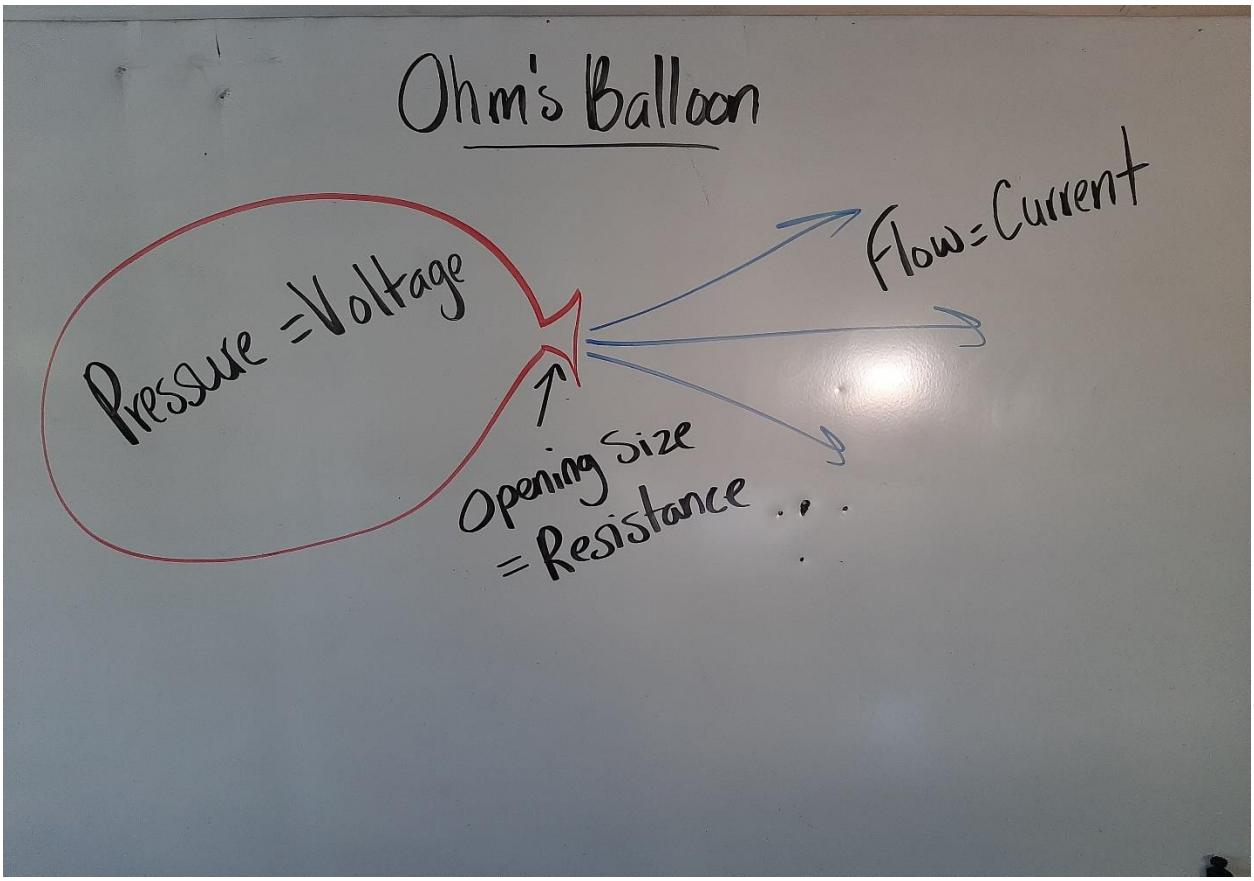
Electricity: Shockingly Difficult for Some!

As a professor of motive power, I consider myself very lucky. Most of my students have a genuine passion for the subject matter and consume information without being asked. This leads to at least a very basic level of prior knowledge and understanding of most concepts, which I need only direct (or redirect) and build upon.

However, one subject area that is a consistent challenge is electricity. It can be a daunting subject area for many students. It is also one of the most important subjects to understand, given the direction the industry has been moving in.

I find that one of the most difficult concepts for first-year students to grasp is the relationship between voltage, current, and resistance. Ohm's law calculations, and lecture-based theory classes seem to build declarative knowledge in most students, but procedural knowledge is much more difficult to achieve. For example; most students will be able to mathematically predict the outcome of changing the resistance of a circuit, but if presented with a physical example of the same thing, would be unable to apply that knowledge.

The way I have simplified this is by using what I call the balloon theory of electricity (or more recently "Ohm's Balloon")



The analogy works like this:

- Have students picture a balloon (or better yet, hand them out)
- Ask “what is the difference in pressure between the air inside and outside of the balloon when it is deflated?” The answer, of course is no difference.
- Ask “how many students have seen a balloon randomly inflate itself?” No one has, there is no reason for air to rush into a deflated balloon.
- Blow the balloon up, “now what is the difference in pressure?” High pressure inside, low pressure outside.
- Ask “what would happen if I let the balloon go?” The air will rush
- Ask “why?” Because the pressure inside is high, and the pressure outside is low.
- Ask “if I repeated that 1000 times, how many times would the air flow into the balloon instead of out of it?” None, aha! We have established some sort of rule here!
- Ask “what if I pinched off the opening half way?” The air would still come out, but at a lower rate.
- Go back to the first point, “when the balloon was full and pinched off, was there any air flow?” No. “Did I have a difference in pressure between the inside and outside?” Yes.

If we look at the picture, and apply the word substitutions, what have we learned?

- Voltage = difference in electrical pressure between two areas
- Current is flow or movement (substitute electrons for air)
- Current always flows from high pressure/potential/voltage to low pressure/potential/voltage (assign positive or negative values based on the current theory you are using)
- If there is no difference in electrical pressure, there will be no current flow
- Resistance = anything that impedes the flow of electrons (current)
- More resistance = less flow
- Less resistance = more flow
- Voltage can exist without current, but current cannot exist without voltage

I believe that using this analogy accomplishes several things:

- It makes the class more fun and engaging, which helps with retention of knowledge and lowering anxiety about the subject matter.
- It provides a quick and easy reference during practical exercises. If a circuit is found to have a lower than expected current flow, I can simply ask “what slows down the air coming out of the balloon?
- It makes a connection to prior knowledge that is easy to understand.

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