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INVESTIGATION 1. WHAT IS A CAPACITOR?

INTRODUCTION:
Capacitors are important components of electrical circuits that are used in every device imaginable: Phone, laptops, LED light bulbs, etc. Their most useful attribute is the ability to store and disburse charge quickly into circuits and are major components in rectifier and filtering circuits. In this investigation, you are going to learn about a few properties of these devices hands-on.

REVIEW:
Before we begin, it is important to review a few properties of circuits we learned last year in AP Physics 1.

1. Conductors: Materials used to carry current with "zero" resistance. Something to recall about conductors from our last unit is that there is no voltage change across any two points of an *ideal* conductor.

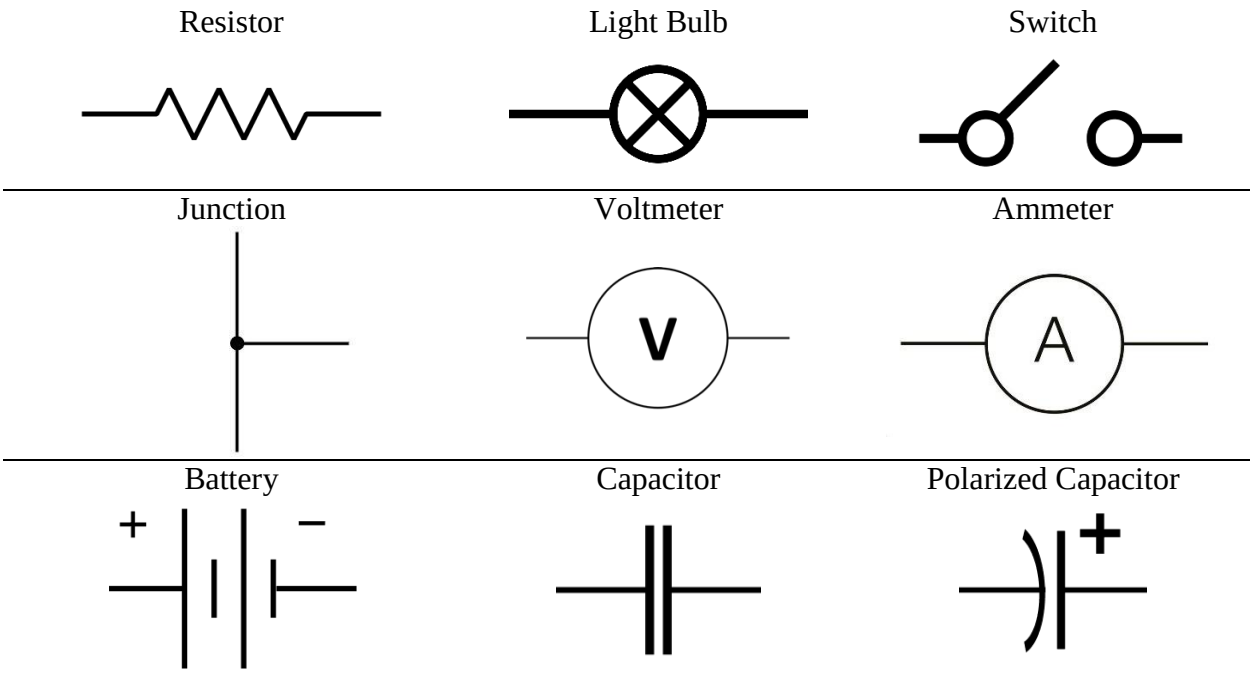
2. Resistors: Materials used to "limit" current in a branch of a circuit by converting electric potential (voltage) to heat. These are often used in circuits to reduce the chance of burning out sensitive electronics such as microchips or LEDs.

3. Mechanical Switches: Devices used to turn segments of a circuit on or off. Required physical movement of the switch to operate.

4. Junctions: A segment of a circuit in which current can split or combine. A junction is indicated by a DOT to show an electrical connection at that point.

5. Voltmeter: Devices which can be used to measure the *potential difference, ΔV,* between any *two points* in a circuit. Ideal voltmeters have *infinite resistance* to not divert current from the main circuit.

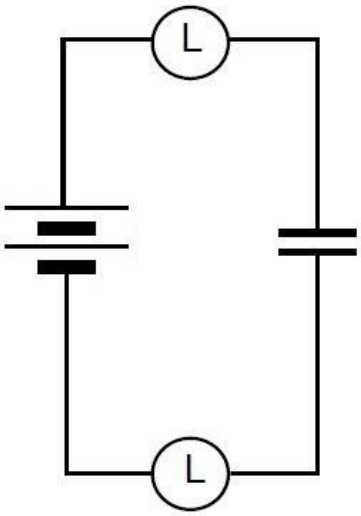
6. Ammeter: Devices which can be used to measure the *current, I,* at any *one point* in a circuit. Ideal ammeters have *zero resistance* to not change the current at that location.



Activity 1.1: Experimenting with capacitors in a circuit

1. To the best of your ability, set up the circuit indicated below which consists of two long-bulbs, a pair of batteries., and a capacitor placed in series with each other.

Figure 1: Charging Circuit

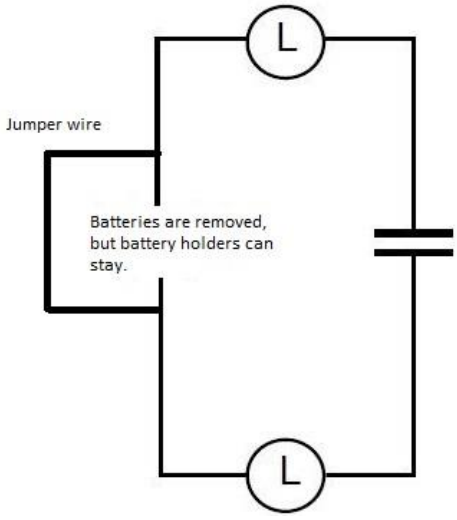


2. **Describe:** What happens to the brightness of the light bulbs when you complete this circuit? Why do you think this happens?

It temporary lights up dimly for a short amount of time. This is probably because since the circuit devices are meant to temporarily store the charge.

3. Next, try to see if you can light the light bulbs up again, but this time without the batteries in the circuit at all. Create the circuit below. To make this process shorter, you can remove the batteries, but leave the battery holders in place in the circuit. Once you have removed the batteries, you can then place a jumper wire across the terminals where the two batteries used to be. **Make sure the batteries are removed before doing this**!

Figure 2: Discharging Circuit



4. **Describe**: What happens to the light bulbs when placed in this orientation? How does it compare to what the light bulbs did in the first circuit?

The light bulb instantaneously lights up dimly for a short period of time, shorter than the light bulbs in the last circuit.

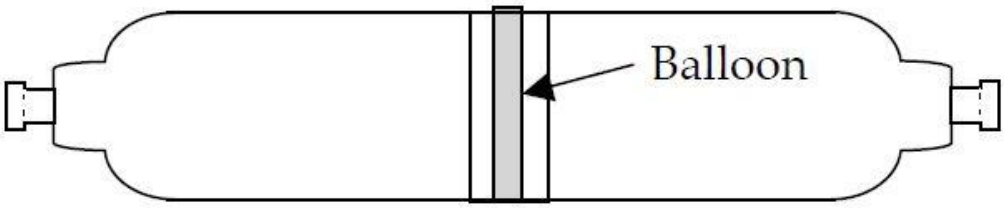
5. Charge the capacitor up again by removing the jumping wire and placing the batteries back in their holders.

6. **Predict**: Will the bulbs light again if you add a second pair of batteries into this circuit? Why or why not?

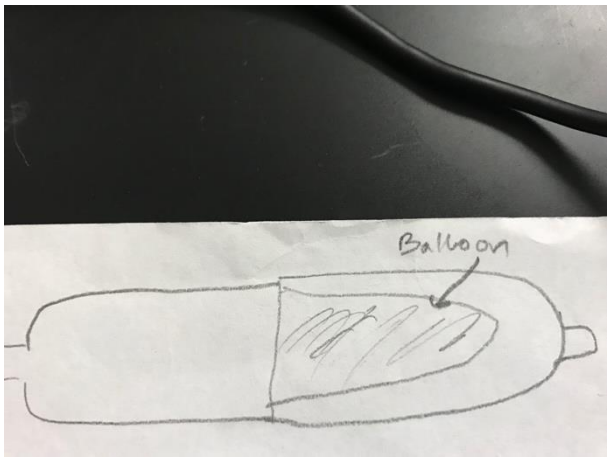
Yes, since the batteries will add to the total potential difference in the circuit.

Activity 1.2: Using air as an analogy

1. The figure below shows and air capacitor with both sides open to the atmosphere through a tube in each side. There is atmospheric pressure in each side, which we will call NORMAL air pressure.



2. **Predict/Sketch**: If you were to blow air into the capacitor from the left side, what would the balloon on the inside of the capacitor look like?



3. Explain why the membrane between the two sides would change shape in such a way.

The membrane of the balloon would expand towards the right since the air travels from the left towards the right side.

4. As air is pushing into the left side of the capacitor, would *air current* be allowed to travel **through** the balloon membrane?

No, since air cannot travel through the latex of the balloon

5. Would air leave the other side of the capacitor it that end was open? How would the amount of air that leaves the right side compare the amount of air that enters the left side?

The latex of the balloon would stop the air from moving to the other side of the capacitor.

6. While we do not have the full air capacitor model, we can make some observations with a standard balloon. Please take a balloon provided by your teacher for the following questions.

7. Blow into the balloon and inflate it as much as you can in **<u>one breath</u>** and hold it there without removing it from your mouth for about 5 seconds. We can call this action "charging" the air capacitor.

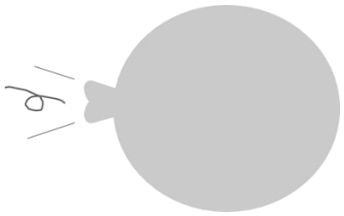
8. **Analyze**: As you hold the balloon in its inflated state with your mouth, how does the pressure inside of your lungs compare to the pressure inside the balloon? How do you know this?

The pressure inside of my lungs would be equal to the pressure inside the balloon, since they are directly connected.

9. In this analogy, what circuit component would your lungs represent? What circuit component would the mouthpiece of the balloon represent? What circuit quantity would pressure represent?

In the analogy, the lungs would represent the battery, the mouthpiece of the balloon would represent the wiring, and the pressure would represent voltage.

10. With the balloon inflated, remove it from your mouth and allow the air to leave the balloon. This could be thought of as the balloon capacitor "discharging"



11. How does the direction of air current through the mouthpiece compare when discharging vs charging?

The direction of air goes in the opposite direction of when it was charging, as it travels left while discharging as opposed to travelling right when charging.

12. How does the amount of time it takes for the balloon to discharge compare to the amount of time it takes to charge with one breath?

Discharging the balloon takes much less time than the amount of time it takes to charge with one breath.

13. **Critical Thinking**: Capacitors are simple devices. They are simply used as "charge banks" that can be filled when the circuit has an excess amount of charge and emptied when the circuit needs a bit of extra charge. They are fairly similar, but not the same thing as, rechargeable batteries. Can you think of any examples of a real use for capacitors in circuits?

Examples of real use for capacitors in circuits may be power banks for emergencies.

This concludes Investigation #1. In Investigation #2, you will be proving many of your predictions in this unit with instruments that can quantify values.