On-line activities for DC circuits labs

Below is the list of experiments (real, video based, simulations-based, and data-based) that students can perform as labs for DC circuits. For each experiment we provide goals, equipment and rubrics for self-assessment. Rubrics can be found at https://sites.google.com/site/scientificabilities/rubrics

1. Observational experiment

Goals: learn what is needed for continuous charge flow

Equipment: none

Rubrics for self-assessment: Ability to conduct an observational experiment: B9.

Watch the following experiment https://youtu.be/IA28ahpNdxk. Describe what you observed, and explain why both electroscopes got discharged. Explain what is happening inside the metal rod right when it touches the electroscopes and at the end of the experiment.

2. Observational experiment

Goal: to construct an idea of what constitutes a complete circuit

Equipment: 1 D or C 1.5 V battery, a small incandescent lightbulb, 2 connecting wires.

Rubrics for self-assessment: Ability to conduct an observational experiment: B5 and B9.

If you have a battery, two wires, and a small lightbulb, follow instructions below.

a. Try different arrangements of these four elements to make the lightbulb glow.

b. Then, remove one wire and try to light the bulb with just a battery and one wire.

c. Draw pictures of the arrangements where the bulb lights and several where it does not. Explain how this experiment is similar to Activity 19.1.1 and how it is different.

d. Think of how an incandescent lightbulb might be constructed.

If you do not have the materials, go to https://phet.colorado.edu/sims/html/circuit-construction-kit-dc/latest/circuit-construction-kit-dc_en.html

Note that the simulation also uses incandescent light bulbs. They are very different from the LED bulbs that you use at home.

a. With PhET drag one light bulb, two wires, and a battery to the center of the screen. Arrange these four elements to light the bulb.

b. Now use only one wire. Can you light the bulb? How is this circuit similar to the first one? How is it different?

3. Observational experiment

Goals: learn how to connect batteries to increase the current in the circuit; learn the difference between series and parallel connections.

Equipment: none.

Rubrics for self-assessment: Ability to conduct an observational experiment: B5 and B9.

Go to https://phet.colorado.edu/sims/html/circuit-construction-kit-dc/latest/circuit-construction-kit-dc_en.html and use available materials to build the three circuits according to the descriptions below.

Experiment 1	Experiment 2	Experiment 3
One battery, one lighted lightbulb, and two wires.	Two batteries arranged so that the positive side of one touches the negative side of the other, forming a chain (in physics they are said to be *in series*); one lighted lightbulb; and wires.	Two batteries arranged so that their positive sides are together and negative sides are together, forming a ladder (*in parallel*); one lighted lightbulb; and wires.

a. Draw each circuit in your notes. Observe the brightness of the lightbulb in each experiment relative to the other experiments and record your findings.

b. Explain the difference in brightness.

4. Application experiment

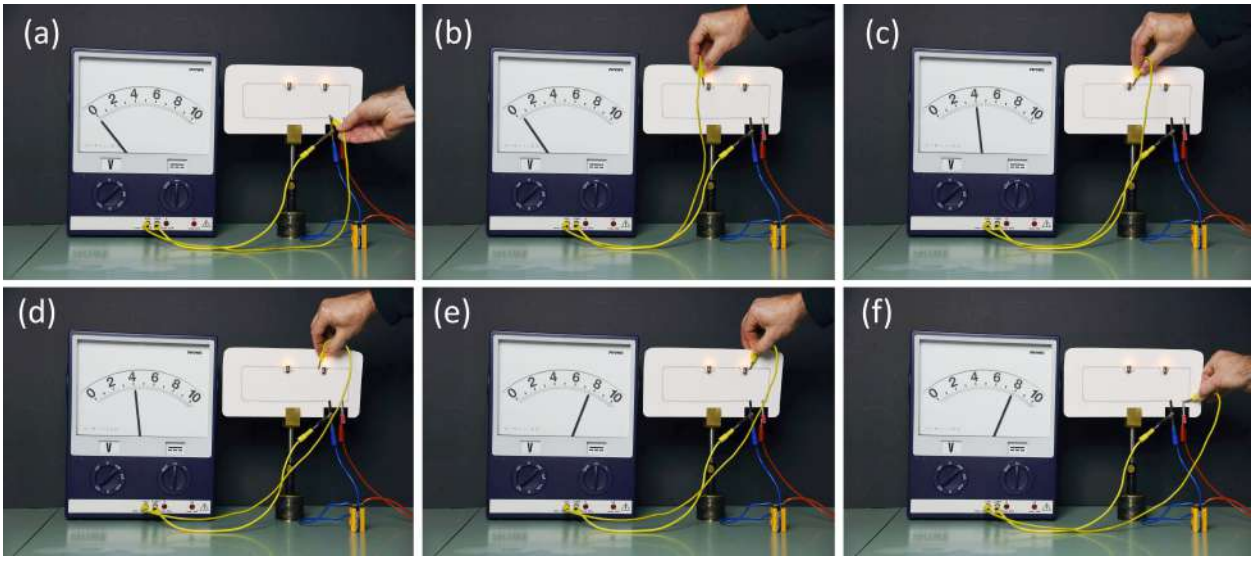
Goal: to investigate the changes in potential along a circuit.

Equipment: none.

a. Draw a sketch of the electric circuit used in the experiment. Carefully follow all connections.

b. Find a pattern in the reading of the voltmeter. What can you say about the changes in electric potential through the circuit?

c. Draw a graph of potential-vs-location. Explain the shape of the graph. Does it make sense to you?



5. Application experiment

Goal: to learn how to use an ammeter and a voltmeter

Your goal is to build an electric circuit in which the lightbulb glows, and an ammeter measures current *through* the bulb, and the voltmeter measures potential difference *across* different elements. You will do it using the circuit construction kit at https://phet.colorado.edu/sims/html/circuit-construction-kit-dc/latest/circuit-construction-kit-dc_en.html.

a. Think of how to assemble the elements. Then examine the materials available for you in the simulation.

b. Draw the circuit you are going to make, including the ammeter so that it measures the current through the bulb. Mark points across which you will connect the voltmeter.

c. Make the circuit and check that the bulb only glows (and the ammeter is showing a non-zero reading) when the switch is closed.

d. Collect the current and potential difference data for different positions of the voltmeter (potential difference across the battery, across the bulb, across the wires, and across the closed and open switch).

e. Record the patterns that you find.

6. Observational experiment

Goal: to find a relationship between potential difference across and current through a commercial resistor.
Equipment: none.
Rubrics for self-assessment: Ability to conduct an observational experiment B2, B2, B4, B7, B8 and B9.

Your goal is to find a relationship between the current through and potential difference across commercial resistors. Use the materials at https://phet.colorado.edu/sims/html/circuit-construction-kit-dc/latest/circuit-construction-kit-dc_en.html

To make a variable power supply to vary the potential difference across a resistor you can place the battery in the circuit construction place, tap on it, and at the bottom of the screen you will see that you can change its emf from 0 to 120 V.

Please address the following points when you write up your report:

a. Describe the procedure for your investigation and describe your experimental design. Include a labeled circuit diagram.

b. What important physical quantities change during the experiment? What are the independent and dependent variables in your experiment?

c. Record your data in a table. Then calculate the ratio of potential difference across the resistor and the current through it for every potential difference reading. What can you say about the ratios if you take uncertainty into account?

d. The ratio of potential difference across the resistor and the current through it for each potential difference reading is called *resistance*. What can you say about the resistance of the resistor for different potential differences across it? Is the resistance of the resistor constant or is it changing?

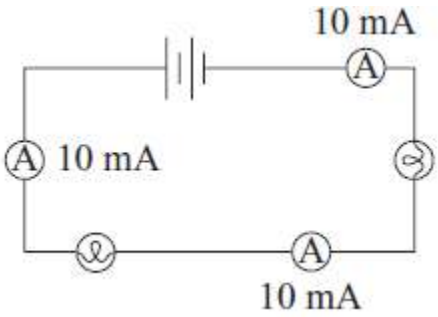
e. Use the ohmmeter to measure the resistance of the resistor that is not connected to a circuit. Does it match your findings in part **c.**?

7. Observational experiment

Goal: to learn what happens to the current through a series circuit.

The readings of three ammeters are shown in the figure below.

a. What can you say about the magnitude of the current through each of the lightbulbs? Explain the pattern.



b. Build a circuit using a battery and two lightbulbs in series using the simulation at https://phet.colorado.edu/sims/html/circuit-construction-kit-dc/latest/circuit-construction-kit-dc_en.html .

8. Testing experiment

Goal: to learn what happens to the potential difference across an open switch.

Use materials at https://phet.colorado.edu/sims/html/circuit-construction-kit-dc/latest/circuit-construction-kit-dc_en.html to build a circuit consisting of a battery (rated 9 V), a lightbulb, and a switch connected in series. Keep the switch open.

a. Draw the circuit diagram of your circuit.

b. Predict the potential difference across the battery, across the lightbulb, across a connecting wire, and across the switch. Now use a voltmeter to check your predictions. Write down the readings. Discuss any surprising results you found and reconcile them with your prediction.

c. Now close the switch and repeat the experiment. Write down the readings. Do they make sense?

d. Watch the following video https://mediaplayer.pearsoncmg.com/assets/_frames.true/secs-experiment-video-37. How do the readings of the voltmeters compare to the readings in your circuit?

e. Discuss whether Ohm's law in the form of $I = \frac{\Delta V}{R}$ applies to a battery and to a switch in an open circuit. Discuss whether Ohm's law applies to a battery, a switch, and a connecting wire in a closed circuit.

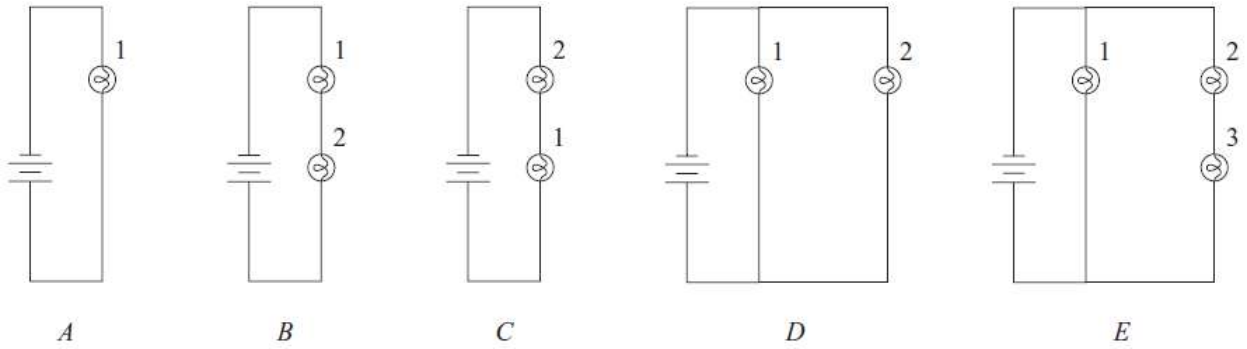
9. Application experiment

Use materials at https://phet.colorado.edu/sims/html/circuit-construction-kit-dc/latest/circuit-construction-kit-dc_en.html

Equipment: battery, 4 identical lightbulbs, connecting wires, and switch.

a. Conduct experiments to see if can you connect both bulbs and the battery so that they both light when the circuit is completed but when one is disconnected, the other one does not shine. Draw a circuit diagram.

b. Use two lightbulbs, a battery, and sufficient number of connecting wires. Devise a way to connect the bulbs to the battery so that when they are both connected, they light up, but one is still shining when the other one is disconnected. Draw a circuit diagram of how you did this in your notes.



c. Build circuit *A* using a battery, wires, and a bulb (see the figure above). Observe and record the brightness of the bulb. Then build circuit *B* with a second identical bulb and notice the brightness of the two bulbs. Explain the differences in your observations using the concept of *V* field (potential difference) or any of the analogies you have developed.

d. Build circuit *C* and notice the brightness of the bulbs. Explain your observations using the concept of current and any analogies.

e. Build circuit *D* and notice the brightness of the bulbs. Now build circuit *E* with a third identical bulb and notice the brightness of the three bulbs. Explain the differences in your observations using the concepts of potential difference and current.

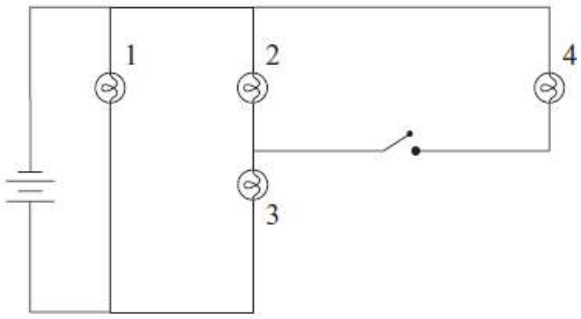
f. Can you say that a battery is a source of constant current? Explain your answer.

g. Rank the bulbs in the circuit shown below according to their brightness, listing the brightest bulb first. Indicate whether any bulbs are equally bright. Explain your rankings.

h. Now rank the bulbs according to their brightness in the circuit when the switch is closed. Explain your rankings.

i. Indicate how the brightness of the first three lightbulbs changes after the switch is closed. Explain.

k. Set up the circuit and conduct the experiment to see if the lightbulbs behave as you predicted.



10. Observational experiment

Goal: to figure out what physical quantities affect the brightness of a bulb
Use materials at https://phet.colorado.edu/sims/html/circuit-construction-kit-dc/latest/circuit-construction-kit-dc_en.html.

Equipment: 2 different lightbulbs, battery, connecting wires, voltmeter, ammeter.

Rubrics for self-assessment: Ability to conduct an observational experiment. Rubrics B5, B7, and B9.

In this activity you will need to use different light bulbs. In the simulation, to make different light bulbs click on the lightbulb and change its resistance. After you have created two different lightbulbs, connect the two bulbs in series with each other and the battery, and compare their brightness.

a. Devise several explanations for why the brightness of the bulbs is different.

b. Design and implement experiments to test the explanations you came up with. Which explanation couldn't you rule out?

c. Use the explanation that you did not rule out to predict the relative brightness of the same bulbs when you connect them in parallel to the battery (if you have not done this experiment yet in part **b**.).

d. Explain why incandescent lightbulbs glow when there is current through them. Where does this light energy come from?

11. Testing experiment

Goal: to test the mathematical model for electric power

Use materials at https://phet.colorado.edu/sims/html/circuit-construction-kit-dc/latest/circuit-construction-kit-dc_en.html.

Equipment: 2 different lightbulbs, battery, connecting wires, voltmeter, ammeter.

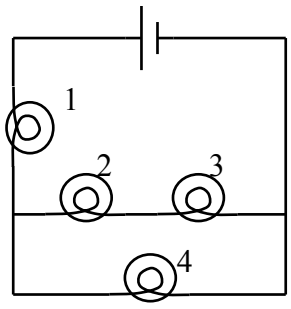
Rubrics for self-assessment: Ability to conduct a testing experiment. Rubrics C1, C4, C7, and C8.

a. Connect the bulbs in parallel and observe that bulb A is brighter than bulb B. Use your knowledge of electric power to explain this observation, and then predict what you will observe if you connect the bulbs in series to the same battery.

b. Perform the experiment and record the outcome. Did it match your prediction? If not, revise your explanation to account for the outcome.

12. Observational experiments

Goal: to discover the junction rule for electric currents and rule for the change of electric potential through the circuit.
Use materials at https://phet.colorado.edu/sims/html/circuit-construction-kit-dc/latest/circuit-construction-kit-dc_en.html.
Equipment: variable power supply (battery with variable emf), 4 lightbulbs (preferably different from each other), connecting wires, ammeters, voltmeters.



Rubrics for self-assessment: Ability to conduct an observational experiment. Rubrics B1, B7, B8, and B9.

a. Design an experiment to investigate the relationship between currents through bulbs 1, 2, 3, and 4, shown in the figure. Describe the experiment and record the results in any format you find appropriate. Identify any pattern you found.

b. Design an experiment to investigate the relationships between the potential differences across bulbs 1, 2, 3, 4 and the battery/power source. Describe the experiment and record the results in any format you find appropriate. Identify any pattern you found.

13. Observational experiment

Goal: to investigate the internal resistance of the battery

Equipment: Real battery, 3 different lightbulbs, connecting wires, ammeter, voltmeter, switch.

Rubrics for self-assessment: Ability to conduct an observational experiment. Rubrics B1, B5, B7, B8, and B9.

To make a real battery, go to https://phet.colorado.edu/sims/html/circuit-construction-kit-dc/latest/circuit-construction-kit-dc_en.html and make battery resistance 1 ohm.

Then design an experiment to investigate how potential difference across this battery changes as the current through the circuit changes. Make sure you start with the case when the current through the circuit is zero and finish with the maximum possible current (without short-circuiting the battery).

a. Draw the circuit for your experiment. Describe the data you plan to collect.

b. Make a table to record the data, and after you make the circuit put the data in the table.

c. Reduce the resistance of the battery to zero and repeat the experiments. Record the data the same way you did in part b.

d. Describe the differences in the patterns you found in parts b and c. How do the emf of the battery and its internal resistance explain the differences?

14. Observational experiment

Goal: to investigate how the presence of a capacitor in a circuit affects the processes in this circuit.

Equipment: battery, lightbulb, capacitor, switch, connecting wires.

For this activity you will need a different simulation. Go to https://phet.colorado.edu/en/simulation/legacy/circuit-construction-kit-ac and download it on your device.

Connect the switch, the light bulb, the capacitor, and the power supply in series. Do not close the switch yet.

a. Close the switch. Describe what you observed. Note also when the bulb is brightest for each process.

b. Sketch qualitative graphs of brightness versus time.

c. Explain the changes in the brightness of the bulb.

Hints: Think about what is happening to the electric charge in the circuit. What is happening to the current in the circuit? What is happening to the potential difference across the capacitor? Try drawing charge diagrams at different points in time.