Circuit Analogy Reflection: Topographic Maps, Rock Climbing, and Circuit Diagrams

Topographic Maps

Topographic maps show the elevation of a region. Modern topographic maps typically use contour lines to convey topographical features. Contour lines follow paths marking the same elevation. In this way, several lines of different altitude are revealed and it is simple to understand the altitude change between each of these lines.

Circuit Diagrams and Topographic Maps

Circuit diagrams have conducting wire of minimal voltage drop that connects various circuit elements with significant voltage drop. As such, circuit diagrams are like topographic maps in which the altitude signifies voltage. Thus, the circuit diagrams are characterized by wires that act as contour lines connecting circuit elements which bridge the gap between these different voltages.

Rock Climbing and Topographic Maps

Rock climbing is one way to quickly change altitude. Some natural rock climbing areas have well-developed, flat paths connecting climbing routes. These connecting paths may be marked on topographic maps as contour lines due to their constant elevation. There are some climbing routes that are called multi-pitch climbs in which climbers must successively climb up one section to a stopping point before immediately continuing to climb upwards. This movement would appear on a topographic map as crossing from one contour line to the next in quick succession. Other times, there are several side-by-side routes that start and end at the same locations. These would look like parallel lines of travel on a topographic map in which the climbers start and end on the same contour lines.

Circuit Diagrams and Rock Climbing

Circuits have different voltage rises and drops based on the configuration of their elements. These various scenarios can be compared to rock climbing routes and the paths connecting them. The circuit elements are similar to rock climbing routes due to their changes in voltage and elevation. The wires are similar to the flat paths because they both connect between areas of great voltage or elevation change but they do not change voltage or elevation. The multi-pitch climbs can also be compared to resistive elements in series as the same climbers move through each successive route just like the same current moves through each resistor. Likewise, the side-by-side routes are like resistors in parallel as they both have the same elevation or voltage change and connect to the same areas.

Cool analogy

100%

Circuit Analogy Reflection

Electric circuits are like closed-loop hydraulic circuits ✓

Deep Structure

A hydraulic circuit is a network of pipes with components attached that moves water around and uses the water to do useful work. A closed hydraulic circuit means that no water is being lost from the circuit. Almost all ideas and components from an electrical circuit can be represented the same in a hydraulic circuit, just with different variable names. Voltage is exactly like pressure, due to the sum of all pressure drops around a closed loop equaling 0. Current is also like flow rate, where the water flowing into a junction must equal the water leaving a junction if the hydraulic circuit is closed. Batteries are just like pumps, as batteries use energy to create a voltage difference, pumps use energy to create a pressure difference. Hydraulic resistance is just like electric resistance, where electrical resistance is caused by the resistivity of a components material, hydraulic resistance can be caused by a shortening in the pipe radius or material in the pipe restricting the flow of water. Ohms law also holds in this analogy. Just like how a voltage drop across an electrical component, divided by its resistance, equals current, the pressure drops across a hydraulic component, divided by its resistance, equals water flow. ✓

This analogy holds true even for energy storage components, such as capacitors or inductors. Capacitors are like hydraulic accumulators, a device that stores energy in the form of pressure. An example of this is a membrane sheet blocking fluid flow. Water flows with the change in pressure due to the sheet stretching but will eventually act like a blocked pipe section if the pressure source is constant. Also, if the pressure across the membrane is large enough, the membrane could rupture, like how a capacitor can spark if the voltage across it is too great. A waterwheel is like an inductor. The energy is stored in the waterwheels inertia, which initially resists the flow of water, but eventually acts as an open pipe section if the pressure source is constant.

Analogy Reflection

Great analogy with excellent deep structure

This analogy reflects one of my experiences from when I decided to assemble my custom computer. I decided to add a custom water-cooling loop to my computer, which was basically a closed loop hydraulic circuit. It had a pump and a water reservoir, with the thermal transfer blocks and radiators acting as hydraulic resistors. It was important that there was sufficient pressure drop across the radiators for there to be enough water flow so that my devices were adequately cooled. It was also important to consider if my pump could supply the needed pressure differential, or if I needed multiple loops with their own pump.

Awesome reflection!

50/50

Circuit Analogy Reflection

Analogy: Capacitors are like water towers.

Deep Structure

Capacitors and water towers share many similarities in how they work. Both capacitors and water towers are able to absorb something or take something in, store it for an amount of time, and then release what was absorbed at a given time and at a given rate. Both capacitors and water towers are used and helpful in everyday life as well. Capacitors work by storing electrical energy. After energy is absorbed and stored over time in the capacitor, the energy is able to be released at a steady rate or very quick rate through an electric circuit when triggered. This is very helpful to add initial voltage and power to many devices, especially rotary devices. Water towers work by storing water for a designated area. Water is absorbed and stored for a given time, and is then able to be released at a given rate when triggered, whether it is a steady rate to supply water to buildings, or in a quick burst to supply water to help put out a fire. While there are many differences between capacitors and water towers, the way that they work is similar in that they can both absorb and store something for a given amount of time, and then release what was stored at a given rate when triggered.

Analogy Reflection

As mentioned in the analogy, capacitors are used in many different devices, especially rotary devices and absorb and store energy and then release it as a specific time and rate. I can personally relate this to an experience that we had with one of our tools a few years ago. My dad and I was trying to cut some wood on our table saw. When we tried to turn the table saw on, the motor would just hum and would not turn. We did some troubleshooting and could not figure out why the motor would not run. We concluded that the motor was getting the required voltage, so the issue must be in the motor. So, we were about to take the motor off of the table saw to take a further look into it to try to find the issue, and my dad recommended that we try one more thing to try to get the motor to turn. We could see where the capacitor was located on the outside of the motor, like they are on many motors. We took a rubber mallet and lightly hit the casing that covers the capacitor. We then tried to turn the motor on and it worked. We figured out that sawdust must have gotten under the casing for the capacitor and hindered the connection to the motor. When we lightly hit the casing for the capacitor, that jolted the dirt or sawdust away and made a better connection. The motor was humming because the magnets were caught between the positive and negative poles in the motor and could not get any help from the capacitor to start to turn the right way. That is how I learned of the importance and necessity of capacitors in many devices. The role of capacitors made sense to me through that experience. The capacitor had absorbed energy and had it stored, but it could not release it to the motor due to a bad connection. When the connection was better, the capacitor released energy to the motor in a quick burst to help the motor get started turning in the right direction and then the magnets with the positive and negative poles in the windings allowed the motor to continue to turn. The capacitor always has energy stored that it previously absorbed to release whenever the motor is switched on. That was an experience that taught me how capacitors work and how they are needed in such devices.

Circuit Analogy Reflection

Comparing the resistance of a circuit to the cost of entering a football game with many different gates.

Deep Structure

Higher expenses is a causation to traveling path of least resistance.

Analogy Reflection

This analogy is simple to understand. It is not one we have discussed in class. Instead I have thought of a new way to think about resistance. For example, when going to a big football game, there are many gates in which to enter. These gates all charge different prices to enter. One gate charges an entry fee of $5.00, whereas another gate charges $10.00, and yet another charges $15.00. In this scenario, the $5.00 gate will be full of people, as many want to go through and pay the least amount of money as possible. The $10.00 gate will contain some people, as those people don't want to wait in the long lines of the $5.00 gate, but also want to minimize cost without wasting time. Lastly, the $15.00 gate with have a very small number of people who go through it because of its high cost. This is similar to resistance. If there are 3 different branches with resistances of 5, 10, and 15 ohms, the relation is the same. Most of the current will travel through the 5-ohm branch, less current will travel through the 10-ohm branch, and nearly no current will travel through the 15-ohm branch.

This relates to my real-life experience because I love going to football games. I have also been intrigued as to why prices differ when considering similar seats. I also find it interesting that prices of games differ when the situations are much the same. For example, the price of an Ohio State football game is much more than the price of an Ohio Northern football game. In both games, I would be watching football, but going to the Ohio State game costs a lot more.