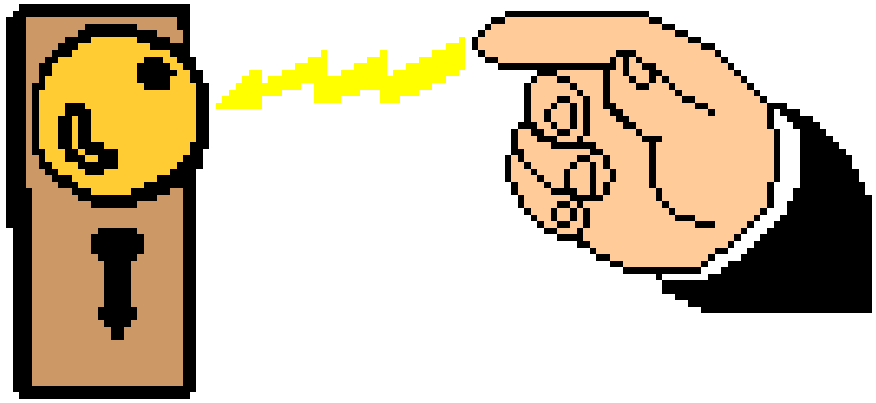
New England Radio Discussion Society:
"Electronics for Amateur Radio operators"

"Getting down to nuts and volts"

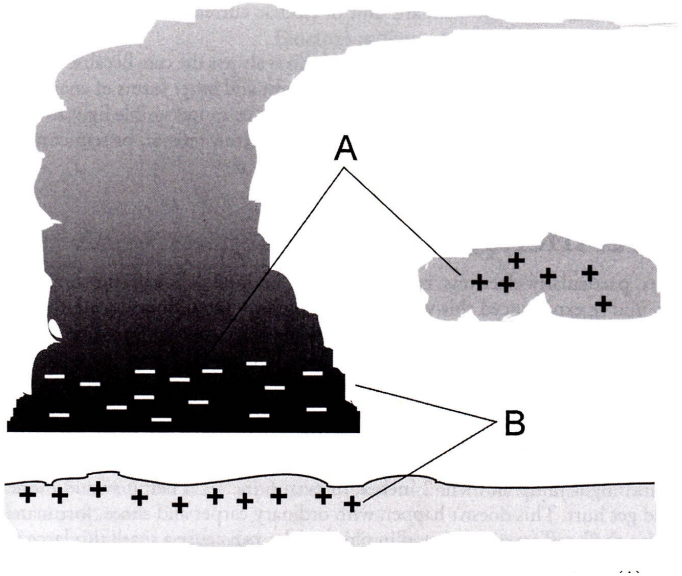
Phase One, July 2016

Sources of electricity: Static electricity



Static electricity ain't necessarily static

In cloud build-up



"Discharges" can occur between clouds and ground, or ground and clouds

Sources of electricity: chemical cells and batteries

Sources of electricity: electro-mechanical generators

Sources of electricity: solar panels

But, what is electricity, anyway?

For some answers look at the nature of the elements.

The ***Periodic Table*** gives clues to the electrical properties of elements.

TABLE
PERIODIC TABLE OF THE ELEMENTS

Atomic Number	*Element Name*	*Symbol*	*Atomic Weight*	*Electrons/Shell* K	L	M	N	O	P	Q	*Discovered*	*Comments*
1	Hydrogen	H	1.007	1							1766	Active gas
2	Helium	He	4.002	2							1895	Inert gas
3	Lithium	Li	6.941	2	1						1817	Solid
4	Beryllium	Be	9.01218	2	2						1798	Solid
5	Boron	B	10.81	2	3						1808	Solid
6	Carbon	C	12.011	2	4						Ancient	Semiconductor
7	Nitrogen	N	14.0067	2	5						1772	Gas
8	Oxygen	O	15.9994	2	6						1774	Gas
9	Fluorine	F	18.998403	2	7						1771	Active gas
10	Neon	Ne	20.179	2	8						1898	Inert gas
11	Sodium	Na	22.98977	2	8	1					1807	Solid
12	Magnesium	Mg	24.305	2	8	2					1755	Solid
13	Aluminum	Al	26.98154	2	8	3					1825	Metal conductor
14	Silicon	Si	28.0855	2	8	4					1823	Semiconductor
15	Phosphorus	P	30.97376	2	8	5					1669	Solid
16	Sulfur	S	32.06	2	8	6					Ancient	Solid
17	Chlorine	Cl	35.453	2	8	7					1774	Active gas
18	Argon	Ar	39.948	2	8	8					1894	Inert gas
19	Potassium	K	39.0983	2	8	8	1				1807	Solid
20	Calcium	Ca	40.08	2	8	8	2				1808	Solid
21	Scandium	Sc	44.9559	2	8	9	2				1879	Solid
22	Titanium	Ti	47.90	2	8	10	2				1791	Solid
23	Vanadium	V	50.9415	2	8	11	2				1831	Solid
24	Chromium	Cr	51.996	2	8	13	1				1798	Solid
25	Manganese	Mn	54.9380	2	8	13	2				1774	Solid
26	Iron	Fe	55.847	2	8	14	2				Ancient	Solid (magnetic)
27	Cobalt	Co	58.9332	2	8	15	2				1735	Solid
28	Nickel	Ni	58.70	2	8	16	2				1751	Solid
29	Copper	Cu	63.546	2	8	18	1				Ancient	Metal conductor
30	Zinc	Zn	65.38	2	8	18	2				1746	Solid
31	Gallium	Ga	69.72	2	8	18	3				1875	Liquid
32	Germanium	Ge	72.59	2	8	18	4				1886	Semiconductor
33	Arsenic	As	74.9216	2	8	18	5				1649	Solid
34	Selenium	Se	78.96	2	8	18	6				1818	Photosensitive
35	Bromine	Br	79.904	2	8	18	7				1826	Liquid
36	Krypton	Kr	83.80	2	8	18	8				1898	Inert gas
37	Rubidium	Rb	85.4678	2	8	18	8	1			1861	Solid
38	Strontium	Sr	87.62	2	8	18	8	2			1790	Solid

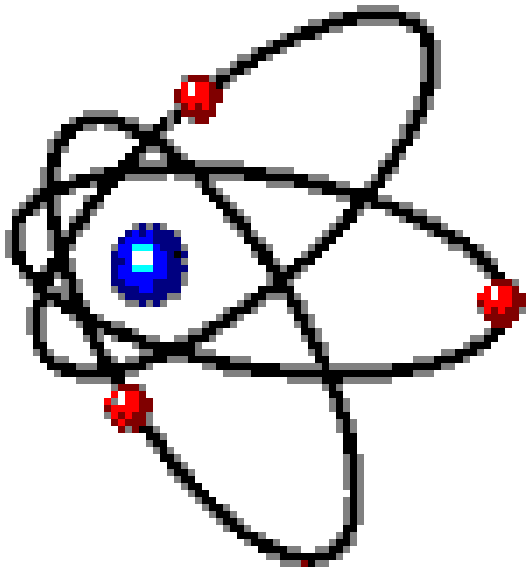
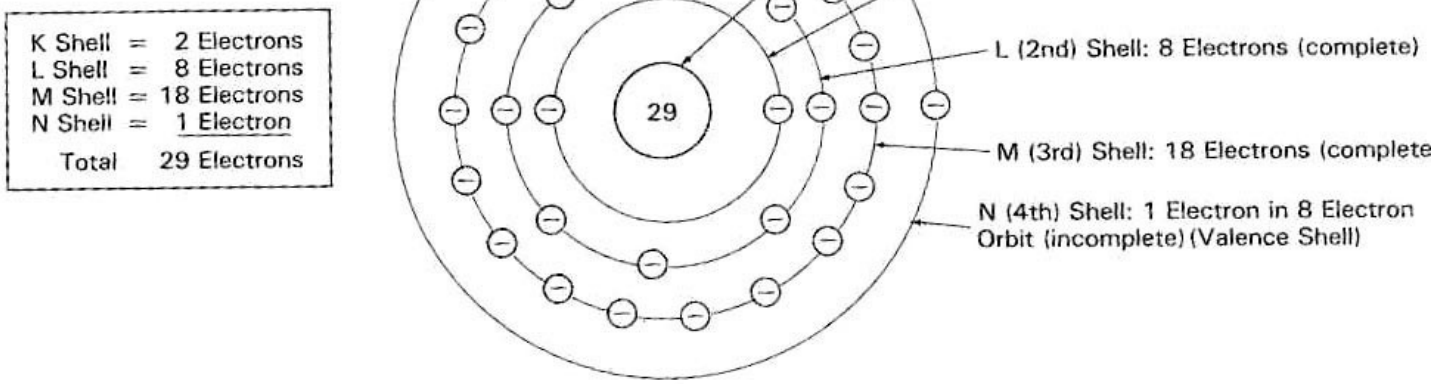


Image_2

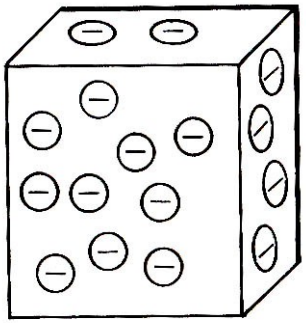


Copper Atom

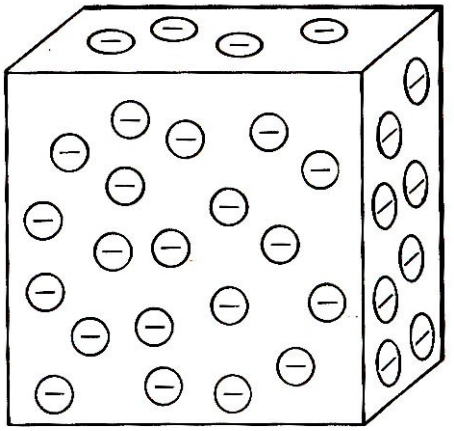
The *Coulomb* is a unit of charge

1 coulomb = 6.24 x 10^{18} electrons

That's 6.24 million million million electrons, or a quintillion electrons



6.24×10^{18} Electrons
= 1 Coulomb of Charge

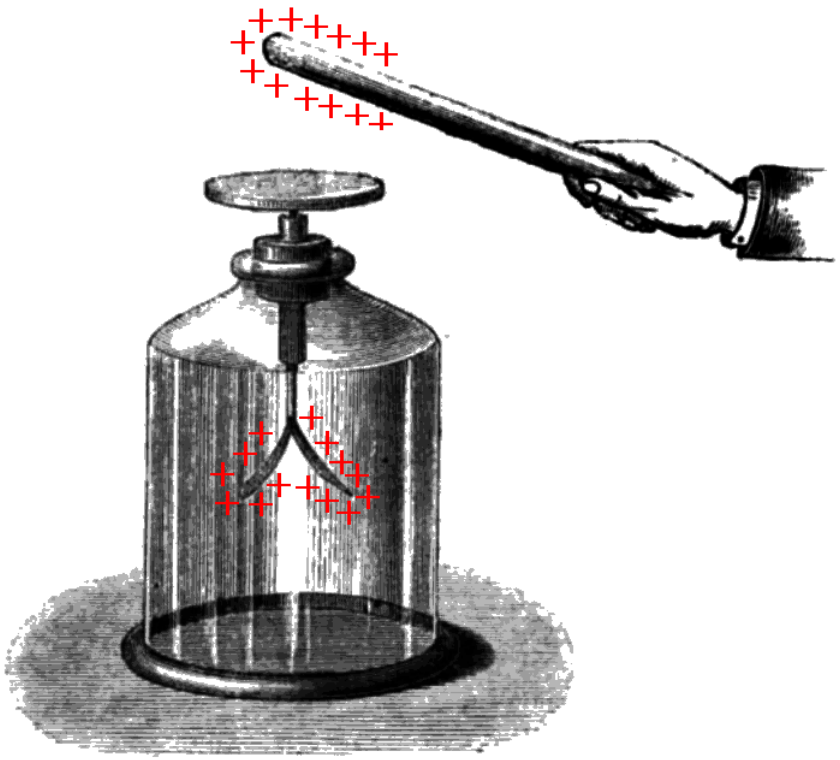


12.48×10^{18} Electrons
= 2 Coulombs of Charge

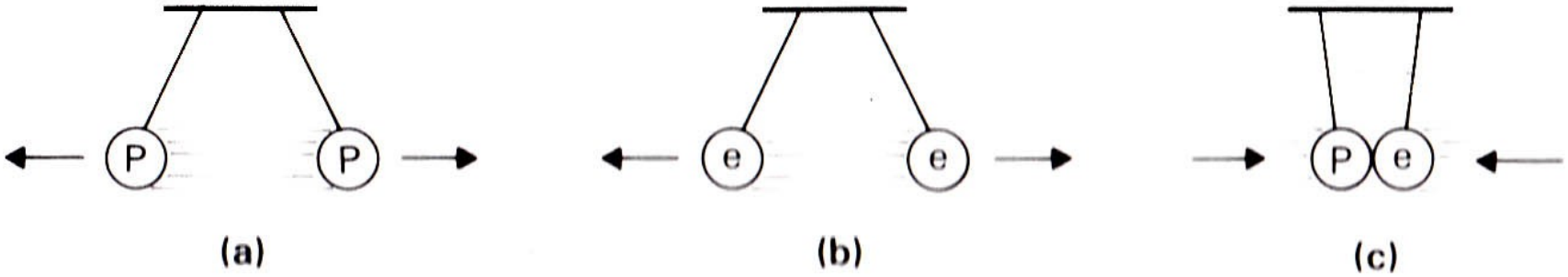
The electroscope

An instrument invented in the 1600s by Dr. Wm. Gilbert.

It detects static charges.



Attraction and Repulsion. (a) Positive Repels Positive. (b) Negative Repels Negative. (c) Unlike Charges Attract.



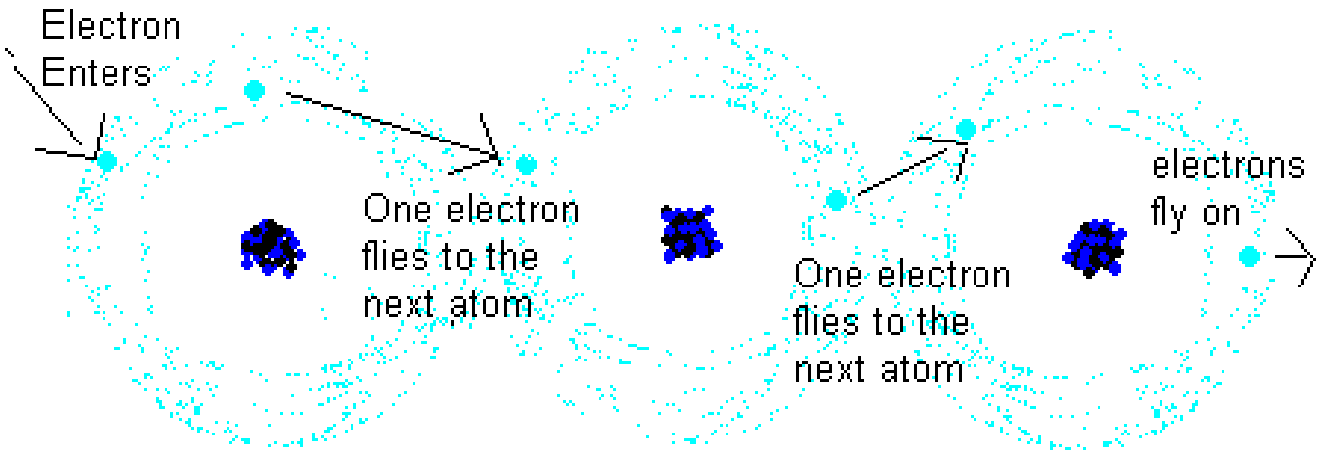
P = Proton (positive)
e = Electron (negative)

Remember: unlike charges attract

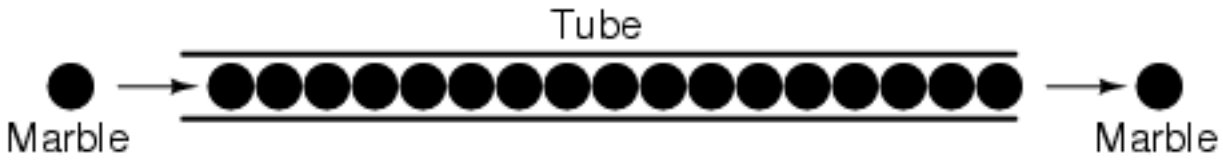
What is current?

- **Electrons normally revolve around the nucleus of each atom of copper in a wire, but when electrical pressure--called *voltage*---from a battery or generator or solar panel is applied, some of these electrons are forced out of their orbits and pass from atom to atom along the length of the wire.**
- **These electrons are called *free electrons* and come from the outer orbit of the atoms.**

Electron flow



Instantaneous flow (an analogy)



One ampere (1A) is the flow of 62,000,000,000,000,000,000 electrons (one Coulomb) per second past a given point!

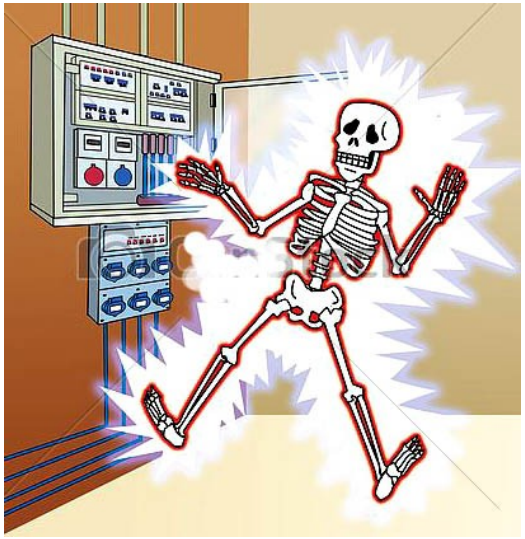
On your calculator, scientific notation indicates there are 18 zeroes in this number. It will show on your calculator as 62^{18} or 6.2^{19}. Either entry is correct and okay.

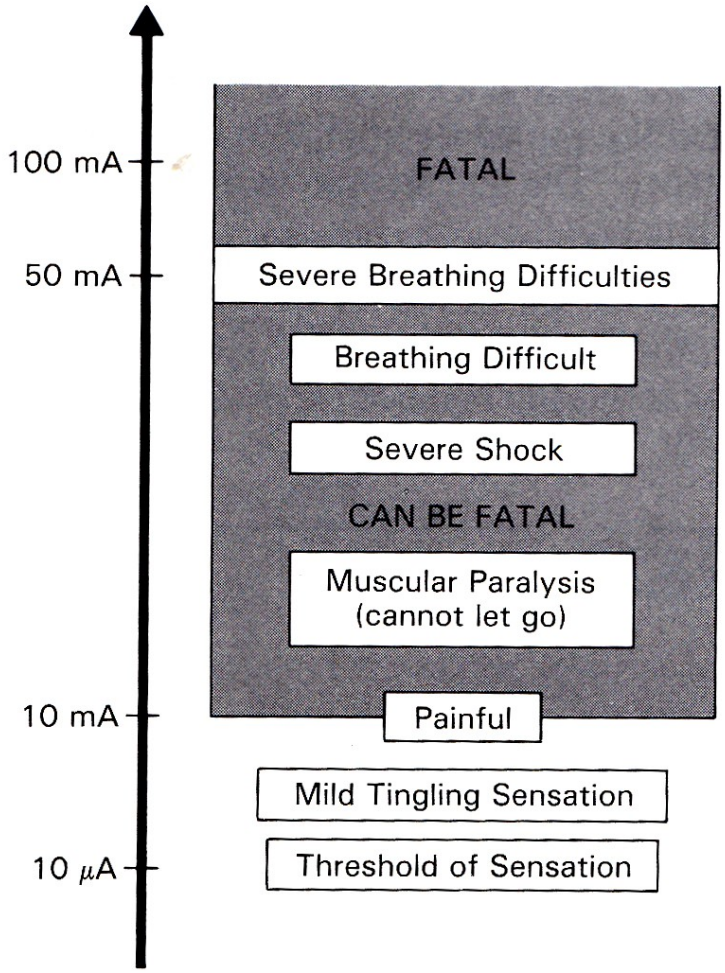
CURRENT UNITS

Name	*Symbol*	*Value*
Picoampere	pA	$10^{-12} = \frac{1}{1\,000\,000\,000\,000}$
Nanoampere	nA	$10^{-9} = \frac{1}{1\,000\,000\,000}$
Microampere	μA	$10^{-6} = \frac{1}{1\,000\,000}$
Milliampere	mA	$10^{-3} = \frac{1}{1\,000}$
Ampere	A	$10^{0} = 1$
Kiloampere	kA	$10^{3} = 1000$
Megaampere	MA	$10^{6} = 1\,000\,000$
Gigaampere	GA	$10^{9} = 1\,000\,000\,000$
Teraampere	TA	$10^{12} = 1\,000\,000\,000\,000$

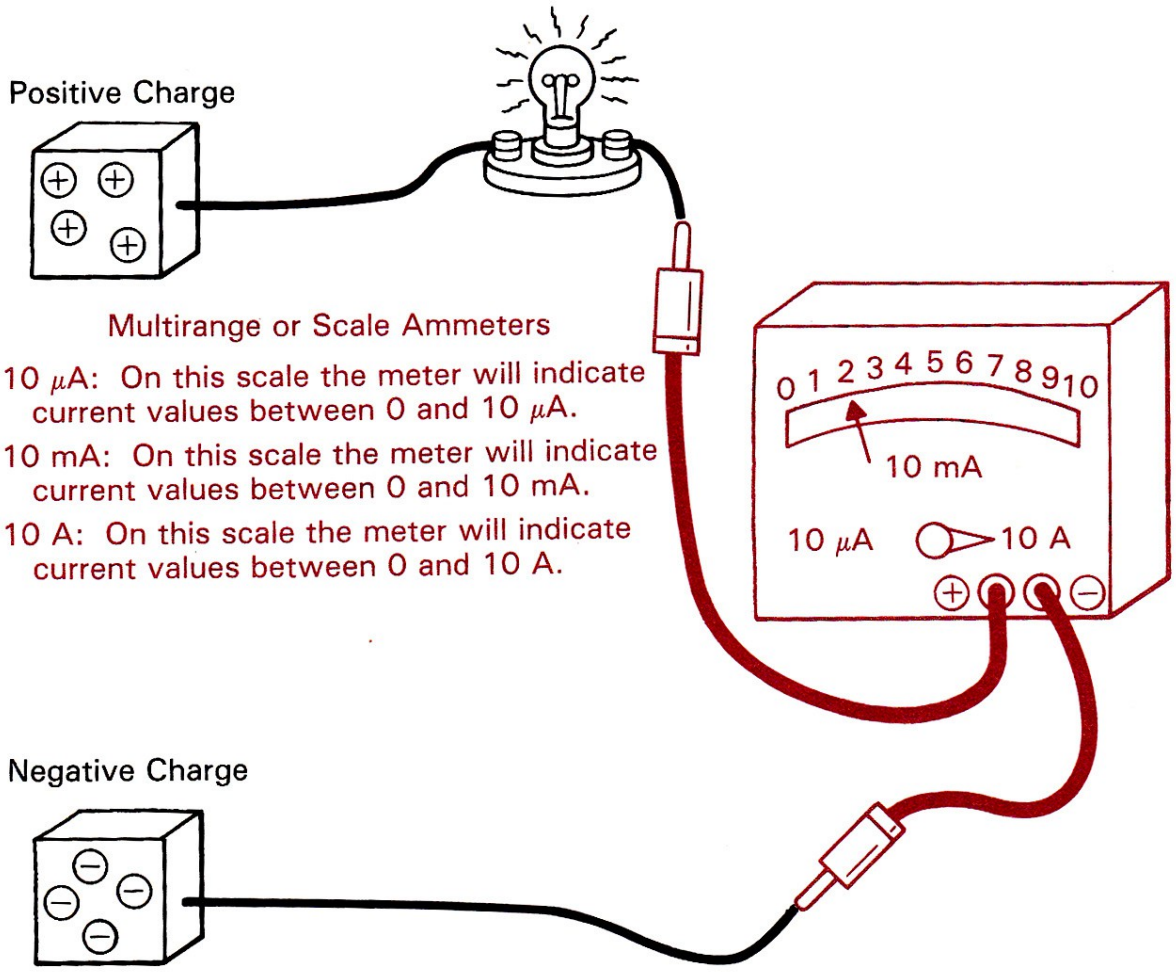
Notice the use of the capital letter A

Current flows and safety





You can measure electron flow with an *ammeter*



Multirange or Scale Ammeters

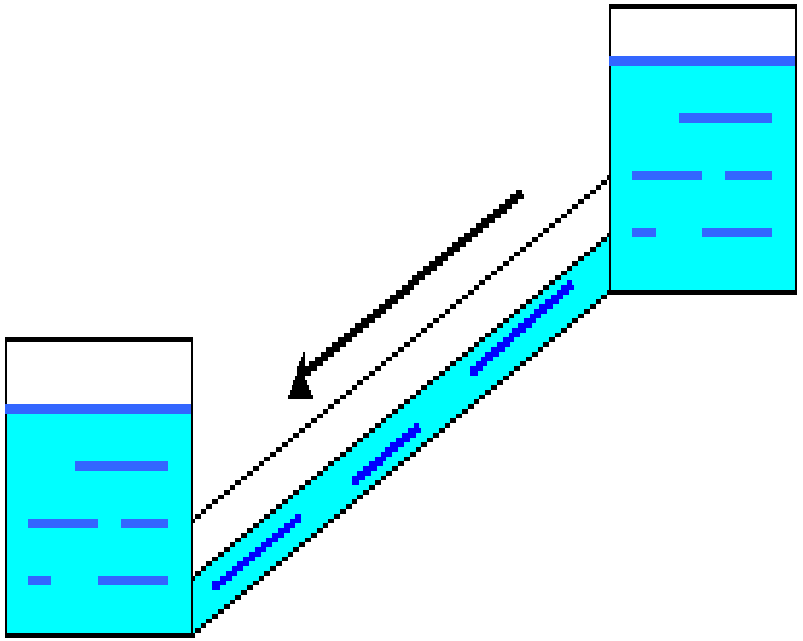
10 μA: On this scale the meter will indicate current values between 0 and 10 μA.

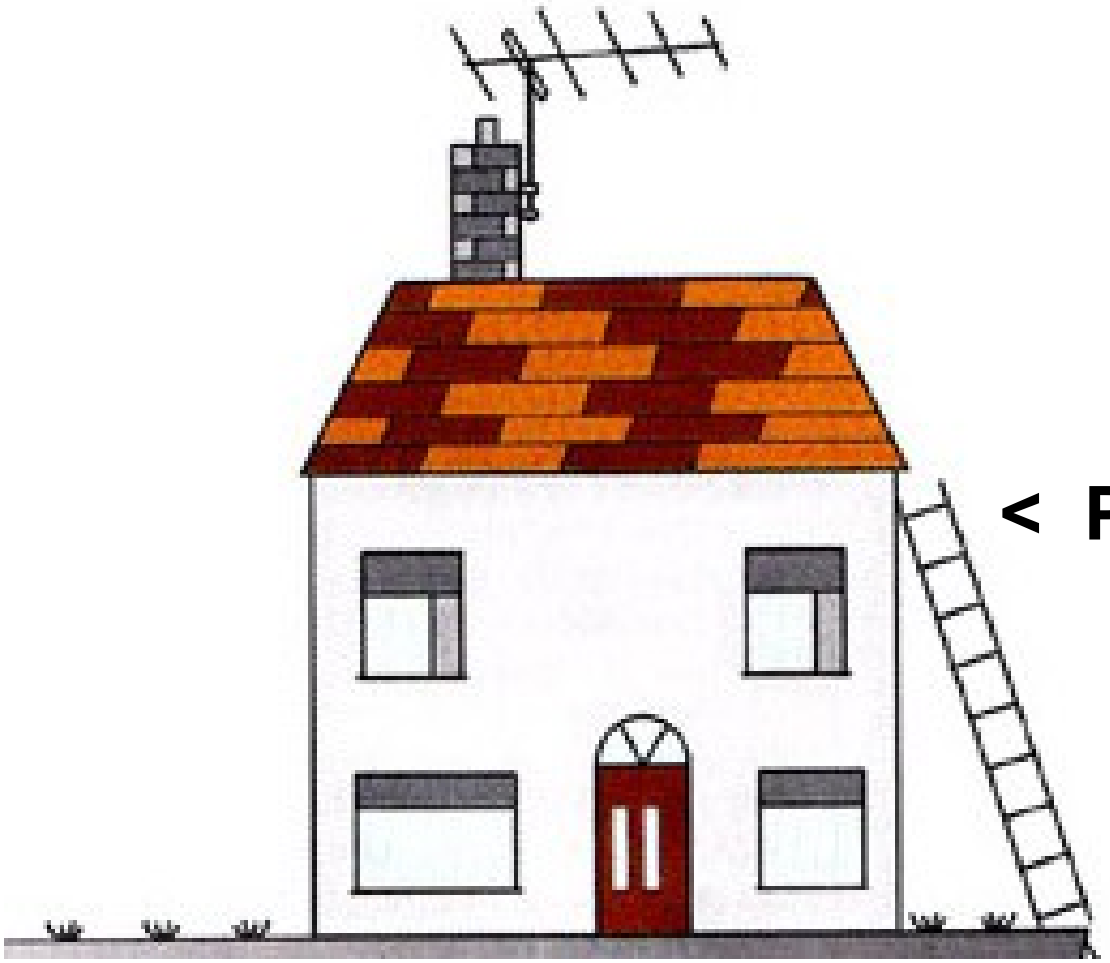
10 mA: On this scale the meter will indicate current values between 0 and 10 mA.

10 A: On this scale the meter will indicate current values between 0 and 10 A.

What is voltage?

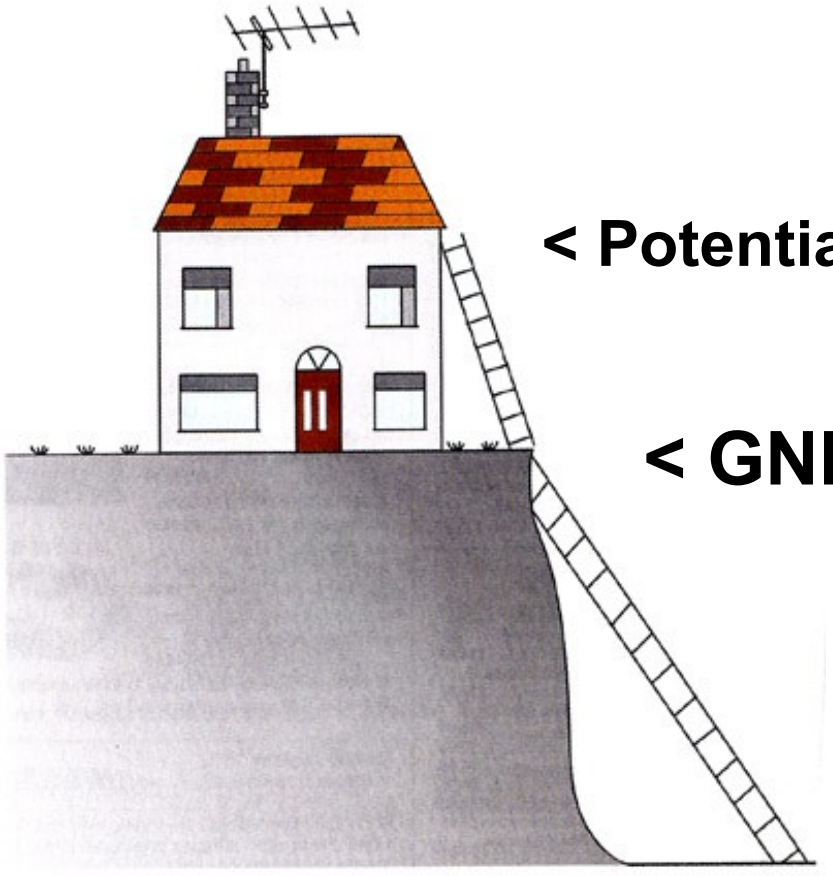
- Voltage is the potential energy that makes the electrical current flow in a circuit by pushing the electrons around. The unit of voltage is the *volt.*
- It is also called electro-motive force, or *EMF*.





< Potential

← GND



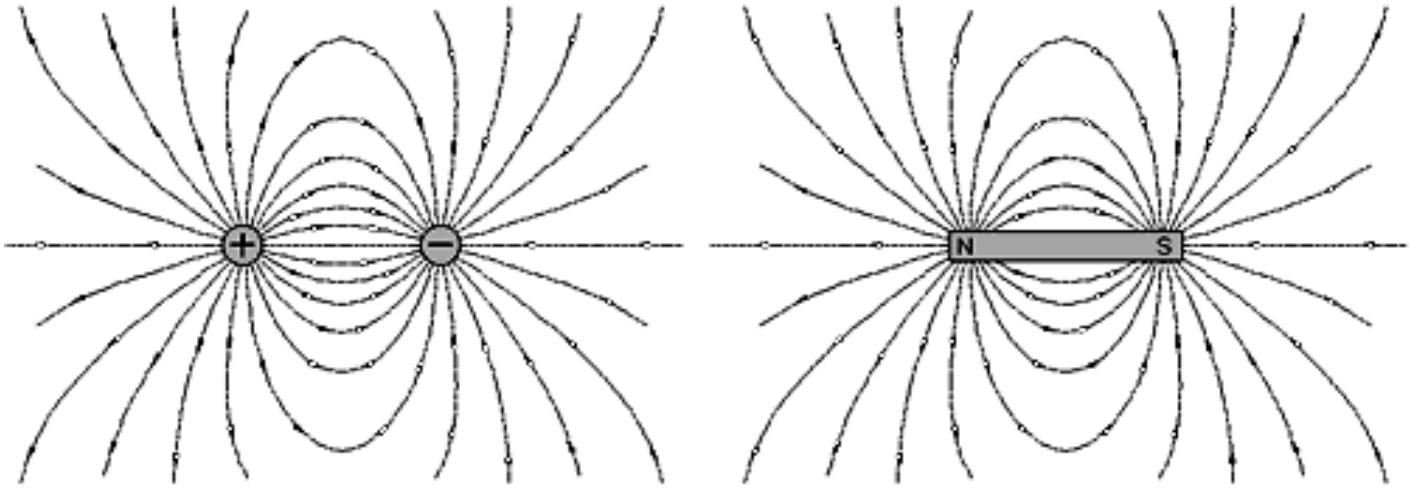
< Potential

< GND

< ***Negative potential*** **!**

“Fields”

- Electrostatic fields and magnetic fields are twins. They are two halves of a duality in the universe.



A *voltmeter* can measure electrostatic field differences, or *potential,* or *EMF*

Voltage notation always uses an uppercase V

Note the red horseshoe magnet in this classroom voltmeter

What is *resistance*?

- **Resistance is the opposition that a substance offers to the flow of electric current.**
- **Resistance is often represented using the uppercase letter *R*.**

Resistance and Resistivity

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

The Greek letter *rho* denotes *resistivity*, not *resistance*

Resistivity of common materials

Resistivities at 20°C	
Material	**Resistivity**
Aluminum	2.82
Copper	1.72
Gold	2.44
Nichrome	150.
Silver	1.59
Tungsten	5.60

The unit of resistance

- **The standard unit of resistance is the *ohm*, sometimes written out as a word, but usually symbolized by the Greek letter omega.**

Ω

The *schematic* symbol usually looks like this:

Now, one *volt* will force one *ampere* of current through one *ohm* of resistance

Stated differently ...

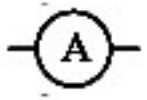
- **When an electric current of one ampere (1A) passes through a component across which a *potential* difference (or voltage) of one volt (1V) exists, then the resistance of that component is one ohm.**

Schematics are diagrams that show how electrical and electronic circuits are wired. Schematics use symbols. Schematics are the "roadmaps" that reflect the configuration of circuits.

Again, here's the symbol for a resistor.

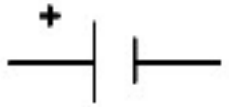
Here are a few more symbols used on schematic diagrams:

AMMETER



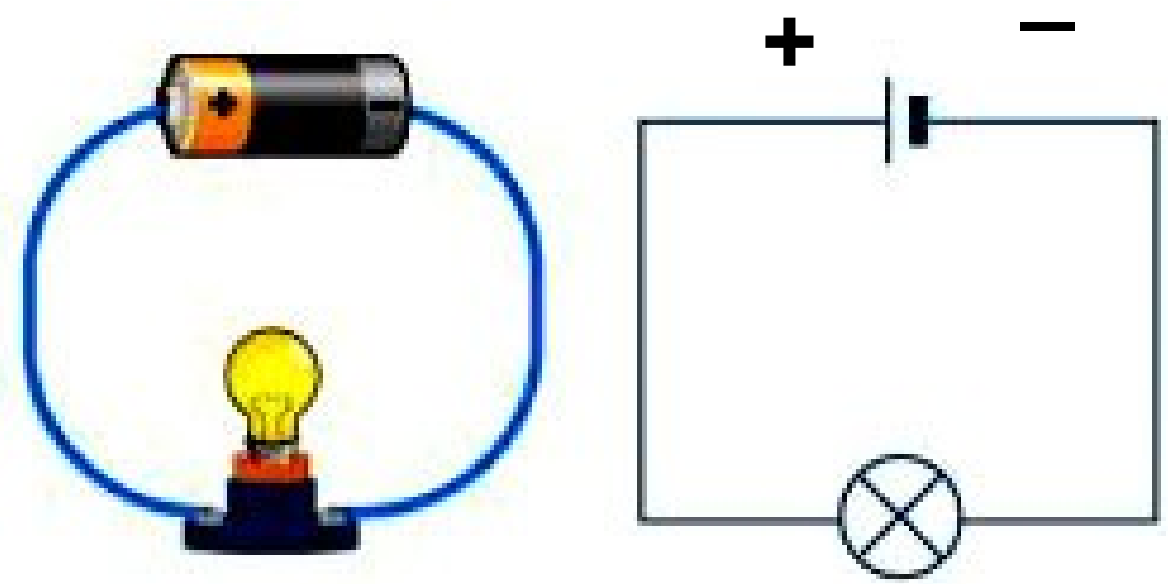
BATTERY
(LONG LINE IS ALWAYS POSITIVE)

SINGLE CELL

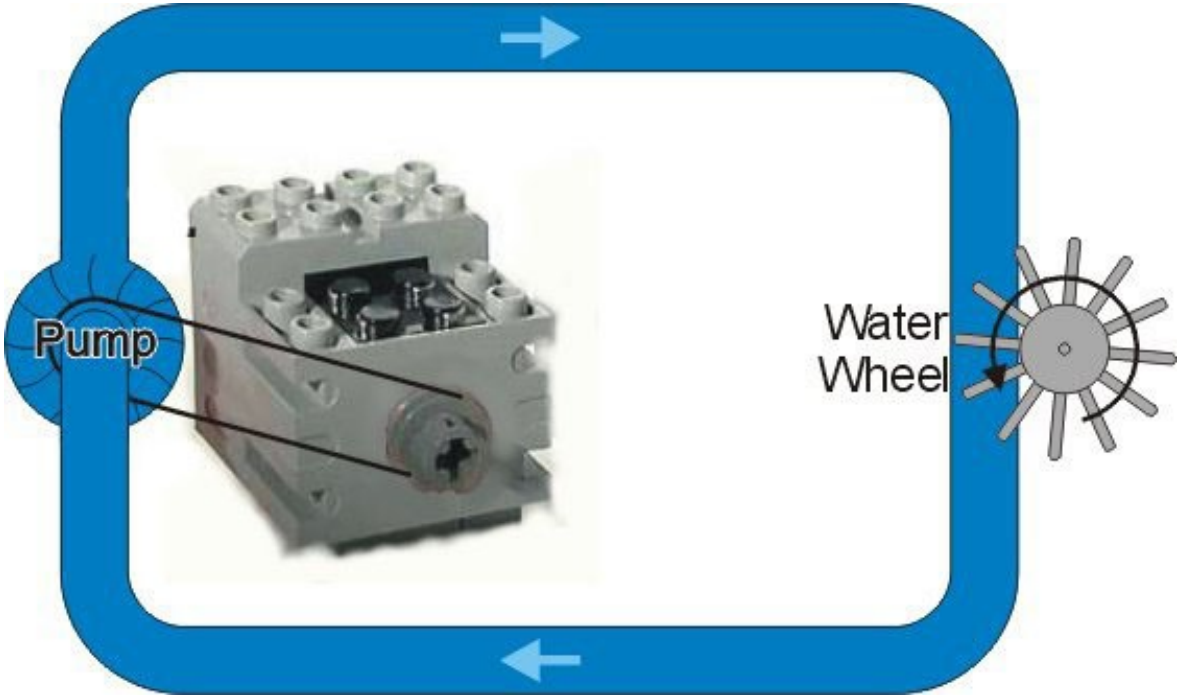


MULTICELL

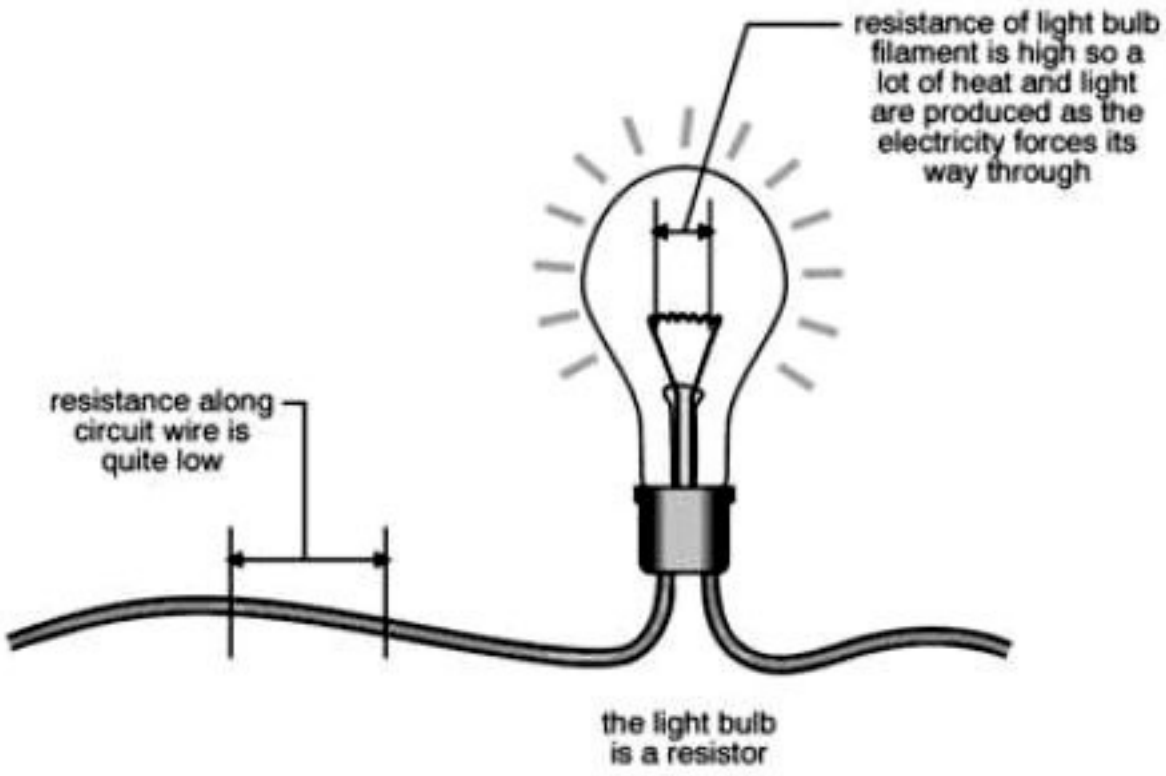
The simplest circuit



The water wheel analogy



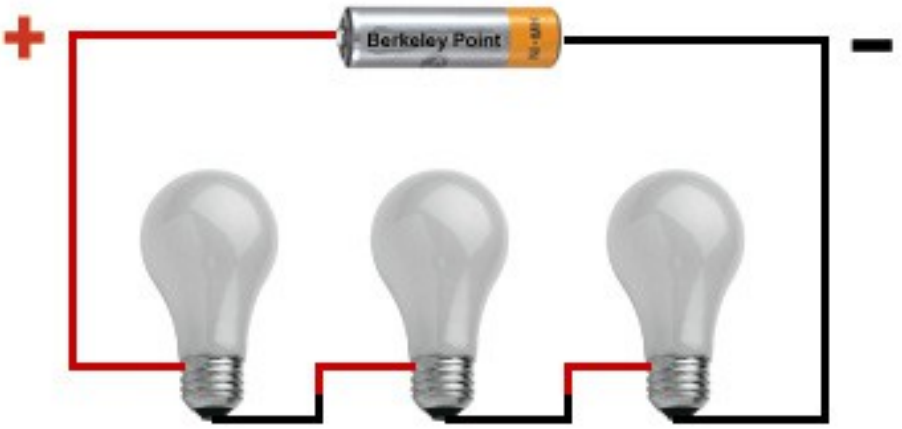
Tying it together



Another kind of resistor

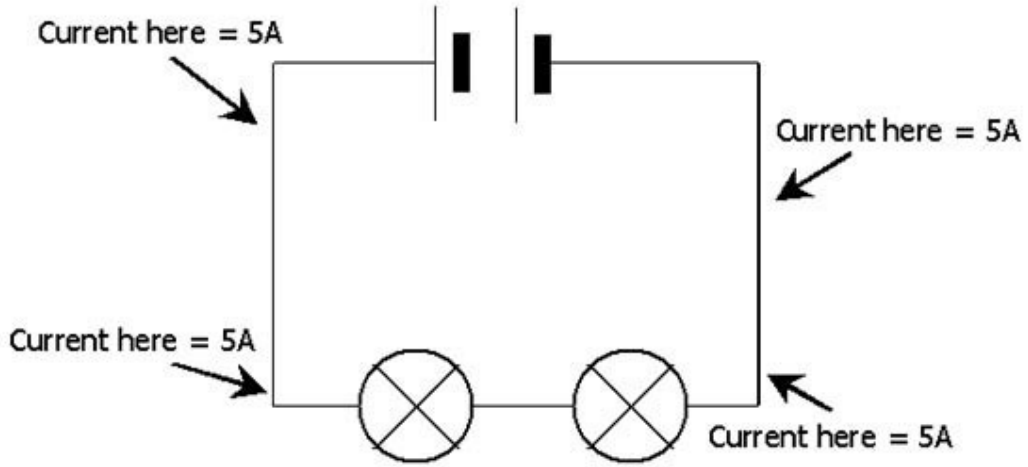
DC series circuits

- Electron flow is the same in all parts of the “series circuit”



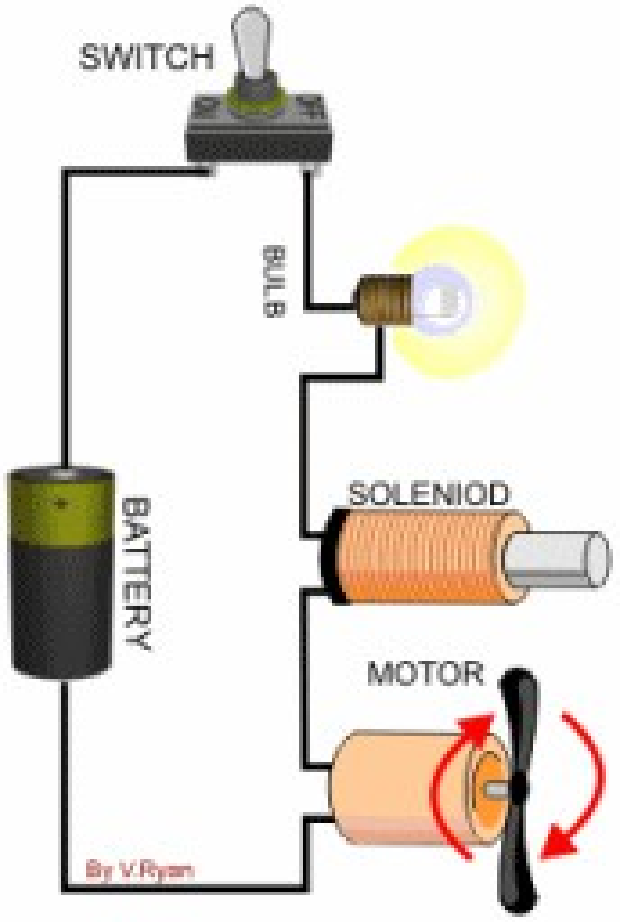
DC series circuits

- The current is the same in all parts of a series circuit, just like water flowing through one continuous pipe



DC series circuits

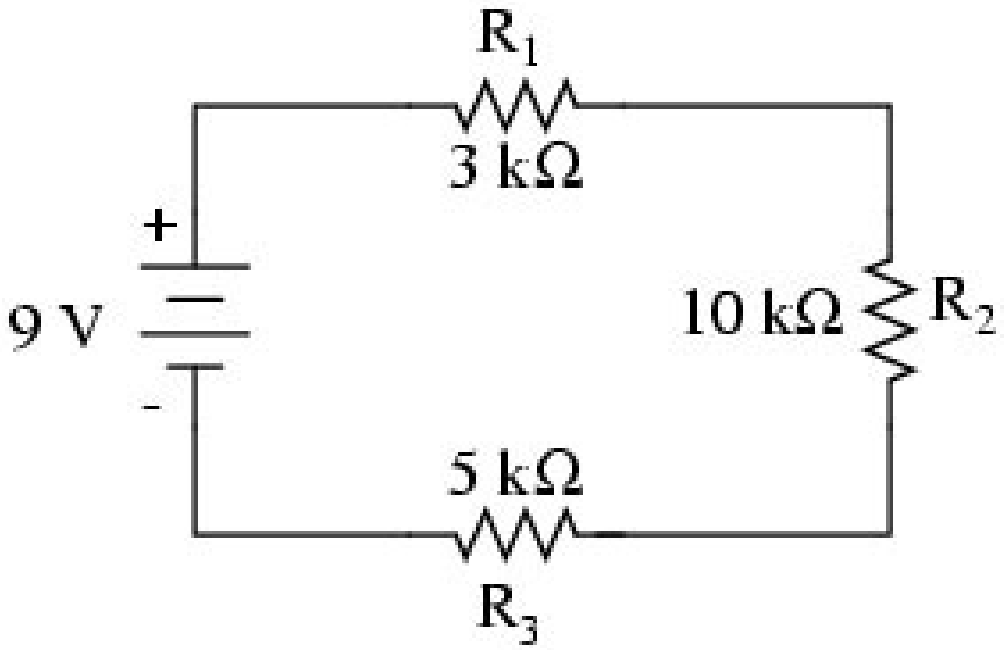
- Series circuits can have various types of devices in series



DC series circuits

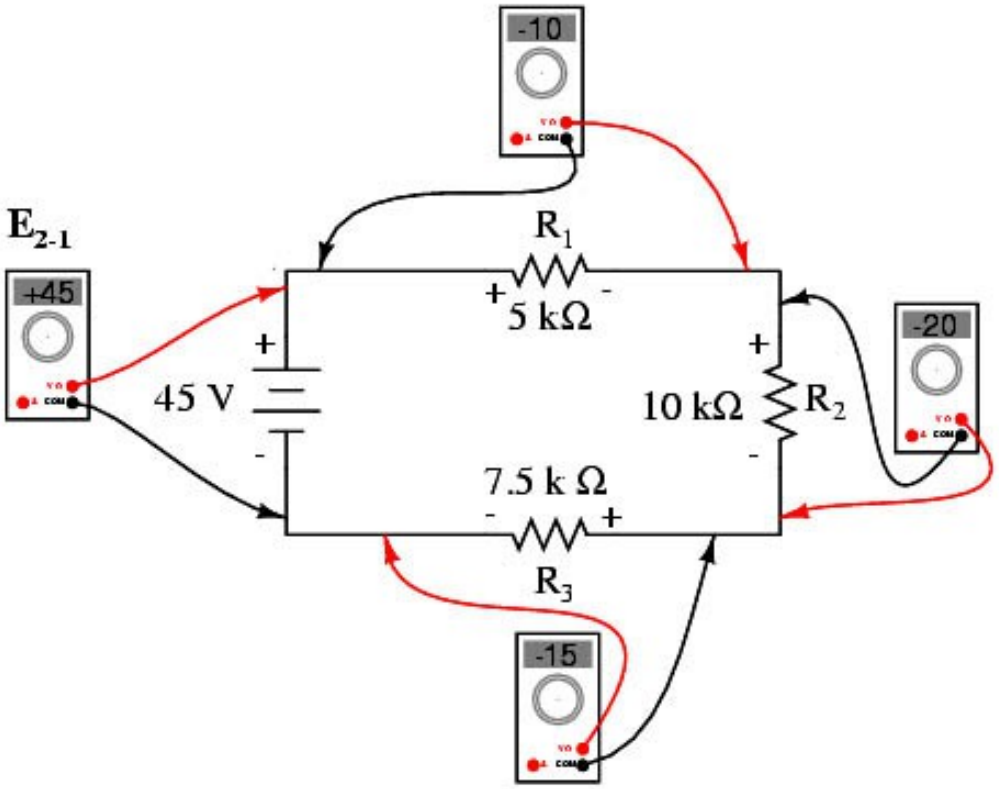
- Here's a series circuit comprised of three different-value resistors

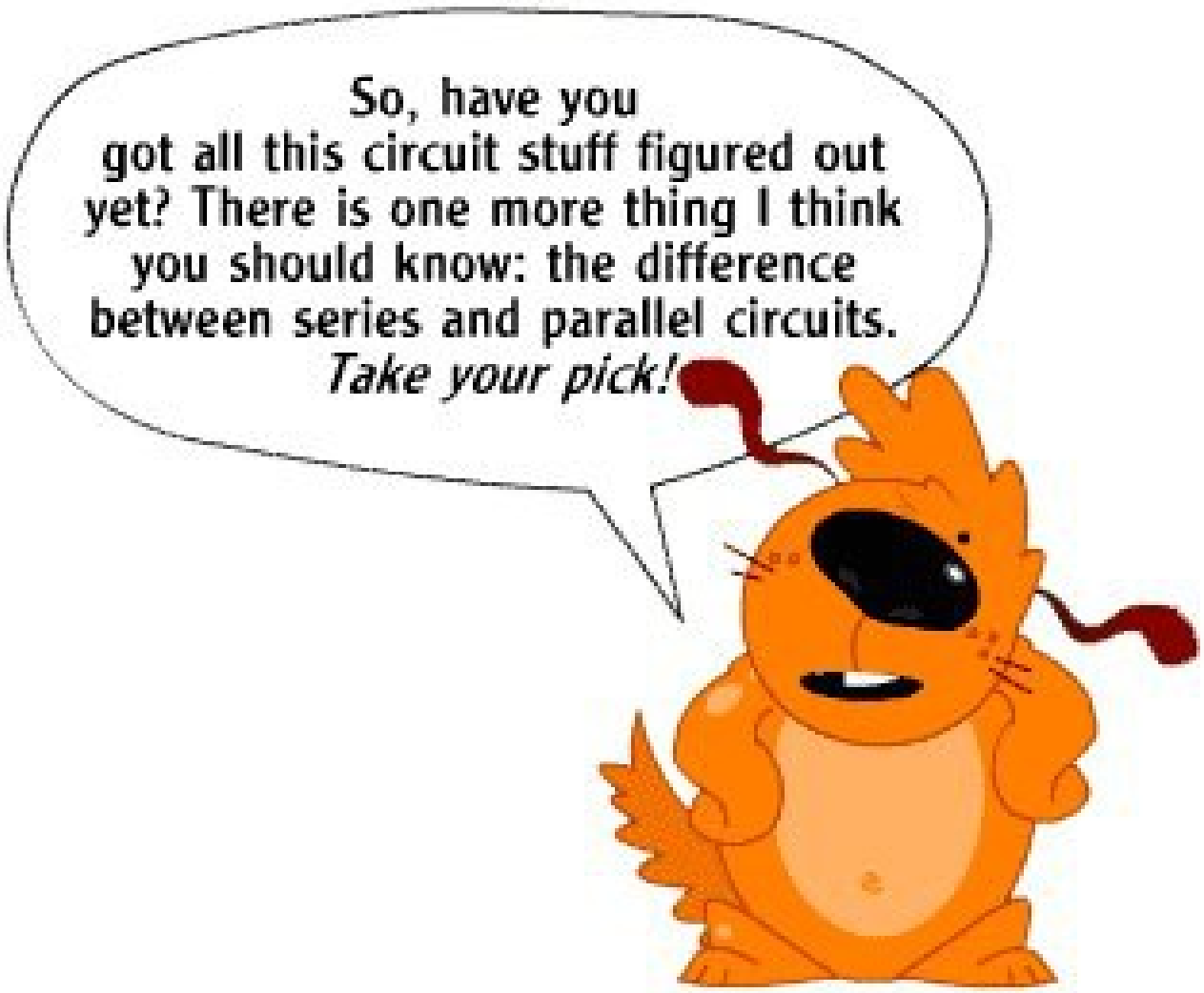
The lower case k is shorthand for a thousand. i.e. 3k is 3000.



DC series circuits

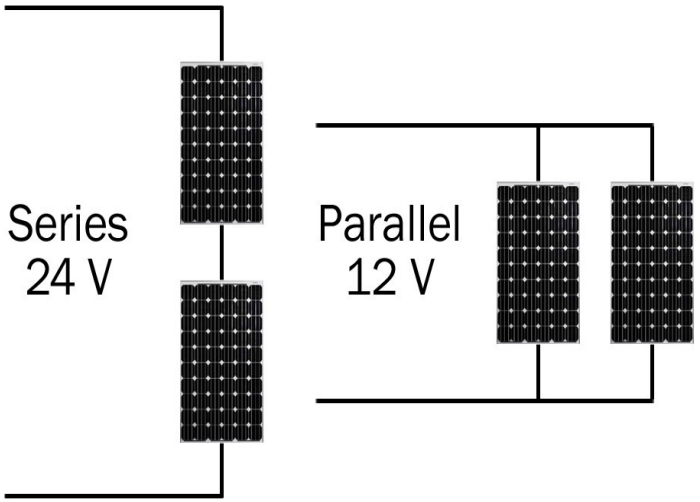
- The sum of the voltages across each component in a series circuit is equal to the source voltage



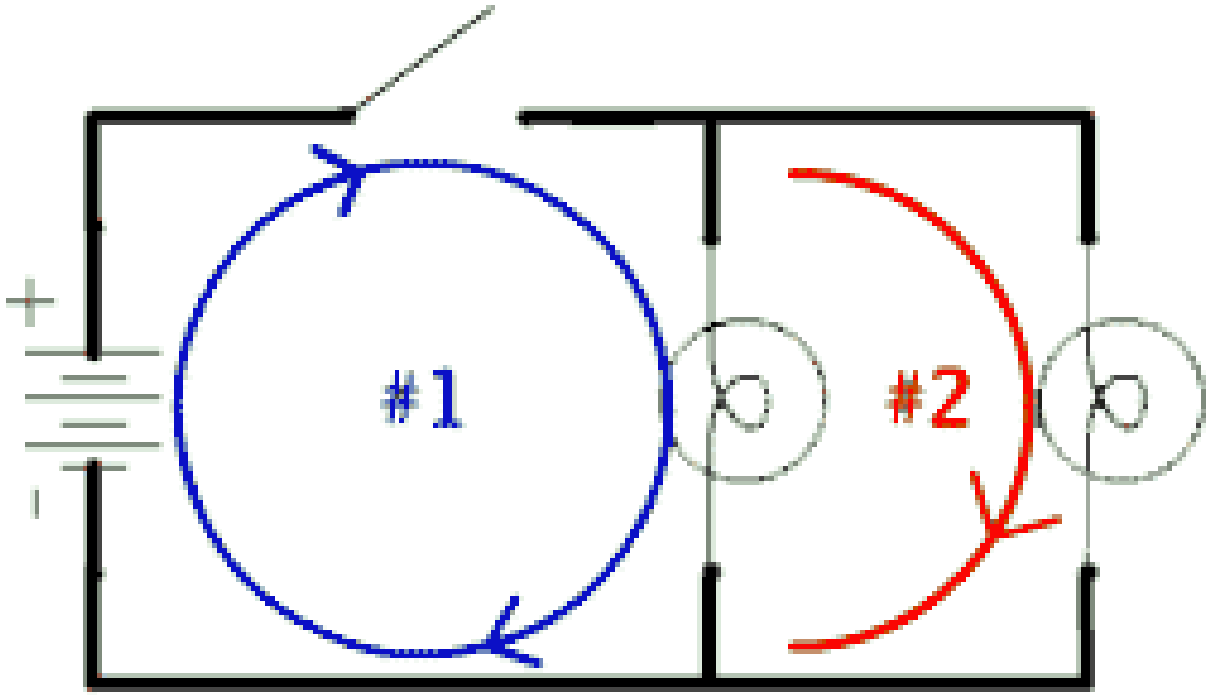

So, have you
got all this circuit stuff figured out
yet? There is one more thing I think
you should know: the difference
between series and parallel circuits.
Take your pick!

Series and parallel DC sources

- Sources can be connected in series or in parallel. Photovoltaic panels are shown here, but the DC source could be chemical cells or batteries.



Current flow in a parallel circuit



Thanks
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