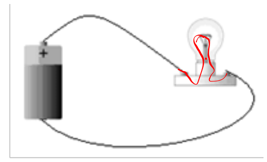
Electric Circuits



1. In the electric circuit shown, there is a

a) transfer of energy from battery to bulb

b) transformation of energy from chemical to electric potential energy to heat/light

2. In general, an electric circuit contains a:

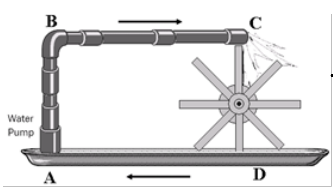
a) closed pathway for transfer of energy – complete circuit

b) flow of electrons that transfer the energy:- current

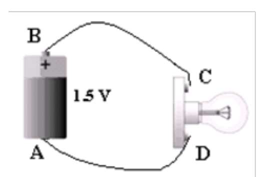
c) source of electrical potential energy: Source of 'Electromotive force' (EMF) or potential difference (or voltage)
examples: battery, solar cell, generator

d) device that uses the energy: source of resistance in circuit (load)
examples: light bulb, motor, hair dryer...

An Analogy



. . . is similar to . . .



What is a "cell?"
a container in which a chemical reaction occurs to release electrical energy

Dry Cell

Dry cell:
dry chemicals - DC, AA, AAA, watch battery, etc.

Wet cell: liquid acid - car battery

Primary Cell: non-rechargeable

Secondary Cell: rechargeable

Electric Circuits

Battery: two or more cells connected together

3. What does it mean for a cell to be rated at 1.5 V?

provides 1.5 J of energy to every coulomb of charge that passes through it

$$V = \frac{E}{q} \left[\frac{J}{C}\right]$$

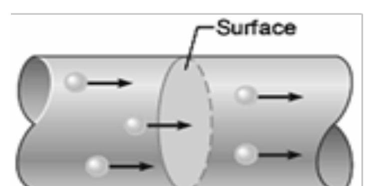
Electric Current


André-Marie Ampère
(France,1775-1836)

Electric Current: rate of flow of electric charge carriers

4. How much is 1 ampere (1 amp) of current?

One coulomb of charge passes a point in one second



Formula: $I = \frac{\Delta q}{t}$

Units: $\left[\frac{C}{s}\right] = [A]$

5. What is the current in a wire in which 600. C of charge pass a point every 4.0 minutes?

Electric Current

6. If a 12.0 A current is allowed to flow for 20. seconds in a circuit,
how many elementary charges pass that point?

$I = q/t$

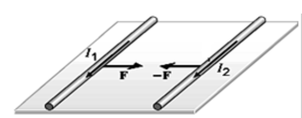
$q = I \cdot t = 12A \cdot 20s = 240c$

$240c\left(\frac{1 e.c.}{1.6 \times 10^{-19} c}\right) = 1.5 \times 10^{21} e^-$

Typical Currents

Computer chip	10^{-12} to 10^{-6} A
Current dangerous to a human	10^{-2} to 10^{-1} A
Household light bulb	1 A
Car starter motor	200 A
Lightning	10^{4} A

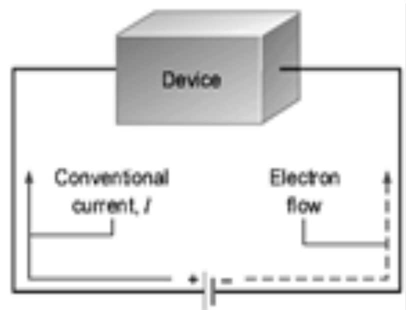
Official Definition of One Ampere (1 A) of current – a fundamental unit
One ampere is the amount of current flowing in each of two infinitely-long parallel wires of negligible cross-sectional area separated by a distance of one meter in a vacuum that results in a force of exactly 2×10^{-7} N per meter of length of each wire.



Short form – Current is defined in terms of the force per unit length between parallel current-carrying conductors.

Electric Current

Direct Current (DC): Current in which the charge flows in one direction only




Thomas Edison

Source of DC: battery, PV cell

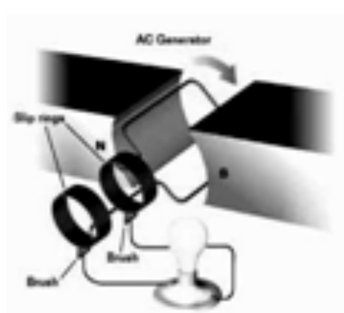
Electron flow: negative charge carriers (electrons) flow from negative to positive

Conventional current: positive charge carriers flow from positive to negative

Electric Current

Alternating Current (AC): Current in which the charges alternate their direction of flow

Source of AC: AC generator

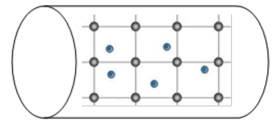



George Westinghouse

Model for the structure of a metal conductor (like a wire or filament)

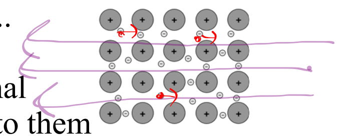
a) positive lattice ions fixed in place

b) freely moving conduction electrons that carry charge



Without an applied potential difference... electrons move randomly

When a potential difference is applied across the conductor..
- a) an electric field is set up in the conductor
- b) conduction electrons accelerate to the positive terminal
- c) and collide with lattice ions thus transferring energy to them

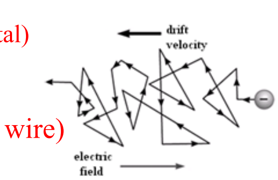


Drift speed: net speed of conduction electrons

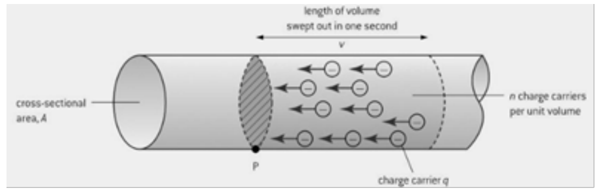
7. Compare the instantaneous speed of the conduction electrons with their drift speed.

Instantaneous speed- very high (near speed of sound in metal)

Drift speed - very low (one hour for one meter of copper wire)



Drift Speed Formula



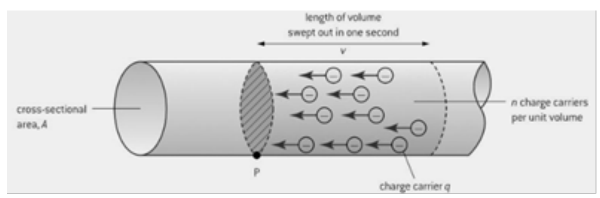
A = cross sectonal area

q = charge

v = drift speed

n = charge density = number of charge carriers per unit volume (per 1 m^3 of volume)

$I = nAvq$



Derivation

In the figure above, charge carriers, each with charge q, move past point P with a speed v.

a) In one second, the volume of charge carriers passing P is equal to

b) The total number of charge carriers in this volume is

c) The total charge of the charge carriers in this volume is

d) Therefore, the current is