Stuff You Should Know About CIRCUITS (but were afraid to ask)

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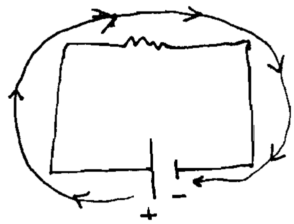
Cutnell & Johnson section 20.1 introduces you to what a battery is. Think of a battery simply as a device that supplies a potential difference (a voltage), kind of like a capacitor except it doesn't discharge as quickly. 20.1 also introduces you to current: the number of charges that pass through a surface per unit time (fig. 20.3), or

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

It's important that you understand current is never "used up", but instead, it flows.

"Conventional current" as defined by Ben Franklin starts at the "+" terminal of the battery and flows to the "−" terminal.



Ohm's Law: (this one's important.)

$$V = IR$$

V = voltage (in V)
I = current (in A)
R = resistance (in Ω)

* current will not flow unless the circuit is complete (i.e. a switch is closed)

or (Voltage across resistor) = (current drawn by resistor)(resistance of resistor)

If I multiply both sides of Ohm's law by I, I have an equation for the power delivered to the resistor:

$$IV = I^2R = P$$

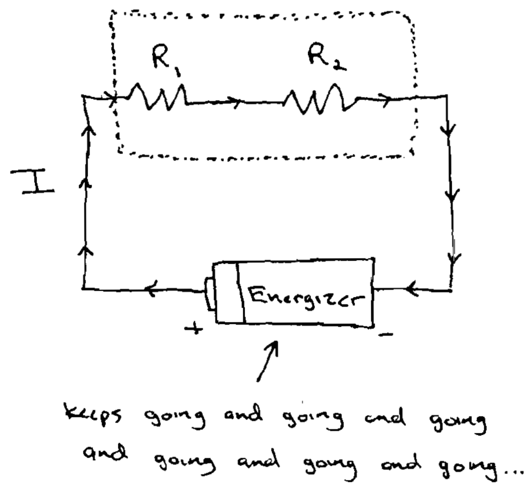
What's a resistor?

A resistor is whatever electrical device you're trying to operate, i.e. a light bulb, a buzzer, your toaster, etc. Each of these has some resistance R

Now let's look at what's up with this "series" and "parallel" business...

Series Circuits

– series circuits are set up so there is the <u>same current</u> passing through each device.



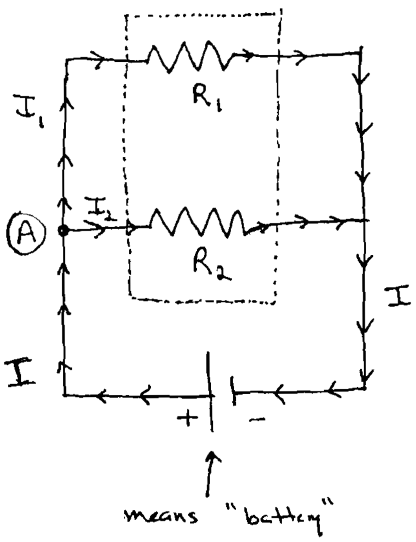
Resistors are placed one right after the other, while the same current passes through them. Light bulbs in this arrangement are usually dimmer, but the key is that they are both <u>equally</u> dim.

<u>In series</u>, the total resistance enclosed by the dotted box is

$$R_{series} = R_1 + R_2$$

Parallel Circuits

– parallel circuits are set up so there is the <u>same voltage</u> passing through each device.



Resistors are placed parallel to each other, and while different current passes through them (I_1 and I_2), they both see the same voltage. Light bulbs in this arrangement appear brighter. Note: when the current I divides at the point labeled (A), it does <u>not</u> have to divide equally; I_1 does not necessarily equal I_2, but the total current must equal the sum of the split currents:

$$I = I_1 + I_2$$

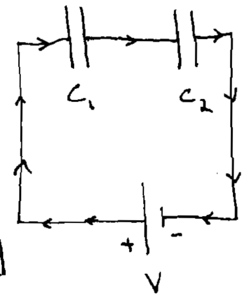
In parallel, the total resistance enclosed by the dotted box is

$$R_{Parallel} = \frac{1}{\frac{1}{R_1} + \frac{1}{R_2}}$$

Capacitors in Series and Parallel

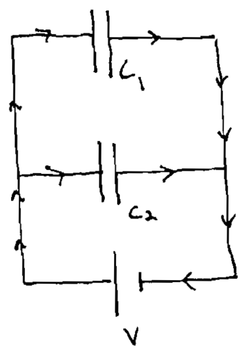
The procedure for adding capacitors together is exactly <u>opposite</u> what you did for resistors:

Series:



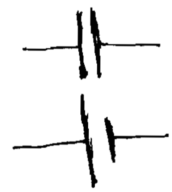
$$C_{series} = \frac{1}{\frac{1}{C_1} + \frac{1}{C_2}}$$

Parallel:



$$C_{parallel} = C_1 + C_2$$

note: do not confuse the circuit symbols for battery and capacitor:



The capacitor symbol shows two equal length plates, but the battery's "+" plate is longer than its "−" plate.

What's the difference between "resistance" and "resistivity"?

<u>Resistivity</u> (which we call ρ) is an "inherent property" of a material, and does not depend on what shape the material has. Another example of an "inherent property" is density - lead has the same density no matter what shape it's in; similarly with resistivity. Resistivity is measured in ohm·meters ($\Omega \cdot m$). Also, it is temperature dependent: $\rho = \rho_0 \left[1 + \alpha(T - T_0)\right]$ (see page 583 for more.)

<u>Resistance</u> is similar to resistivity except that it <u>does</u> depend on what shape the material has. It is related to resistivity by $R = \rho \frac{L}{A} = \rho \frac{(\text{length of wire})}{(\text{cross-sectional area of wire})}$

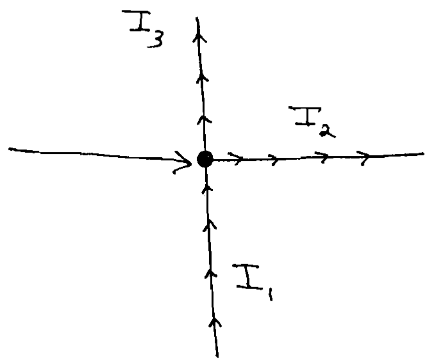
Kirchoff's Rules

Don't worry - it took me a long time to learn this part, too. But you can benefit from my mistakes. Here's what you need to remember:

Whoever this Kirchoff guy was, he came up with 2 Rules:

1) The Junction Rule - all the currents going into a point on the wire must equal all the currents coming out of that point.

a point on the wire
→ call it (A)

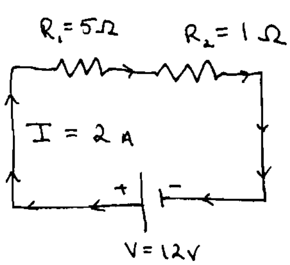


Current going into (A)	Current coming out of (A)
I_1	I_2 and I_3

→ then by the Junction Rule,

$$I_1 = I_2 + I_3$$

2) The Loop Rule - for a closed circuit, add up all the voltages supplied by the batteries (V), and then add up all the voltage drops across the resistors (IR). The two sums must be equal.



Voltage from Battery	Voltage Drop across Resistors
12 V	$I(R_1 + R_2)$
	$= (2A)(5\Omega + 1\Omega)$
	$= 12V$

✓

Side note: If you really hate Kirchoff's Rules as much as I did when I was learning them, there's a sadistically funny diagram on page 605, 20.41b. Pretend that guy is Kirchoff.