moving charged particles constitutes an electric current. If we observed any cross section we can determine the current by



$$\text{current} = \frac{\text{charge passing cross section}}{\text{time taken to pass}} \qquad I = \frac{Q}{T}$$

charge passing cross section: Coulombs

time taken to pass: seconds

current: Amps

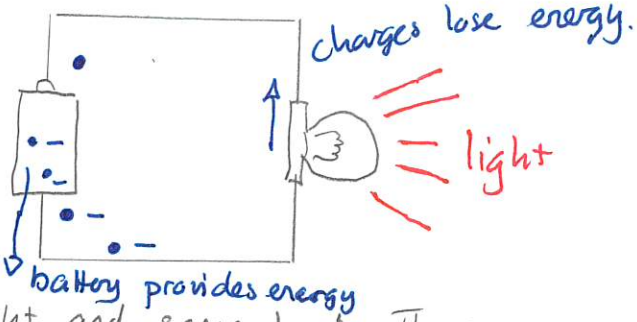
Typical household appliances and electronics involved large numbers of moving charges. However, each charged particle has a very small charge and so currents are usually in the following range:

* entire house : 20 → 100 A
* household appliance : 1A → 20A
* electronic devices : milliAmps. 0.001A → 0.100A

microAmps: ~ 0.000001A

Energy in Circuits

Consider a circuit that consists of a single bulb connected to a battery. The circuit operates by having charges flow



DEMO: Create PhET circuit

We know that the bulb produces light and some heat. These are forms of energy.

Quiz 1 60% - 90%

The charges that flow through the bulb lose energy. The battery supplies this energy. The amount of energy that the battery provides depends on the total charge that the battery delivers. For a given (properly functioning) battery, the battery provides the same energy to each electron. It is therefore useful to refer to the energy that the battery supplies per charge. This results in:

$$\text{voltage} = \frac{\text{total energy supplied to a group of charges}}{\text{total amount of charge}}$$

Joules J ~~Coulombs C~~ ← Coulombs C

Volts V

Voltage is easily measured. → Show with PhET.

Quiz 2 70%

In general we can show that

$$\text{Power delivered} = \text{voltage} \times \text{current}$$

↳ Energy per second

1 Elevator motor

An electric motor is used to lift a 1000 kg elevator. The elevator moves upwards a distance of 6.0 m. The eventual aim of this exercise is to use energy to determine the amount of charge supplied by the battery that drives the motor. We will assume that the motor and associated electrical circuitry is perfectly efficient.

a) Basic physics shows that the amount of energy required to lift the elevator this way is approximately 600000 J. Suppose that it takes one minute to do this. Determine the power provided to do this.

b) Suppose that the battery connected to the electric motor provides a voltage of 200V. Determine the current that the battery provides.

c) Determine the total charge provided by the battery to lift the elevator.

d) Determine the total number of electrons provided by the battery.

Note that this analysis ignores many details: alternating current circuits, imperfect energy transfer, etc.

Answer: a) $\text{Power} = \frac{\text{energy}}{\text{time}}$

$= \frac{60000\,\text{J}}{60\,\text{s}} = 10000\,\text{W}$

b) Power = Voltage × Current

$10000\,\text{W} = 200\,\text{V} \times \text{Current}$

$\Rightarrow \text{Current} = \frac{10000\,\text{W}}{200\,\text{V}} \Rightarrow \text{current} = 50\,\text{A}.$

c) $\text{Current} = \frac{\text{charge}}{\text{time}} \Rightarrow 50\,\text{A} = \frac{\text{charge}}{60\,\text{s}}$

$\Rightarrow \text{charge} = 50\,\text{A} \times 60\,\text{s} = 3000\,\text{C}$

d) $\text{number electrons} = \frac{\text{total charge}}{\text{charge one electron}} = \frac{3000\,\text{C}}{1.6\times10^{-19}\,\text{C}}$

$= 1.9\times10^{21}$