FREQUENTLY ASKED QUESTIONS

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Content Questions

Do charges only flow along the surface of conductors as well?

Strictly, the argument I made about potential being constant inside a conductor because the charges arrange themselves to cancel the field inside is true only in a static situation. In a dynamic situation involving moving charges, such as current in a wire, this condition is violated. The actual charge distribution will be determined by the solution to Maxwell's equations for the given situation, and may include moving charges in the bulk (a good description for DC current) or more along the edges (better description for AC current)

Nevertheless, it is a very useful approximation to consider the potential as constant everywhere inside a conductor, even for a current-carrying wire.

What's the difference between EMF and voltage?

"Voltage" is a generic term referring to a potential difference between any two points in a circuit. An "EMF" usually refers to a device that *creates* a voltage, by expending energy to maintain a separation of charge.

Is EMF referring to both voltage and current sources? Do any other types of EMF exist?

EMF ("electromotive force"– a poor nomenclature!) refers to a voltage provided by a battery or power supply of some kind. A current source is a device that provides constant current, not constant voltages, and is not referred to as an EMF.

Doesn't a battery provide a current source since $V = IR$ and since V is constant for a battery and R is constant for a given circuit?

No– the meaning of "ideal current source" is that the device provides a constant current *no matter what resistance you attach across it.*

Similarly, an ideal voltage source provides a constant voltage no matter what you attach to it. If you change R, the battery (which provides constant

V no matter what R is) will give you a different current. A battery is a voltage source, not a current source.

Some terminology: what you attach across a source is often referred to as a "load". Ideal sources are independent of load.

Why is current always equal across series resistors? Couldn't the speed of charges decrease due to the resistor?

In a steady state, amount of charge moving through a conductor per time (i.e., current) must be constant in a steady state because otherwise it would be building up or disappearing; charge doesn't appear out of nowhere or vanish (it's *conserved*).

You can consider flowing charges to be like continuously flowing water: as water flows through a channel, the mass per time crossing some point must be constant, or else the water would be pooling or leaking.

Note that *speed* of individual charge flow is not the same as current. Current, $I = dq/dt$, is amount of charge flowing past some point per time. You could have lots of charge flowing slowly or less charge flowing quickly to get the same current (charge per time). In the flowing-water analogy, current is analogous to dm/dt, mass per time flowing past a point. You could have less mass flowing faster (just as water flows fast through a small opening) or more mass flowing faster (just as water slows down going from small to large cross-sectional area channel). You may remember the "equation of continuity", $A_1 v_1 = A_2 v_2$ from your mechanics course.

We'll talk more about this next class when we discuss Kirchoff's laws.

Why do parallel resistors have the same voltage across them?

Remember that everywhere in a wire the voltage is the same. On one side, say side A on the left of the parallel configuration, the voltage is the same everywhere, V_A. On the other side, say side B on the right, the voltage is the same everywhere, say V_B. So the voltage across either resistor is $V_{AB} = V_B - V_A$.

Which is the ideal voltage source, the battery symbol (parallel long and short line) or the battery symbol combined with the internal resistor?

These are different levels of idealization. A *truly* ideal voltage source would have zero resistance, but such an object can't really exist because it would produce infinite current for a given potential difference. So we often consider a voltage source to have some internal resistance (but we still often apply the term "ideal voltage source" to the thing with the resistance).

Sometimes, though, we neglect the internal resistance of a voltage source, for convenience, since the resistance might be small enough not to matter much in our treatment of the system. It all depends on what level of precision you need to describe the system reasonably.

What does an ideal current source look like physically?

Well, of course a *truly* ideal current source does not exist, since it would have to provide infinite voltage for zero resistance. But approximations do exist, in various designs. Actually, a van de Graaff generator acts approximately as a current source, with a very high voltage across it. There are also various ways to implement current sources with, e.g., op-amps, using feedback principles (we will likely be seeing some later in the course). Physically, these look pretty much like other integrated circuits (chips).

What are the practical differences between a constant current and a constant voltage source? Why would you want one over the other?

Constant voltage sources are a lot more commonly seen than constant current sources. In many (maybe almost all) real circuit designs, you want to have some kind of well-defined voltage no matter what load (resistance) you put across it. This kind of thing is provided (to a very good approximation in reality) by a battery or power supply. One sees current sources a lot less often, but they are used as components of some circuit designs (possibly we will see some later).

Why does actual ground not always work as a ground?

A perfect ground is an infinitely large, perfect conductor, so that any current in contact with it will immediately flow to infinity, and the potential is perfectly constant everywhere. Actual ground is made up of various materials, all of which are not perfect (or even good) conductors. The actual ground conductor in contact with a circuit's ground is also not infinitely large.