Chapter 16
Electrical Energy and Capacitance

Chapter 17
Current and Resistance

Assignments for the week:

Reading 16.6-16.9; 17.1 – 17.4

Recitation problems:

Ch. 16: CQ-8, 13, 15; P-24, 27, 31, 43.

Ch. 17: CQ-3, 4, 5; P-4, 5, 6, 8.

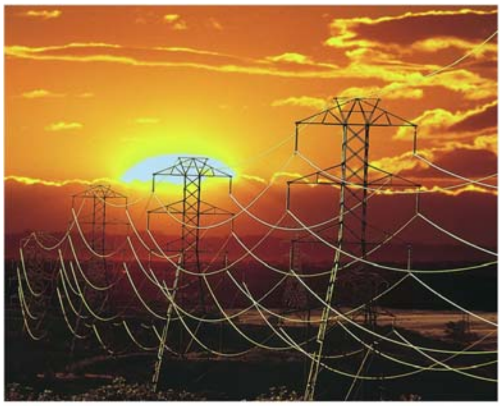
Homework problems (Due: Monday 02/28/2008):

Ch.16: P-30; **Ch.17**: P-7

Chapter 17
Current and Resistance

Electrostatics => Charges not moving (macroscopically).

Electric current => Charges flow.



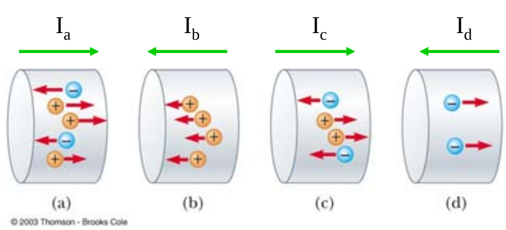
1. Electric Current
(a) How to define the current precisely?

The *current, **I***, is the *rate* of charge flow through a surface :

$$I \equiv \frac{\Delta Q}{\Delta t}$$

-- SI unit for current is the ***ampere (A):*** 1 A = 1 C/s
-- The *direction* is defined as that of the flow of ***+ charge***.
- This is called the "conventional current flow". In metals, current is due to the motion of electrons.

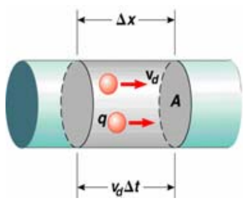
Question: Which of the following has the highest current?



Question: 1.67 C of charge passes through a lightbulb in 2 s, (a) What is the current? (b) How many electrons pass the filament in 0.10 s?

2. Current and Drift Speed (A *Microscopic* View)

(a). How is a current related to the speed of the charges?



The charge passing *A* in *Δt* is:

$$\Delta Q = nqAv_d\,\Delta t.$$

n - particles/volume, $\boldsymbol{v_d}$ – speed.

By definition:

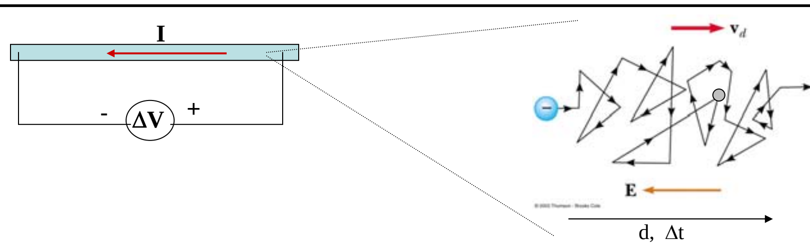
$$I = \frac{\Delta Q}{\Delta t} = nqAv_d$$

$\boldsymbol{v_d}$ is called the ***drift speed***.

(b) How do electrons move in a wire?

To have a current, a ***potential difference*** has to be applied, and an ***electric field*** is set up ***inside*** the wire.

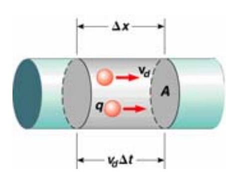
Active figure 17.04



The ***electrons*** move along a ***zig-zag path*** toward the direction opposite to E, with an average speed v_d.

(c) How large is v_d?

Example: For a copper wire, A = 3.00x10^{-6} m^2, I = 10.0 A, and n = 8.48x10^{28} free electrons/m^3. What is $\boldsymbol{v_d}$ of the free electrons?

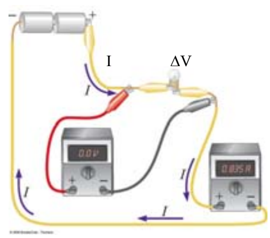


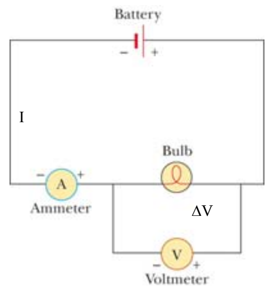
$$v_d = \frac{I}{nqA} = \frac{10.0A}{(8.48\times10^{28}\,ele/m^3)(1.6\times10^{-19}\,C)(3.00\times10^{-6}\,m^2)}$$

$$= 2.46\times10^{-4}\,m/s$$

The electrons will travel **1 meter** in **68 minutes**!

3. Current and Voltage Measurements

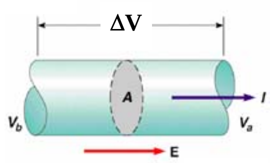




4. Resistance and Ohm's Law

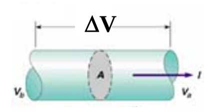
Electrons collide with the atoms in a conductor, so the material has "resistance" to the current.

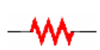
(a) What is the resistance of a conductor?



It was found via experimental measurements that, for many conductors, I ∝ ΔV

The ***resistance*** is defined as: $R \equiv \dfrac{\Delta V}{I}$



-- The SI unit for R is the ***ohms*** (Ω). 1 Ω = 1 V/A.
-- *R* depends on the material as well as on the geometry.
-- The symbol for resistor is  .

(b) What is the Ohm's Law?

ΔV = I R

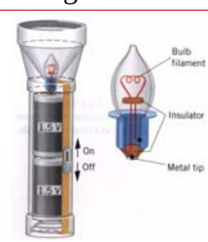
or

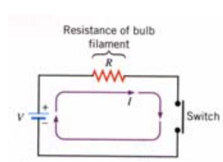
I=ΔV/ R

or

R= ΔV /I

Question: What is the resistance of the flashlight filament if the current is 0.4 A?

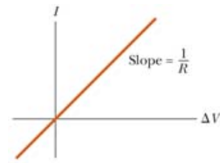




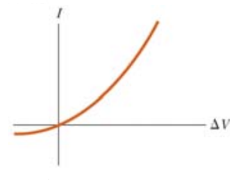
(c) Do all materials obey Ohm's law?

The answer is: **NO**.

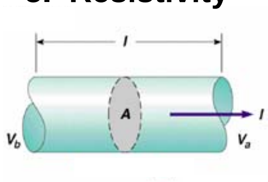
Materials obeying ohm's law are called ***ohmic*** materials.



Material not obeying ohm's law are called ***nonohmic*** materials.
(we are not going to study these)



5. Resistivity



R depends on the ***material*** as well as on the ***geometry*** of the conductor:

$$R = \rho \frac{l}{A}$$

R is a design property
ρ is a material property

ρ => ***resistivity***. Unit: **Ω m**.