Electricity: Current, Resistance and Power: Ohms Law

Name: Ky Period: 8th Date: ________

Electric Current in a Wire

The movement of charges in a conductor is known as electric current.

The quantitative definition of a current, I, is the amount of charge, ΔQ, that passes a point a given time interval, Δt.

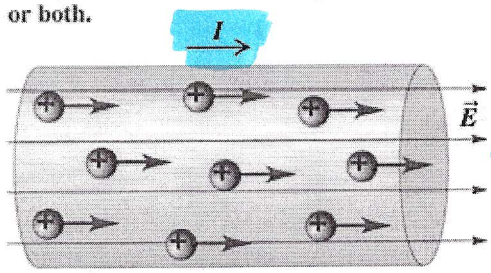
$$I = \frac{\Delta Q}{\Delta t}$$

Where:
I: Current (Ampere-A)
ΔQ=Charge (Coulomb-C)
Δt=time (time-s)

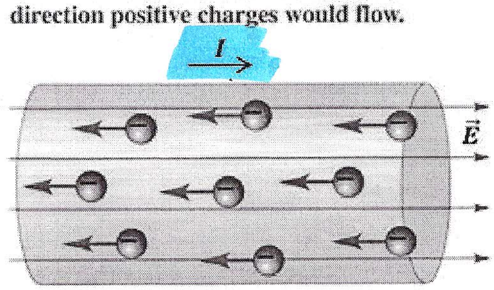
SI UNIT

$\frac{C}{s} = A$

A **conventional current** is treated as a flow of positive charges, regardless of whether the free charges in the conductor are positive, negative, or both.



In a metallic conductor, the moving charges are electrons — but the *current* still points in the direction positive charges would flow.

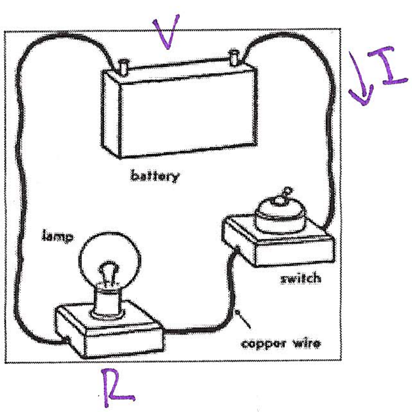


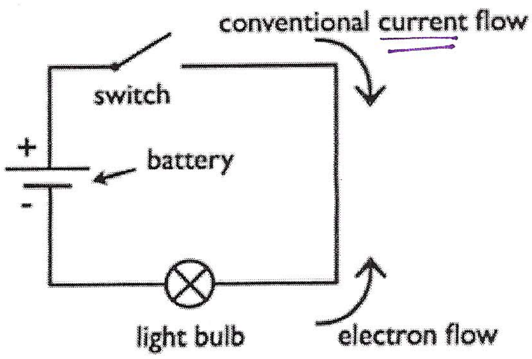
The electrons in a wire with no **Electric Field** are generally moving around in a random fashion.
When an **Electric Field** is applied to the ends of the wire (a battery is hooked-up) there is a net movement of electrons along the **Electric Field** (in one direction).
The **velocity of the electrons** after the **Electric Field** is applied is actually very slow. The **Electric Field** is fast and is applied throughout the wire almost instantaneously.

Electric Circuit

In electricity, it is the battery that supplies the potential difference (Voltage, V) needed to maintain a continuous flow of charge. All batteries have two terminals (positive) and negative).

When conducting wire attached and looped around to the other end, a complete circle of wire (a circuit) is produced, allowing for the continuous flow of charge. The battery acts like a pump, forcing electrons off the negative side onto the positive side using chemical reactions. The moving electrons can then do WORK since they carry energy. This WORK is electricity with which we have become so familiar in our modern world.





For AP Test Purposes

The direction of the current is taken to be the direction that **POSITIVE** charge carriers would move.

So, if the conduction electrons move to the right, we would say that the current points towards the left.

Ohm's Law

The current flow through a metal wire is proportional to the Voltage, V, across the wire. The current flow is also inversely proportional to the Resistance R, the wire offers to the flow of electrons. Therefore, the voltage, current and resistance are related by Ohm's Law:

$$V = IR$$

$$I = \frac{V}{R}$$

Where:
V=Voltage (Volts-V)
I=Current (Ampere-A)
R=Resistance (Ohms-Ω)

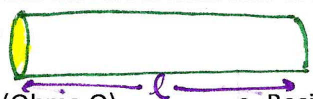
Resistance in a Wire

Electrical resistivity (also known as **resistivity** (ρ)) quantifies how strongly a given material opposes the flow of electric current. A low resistivity indicates a material that readily allows the movement of electric charge.

The Resistance, R, of a conductor of length l, with a uniform cross sectional area, A, is given by:

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

$A = \pi r^2$



Where:
R=Resistance (Ohms-Ω)
l=Lenght (Meters-m)
ρ=Resistivity (Ohm.meter-Ωm)
A= Cross-Sectional Area (m^2)

Power

The Power, P, dissipated as heat by a resistor is equal to the change in potential energy, ΔU, of the flowing charges during a given time interval. The power is therefore related to the current and the voltage across the resistor by:

$$P = IV$$

Where:
P=Power (Watts-W)
I=Current (Ampere-A)
V=Voltage (Volts-V)

λ

Example 1: Copper wire is being used in a circuit. The wire is 1.2m long and has a cross-sectional area of $1.2\times10^{-8} m^2$ at a constant temperature of 20°C. Resistivity of copper is 1.69×10^{-8}Ω m.

a. Calculate the resistance of the wire

$R = \rho \frac{l}{A} = (1.69\times10^{-8})\left(\frac{1.2}{1.2\times10^{-8}}\right) = 1.69\,\Omega$

b. If the wire is connected to a 10V battery, what current will flow through it?

$I = \frac{V}{R} = \frac{10}{1.69} = 5.92A$

c. Calculate the Power dissipated

$P = IV = (5.92A)(10)$

$P = 59.2W$

Example 1: A wire of radius 1mm and length of 2m is made of platinum (resistivity=1×10^{-7}Ωm). If a voltage of 9V is applied between the ends of the wire, what will be the resulting current?

$r = 1mm$
$l = 2m$
$\rho = 1\times10^{-7}\Omega m$
$V = 9V$

$1mm \cdot \frac{1m}{1000mm} = .001$

$I = \frac{V}{R} = \frac{9V}{.06} = 150A$

$R = \rho\frac{l}{A} = 1\times10^{-7}\frac{2m}{\pi(.001)^2} = 0.06\Omega$