Thinking About Causality and the Simple Circuit: Why is it so Hard?

Many people have trouble understanding how a simple circuit works. They find it hard to: 1) use cyclic instead of linear causality, and 2) use simultaneous instead of sequential causality.

Linear Versus Cyclic Causality

One of the challenges of learning about circuits is to reason about what is happening using circles (cyclic) instead of lines (linear). How are they different? Here is an example. When we think about how things happen, we often say that one thing makes another thing happen—in a line. For example: Your friend does something to you that isn't nice, so you get mad.

Your friend isn't nice. ➡ You get mad.

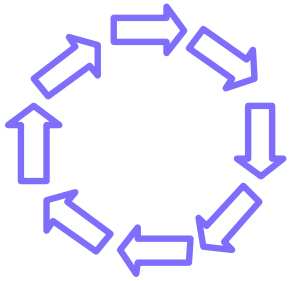
Before people really understand how a circuit works, they might try to use a Linear Model to think about what makes the bulb light up.

The battery sends power to the bulb. ➡ The bulb lights up.

In linear causality:

- One thing is a cause and one thing is an effect.
- The cause is the beginning and the effect is the end.

Sometimes linear causality is the simplest and best way to explain something. At other times, it doesn't tell the whole story. For instance, in the story about your friend, maybe you said something to hurt her feelings so she did something that wasn't nice to you, so you get mad and aren't nice to her. Then she isn't nice to you, and so on. This story is more like a circle than a line.



In cyclic causality:

- There is no real beginning or ending, at least not once the cycle gets started.
- Something can be a cause and an effect.
- If you break the story into a line, it loses important parts of the story.

Sequential Versus Simultaneous Causality

A second challenge of learning about circuits is to reason about what is happening by thinking about it all at once (simultaneous) instead of step-by-step (sequential). How are these approaches different? Here is an example. When we think about how things happen, we often use steps even when it is not how things work. For example, the hands of a clock all move at once, but we might break it down into the following steps:

1. The second hand moves.
2. Then, the minute hand moves.
3. Then, the hour hand moves.

Before people really understand how a circuit works, they might use sequential causality to think about what causes current flow.

1. Electrons crowd onto the wire.
2. Then, they move to where the bulb is.
3. Then, they light the bulb.
4. Then, they continue through the wire to the battery.
5. Then, they make the trip again.

In sequential causality:

- Things happen step by step or in order.
- There is a pattern that unfolds over time.
- Causes occur before effects.

However, some events are not sequential. They can be simultaneous. This means that they happen all at once. For example, the clock hands really all turn at once. We just break it down into steps to make it easier to think about. Circuits are also like that. Electrons repel the ones "ahead" of them while being repelled by the ones "behind" them. It happens all at once and the current flows or moves the way that a bicycle chain moves.

In simultaneous causality:

- Things happen all at once.
- There is a pattern that unfolds over time.
- Causes and effects happen at the same time.

Simultaneous causality is hard to understand because causes and effects can happen at the same time. We usually expect causes to come before effects. Simultaneous causality is also hard to talk about because if you break it up into steps to tell the story of what happens, you lose the idea that it all happens at once.