

Energy Conservation in Circuits Final Charge on a Capacitor

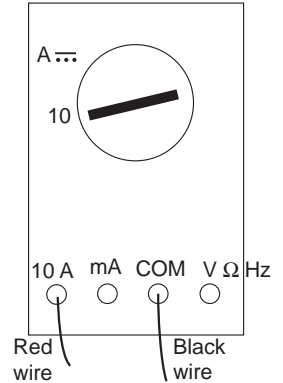
Recorder _____ Manager _____

Skeptic _____ Energizer _____

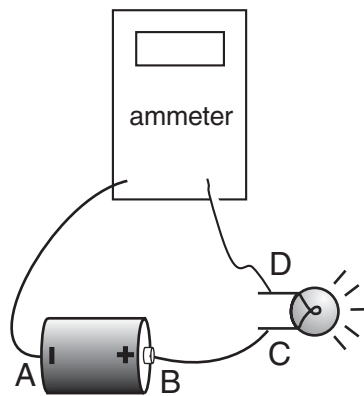
Using an ammeter

Set up a digital multimeter to be an ammeter. Since you will be measuring currents larger than 200 mA, it is important to set up the meter correctly, so you don't blow a fuse, rendering the meter useless.

- Connect the black wire to COM, as shown at right.
- Connect the red wire to the left most connector, labelled 10A.
- Set the dial to DC Amperes (A $\overline{\cdot\cdot\cdot}$)



Unlike a voltmeter, an ammeter must be inserted into a circuit. Set up the following circuit, using one battery and one round bulb, **BUT DO NOT MAKE THE FINAL CONNECTION UNTIL AN INSTRUCTOR HAS CHECKED YOUR SETUP.** You may want to use clip leads to connect the ammeter probe wires to the circuit.



**Have an instructor check your setup
BEFORE making the final connection.
Otherwise you could damage the ammeter.**

What is the conventional current in the circuit at left?

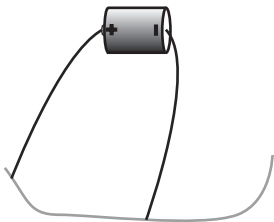
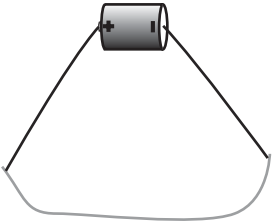
$I =$ _____

1 Predictions (based on fundamental principles) and Experiments

For each circuit depicted below,

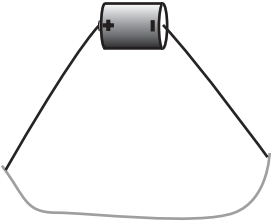
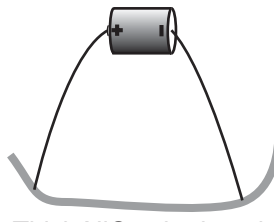
- (1) write an energy conservation equation (round-trip ΔV)
 - (2) solve symbolically for E in terms of the length of the wire ($L/2$ or L) and the **emf** of the battery.
 - (3) using basic equations relating current and electric field, predict how the current in the circuit on the left should compare to the current in the circuit on the right.
 - (4) insert an ammeter into the circuit, and measure and record the current in each circuit.
- Find the two nichrome wires in your experiment kit. Make sure that you have one thick and one thin wire. It is easier to compare the wires by touching them than by looking at them. The ratio of their cross-sectional areas is approximately 2:1.
 - **You will need: Multimeter, batteries, connecting wires, two nichrome wires of different thickness.**

1.1 Double the length of a nichrome wire

<p>Circuit 1: Thin nichrome wire of length $L/2$ (DO NOT CUT THE WIRE; CONNECT THE CLIP LEAD TO THE EXACT MIDDLE OF THE WIRE).</p>  <p>Thin NiCr wire length $L/2$</p>	<p>Circuit 2: Thin nichrome wire of length L</p>  <p>Thin NiCr wire length L</p>
<p>Energy conservation equation:</p>	<p>Energy conservation equation:</p>
<p>$E_1 =$</p>	<p>$E_2 =$</p>
<p>prediction: How should currents i_2 and i_1 be related? electron current $i_2 = \text{_____} \times i_1$</p> <p>reasoning:</p>	
<p>observed conventional current:</p>	<p>observed conventional current:</p>

Check section 1.1 with a neighboring group, then both groups check with instructor. The instructor will look for all questions having been addressed.

1.2 Double the cross-sectional area of a nichrome wire

<p>Circuit 3: entire length L of thin nichrome wire</p>  <p>Thin NiCr wire length L</p>	<p>Circuit 4: same length L of thick nichrome wire (whose cross-sectional area is approximately twice that of the thin wire)</p>  <p>Thick NiCr wire length L</p>
<p>Energy conservation equation:</p>	<p>Energy conservation equation:</p>
<p>$E_3 =$</p>	<p>$E_4 =$</p>
<p>prediction: electron current $i_4 = \text{_____} \times i_3$</p> <p>reasoning:</p>	
<p>observed conventional current:</p>	<p>observed conventional current:</p>

1.3 Double the emf.

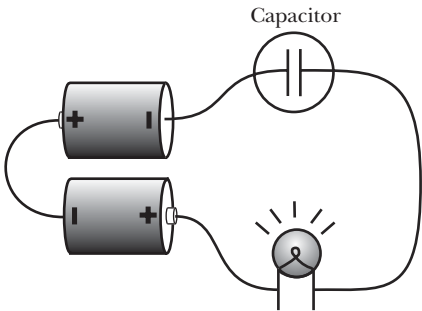
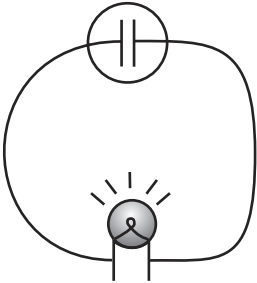
Circuit 5: One battery, entire length of thin nichrome wire.	Circuit 6: Two batteries, entire length of thin nichrome wire.
Energy conservation equation:	Energy conservation equation:
$E_5 =$	$E_6 =$
prediction: electron current $i_6 = \text{_____} \times i_5$	
reasoning:	
observed current:	observed current:

Check sections 1.2 and 1.3 with a neighboring group, then both groups check with instructor. The instructor will look for all questions having been addressed.

2 Charging and discharging capacitors

Two batteries, connecting wires, round bulb, long bulb, socket, capacitor, stopwatch.

In each case, record your observations, then repeat them and time the phenomenon.

<i>Make sure the capacitor is uncharged before charging: connect a wire across it for several seconds</i>		
2.1 Discharge. Then connect the capacitor in series with a ROUND bulb and two batteries. (Fig 2.1)	What do you observe?	How long does this last?
2.2 Remove the batteries and connect the ROUND bulb directly to the capacitor. (Fig 2.2)	What do you observe?	How long does this last?
2.3 Discharge. Then connect the capacitor in series with a LONG bulb and two batteries.	What do you observe?	How long does this last?
2.4 Remove the batteries and connect the LONG bulb directly to the capacitor.	What do you observe?	How long does this last?
Figure 2.1 Circuit for charging a capacitor 	Figure 2.2 Circuit for discharging a capacitor 	

3 THE EFFECT OF DIFFERENT BULBS ON THE FINAL CHARGE ON A CAPACITOR

In this portion of the lab you will:

- Formulate and clearly state a hypothesis
- Perform an experiment to test your hypothesis
- Draw a conclusion regarding your hypothesis, taking into account the error of your measurements

Equipment: Two batteries, round bulb, long bulb, capacitor, connecting wires. You may also need other equipment, such as a stopwatch or a compass.

3.1 HYPOTHESIS:

- On the previous page you observed different behavior (time, brightness) when charging a capacitor through a long bulb vs. through a round bulb.
- In which situation (long bulb vs. round bulb) do you think more charge accumulates on the plates of the capacitor? Formulate a hypothesis about this, and state it clearly.
- It is ok if your hypothesis turns out to be incorrect - that's what experiments are for! However, it must be clearly stated, and you must give at least one reason you think it may be correct.

HYPOTHESIS and reason:

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3.2 PLANNING AN EXPERIMENT: On the next page you will perform the following experiment to test your hypothesis (if you have a different or better idea for an experiment, discuss this with your instructor):

Charge capacitor through ROUND bulb, then \Rightarrow	Discharge capacitor through ROUND bulb Time how long the bulb stays lit
Charge capacitor through LONG bulb, then \Rightarrow	Discharge capacitor through ROUND bulb Time how long the bulb stays lit

Think about how performing this experiment would allow you to determine if your hypothesis is correct or not.

If your hypothesis is correct, what should you observe? Should the effects be large or small?

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If your hypothesis is incorrect, what should you observe? Should the effects be large or small?

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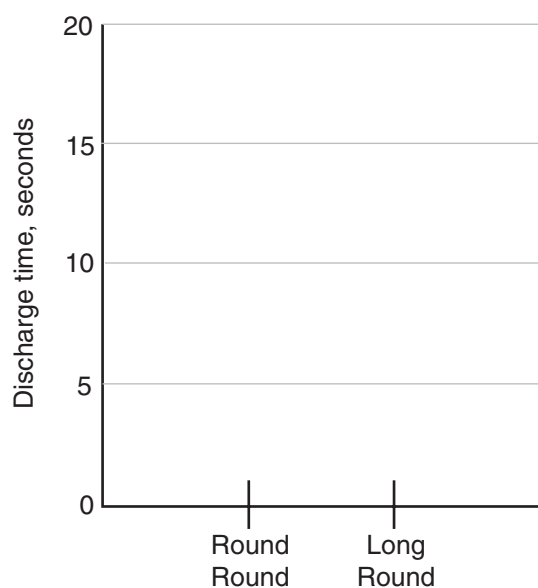
**Check with a neighboring group, then both groups check with instructor.
Do you have a hypothesis, reason, and predictions?**

3.3 EXPERIMENTAL DATA: Clearly report your measured data here, in a table. Repeat all measurements 4 times. In the table, show all measured values, average value for each condition, and either maximum deviation or standard deviation, for each value.

- Make sure the capacitor is uncharged before charging: connect a wire across it for several seconds.
- *Always have the same person determine when the bulb stops glowing*, since different people may decide differently, which can introduce an additional and undesirable source of variation.

Discharge capacitor. Charge with ROUND Discharge with ROUND	Discharge time 1	Discharge time 2	Discharge time 3	Discharge time 4	Average discharge time	Maximum deviation
Discharge capacitor. Charge with LONG Discharge with ROUND	Discharge time 1	Discharge time 2	Discharge time 3	Discharge time 4	Average discharge time	Maximum deviation

3.4 ANALYSIS AND CONCLUSIONS



Graph your data.

For each condition, show average value and error bars, based on your data in section 3.3 above, and on these instructions:

A brief handout explaining deviation and error bars is on the course website lab calendar.

CONCLUSION: Explain clearly and rigorously (do not leave out steps in reasoning) whether your results confirm or contradict your hypothesis. **Do not change your hypothesis!** Are the size of the effects consistent with the nature of your hypothesis?

**Check with a neighboring group, then both groups check with instructor.
You need to show numeric data, a graph with error bars, and a conclusion.
Then turn in this report to the instructor to be graded.**