Name: ________________________________

Partner(s): _____________________________

1225 Section: _______

Desk # _____________

Date: ________________

Capacitors in DC Circuits

This lab is due at the end of the laboratory period

Purpose: To investigate the behaviour of capacitors in simple DC circuits.

Report format: Record your observations and answer the specified questions in the boxes provided on these pages. Your observations will be checked for correctness, completeness and clarity. Note that the material covered in this lab, as in other labs, is testable and will be on exams.

(This lab is adapted from Chapters 5 and 7 of *Electric and Magnetic Interactions, Chabay and Sherwood*, 1999.)

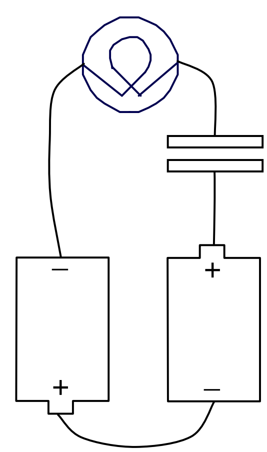
Apparatus

Kaise analog ammeter, two 1.5 V D-cell batteries with battery holders, one round light bulb, one long light bulb, bulb sockets, six alligator-to-alligator wires, two alligator-to-plug wires, 1 F capacitor.

> *To quickly discharge a capacitor, connect a wire between the two leads of the capacitor for 5 seconds. This is also called "shorting" a capacitor.*

1. Charging a Capacitor through a Light Bulb

(a) Connect a round bulb, a discharged capacitor and two batteries, in series as shown. Let the circuit run for a while.



What do you observe?

(b) How does the brightness of the bulb **immediately after the circuit is connected** compare to the brightness of the bulb when it is connected directly to the batteries (without the capacitor)?

brighter less bright about the same

(c) After the circuit has been running for 30 seconds or more, is light bulb still on?

Yes	No

Is there a current flowing through the wires now?

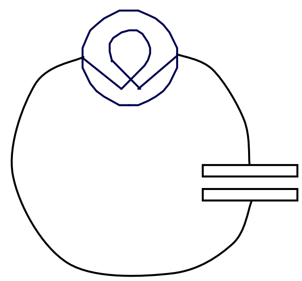
Yes	No

Why did this happen?

2. Discharging a Capacitor through a Light Bulb

With your capacitor fully charged, carefully remove the batteries from the circuit and make a circuit consisting of just the bulb and the capacitor as shown.

What do you observe?



How does the brightness of the bulb immediately after the circuit is connected compare to the brightness of the bulb when it is connected directly to the batteries?

brighter less bright about the same

How does the discharge time compare to the charge time?

about the same more less

3. Effect of Bulb Type

(a) Charge your capacitor through the long bulb.

How does the charging time using the long bulb compare to the charging time using the round bulb?

about the same more less

(b) After the long bulb is completely dark (about 2 minutes), discharge the capacitor through the *round* bulb as you did in Step 2.

Do you notice any change in the initial brightness of the bulb? yes no

Do you notice any change in the discharging time? yes no

(c) Now compare the following two processes:

(c1) The capacitor was charged through a round bulb and discharged through a long bulb.
(c2) The capacitor was charged through a long bulb and discharged through a long bulb.

How do the discharge times compare for (c1) and (c2)?

about the same more if charged through round more if charged through long

How do the discharge times compare for (c1) and Step 2?

about the same more if discharged through round more if discharged through long

(d) From your observations, does the discharging time depend on which bulb was used for charging?

yes no

(e) Does the discharging time depend on which bulb was used for discharging?

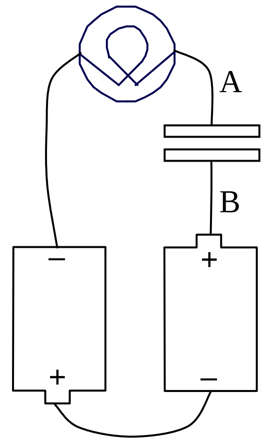
yes no

(f) Compare the discharging processes by filling in the table below with words "same" or "different". Both discharging processes start with a fully charged capacitor.

	discharge through a round bulb or discharge through a long bulb
discharging current	
discharging time	
initial charge on the capacitor	

4. Currents in different parts when charging/discharging a capacitor

(a) Using the ammeter, measure the current at points A and B in the diagram 2 seconds after the charging through a round bulb has started. Record the magnitude of the current in the table below.



Note: (1) You must start with a fully discharged capacitor for both A and B.
(2) The ammeter must be connected in series.

2 seconds after charging starts	current I (A)
uncertainty	
reading at A	
reading at B	

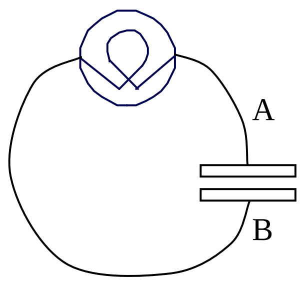
Is the charging current at A the same as the current at B?

yes no

Indicate on the diagram at the right: (1) the direction of the charging current (conventional) at A and B, (2) the sign of charges on each plate of the capacitor after charging for 2 seconds.

(b) Repeat the measurements for the discharging process, starting with a fully charged capacitor for both readings. Indicate the direction of the current and the sign of charges on the diagram.

2 seconds after discharging starts	current I (A)
uncertainty	
reading at A	
reading at B	



Is the discharging current at A the same as the current at B?

yes No

5. Current as a function of time

(a) Start with a discharged capacitor and charge it through a bulb. Complete the tables below for each type of bulb. Your first reading should be at around *t* = 2 seconds for both bulbs, but for subsequent readings, use a longer time interval for the long bulb so that you include the entire charging process in 10 readings. You may use the video function on your cellphone.

charging through round bulb

time *t* (sec)	current *I* (A)

charging through long bulb

time *t* (sec)	current *I* (A)

(b) In the space below, sketch (not plot) a graph of current versus time for each type of bulb. Draw both curves in the same graph (using the same set of axes). Label the axes with approximate scales. Indicate which curve is for which bulb.

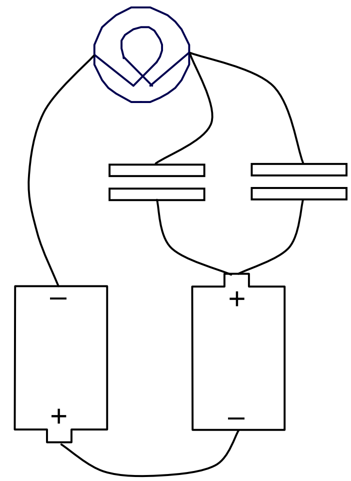
Fill in blanks with proper terms, choosing from:

slope, y-intercept, area, derivative, integral, time, current, voltage, charge, power

The two charging curves, although quite different in shape, have one quantity that is the same.
In mathematical terms, this quantity is the __________________ or the ____________________.
In physics terms, it is the __________________.

6. Two capacitors in parallel

Before connecting two fully discharged capacitors in parallel and charging them up through a round bulb, as shown, discuss with your partner how you think the charging time will compare to a circuit with one capacitor.



(a) Set up the circuit. How does the time to charge two capacitors in parallel compare to the time to charge one capacitor?

longer shorter about the same

(b) Explain your result.

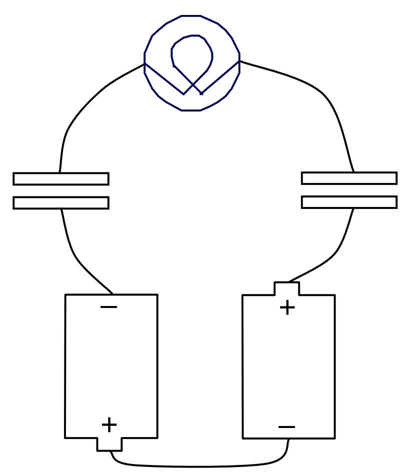
(c) How does the charge stored on each capacitor compare to the charge stored on a single capacitor that it is charged up by itself with one round bulb and two batteries (as in 1 in Part 1)?

same more less

(d) How would you check? (Do not use the ammeter.)

7. Lighting an isolated bulb

Before connecting one fully discharged capacitor, a round bulb, and another fully discharged capacitor with the batteries, as shown, discuss with your partner what you expect will happen. Note that the round bulb is completely isolated from the batteries.



(a) Set up the circuit. What happens?

(b) To understand what happens, let's find the potential difference (P.D.) across the bulb:

Just after the circuit is connected,

The charge on each capacitor is _____.

Because $V=Q/C$, the P.D. across each capacitor is _____.

Therefore, the P.D. across the bulb equals to that from the batteries, which is about _____ V.

With time, the charge on each capacitor ______________ and the current through the light bulb ______________. Therefore the brightness of the bulb _______________. (increases/decreases)

Eventually,

The current through the bulb is _____.

According to Ohm's law, the P.D. across the bulb is _____.

The charge and the P.D. on each capacitor are equal, and their P.D. is about _____ V.

(c) How does the charge stored on each capacitor compare to the charge stored on a capacitor that is charged up by itself with one round bulb and two batteries (as in 1 in Part 1)?

same more less

(d) How would you check? (Do not use the ammeter.)

8. Reversing the capacitor

Fully charge the capacitor using only **ONE** battery and a round bulb.

Before reversing the connections to the capacitor while leaving everything else in the circuit the same, discuss with your partner what you expect will happen.

(a) Now reverse the capacitor. What do you observe just after the reversal?

(b) Explain what happens.

(c) Why is it important to use only one battery?

(d) Is the capacitor charged after you have left the circuit running for a while?

yes no

How do you check? (Do not use the ammeter.)

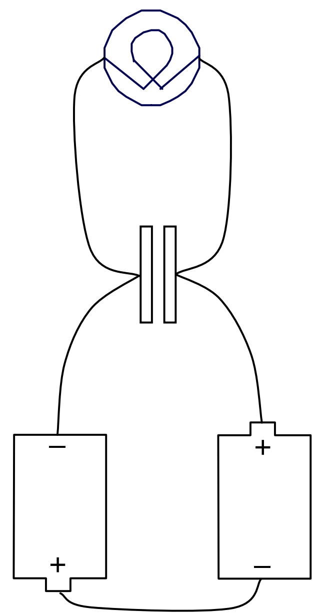
How does the charge on the capacitor compare to when it was charged up before reversing?

same amount and same signs same amount but opposite signs not the same amount

9. A practical use for a capacitor

Connect the capacitor and a long bulb in parallel to the batteries as shown.

Let the circuit run until the capacitor is fully charged. Break the connection to the batteries to simulate a momentary power outage. What happens to the brightness of the bulb in the first few seconds?



What will happen to the bulb during a momentary power outage without the capacitor in the circuit?

Conclusion: