TechLab: Capacitor Graph

an investigation of charge vs. voltage

PERIOD	1.		
	2.		
GROUP	3.		
	4.		

• Purpose •

In this activity, you will investigate the energy associated with a capacitor as it charges and discharges in a resistor-capacitor (*RC*) circuit.

• Apparatus •

___ 1.0 F capacitor
___ mini bulb in socket [6.3 V]
___ 2 C- or D-cell batteries
___ 3 battery connectors (optional)
___ single throw double pole switch
___ connecting wires
___ computer
___ data analysis software (DataStudio)
___ interface device (USB Link)
___ current/voltage sensor
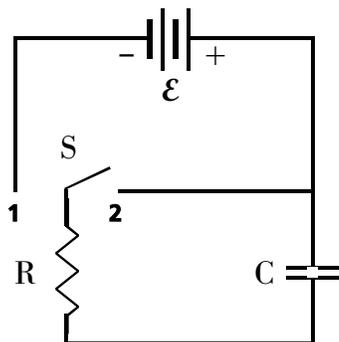
• Set Up •

1. Turn on the computer and set it aside.

2. Connect the circuit shown. Note: the switch is in an open (up) position during circuit construction.

3. Connect the current/voltage sensor so that it measures the current through the capacitor and the voltage across the capacitor.

4. Connect the current/voltage sensor to the interface device.

5. Connect the interface device to the computer.

6. When the computer detects the sensor and asks what you would like to do, select DataStudio.

7. When DataStudio asks what you would like to do, select Create Activity.

8. Make certain the capacitor is discharged by touching opposite ends of a wire to both terminals of the capacitor for a few seconds.

• Procedure •

1. Observe the charging of the capacitor while recording the current and voltage.
   a. Drag the Graph display onto the Voltage measurement to create a graph of Voltage vs. Time.

   b. Drag the Current measurement onto the Voltage graph window to create a graph of Current vs. Time.

   c. Click the on-screen "Start" button to initiate data sampling.

   d. Close the switch to position 1 and wait for the capacitor to completely charge.

   e. Open the switch and click the on-screen "Stop" button to stop data sampling.

   f. Save the activity to the appropriate location, using an appropriate file name.

2. To determine the charge separation in the capacitor, integrate the current with respect to time.
a. Create a new measurement by clicking the on-screen "Calculate" button. If you do not see the "Calculate" button in the button bar, ask your instructor for assistance. A new Calculator window should appear.

   b. In the equation field, delete "y = x" and type in "Charge =" (without the quotation marks).

   c. From the function menu, select "Integral(x)." Then replace the "x" with "I".

   d. Click the "Accept" button. Below the equation field, DataStudio will ask you to "Please define variable I."

   e. Define "I" as the Data measurement of Current (A).

   f. Click the "Properties" button.
      i. In the Label field, change "Y" to "Charge."
      ii. In the Units field, type "C" for coulombs (without the quotation marks).

   g. Approve the settings and close the Calculation window.

3. Delete the Voltage vs. Time graph and the Current vs. Time graph.

4. Create a Charge vs. Time Graph.

5. a. Replace the Time axis with Voltage by dragging the Voltage measurement to the Time axis and placing it there. If you are successful, you will have a single Charge vs. Voltage graph. If not, you will have two graphs stacked on top of each other.

b. Resave the newly-modified activity.

6. Use the graph to determine an experimental value for the capacitance of the capacitor. Hint: refer to *Phyz Springboard: Capacitance.* Describe your approach and record the result.

7. Use the graph to determine the energy stored in the capacitor. Hint: refer to *Phyz Springboard: Capacitance.* Describe your approach and record the result.

8. Create a second set of voltage, current, and power graphs. File > Open Activity > "2.07 Power in the Plates."

9. Before recording data, make sure the capacitor has a full charge. Then observe the discharging of the capacitor while recording the current, voltage, and power.
    a. Click the on-screen "start" button to initiate data sampling.

    b. Close the switch to position 2 and wait for the capacitor to completely discharge.

    c. Open the switch and click the on-screen "Stop" button to stop data sampling.

10. Determine the energy released by the capacitor while it discharged.
    a. Describe your method.

    b. Show the result.

    c. How does the energy released by the capacitor during discharge compare to the energy added while it was charging?

    d. Determine an "efficiency" (e) by dividing the energy released by the energy added.

• Challenge •

1. Generate a plot of charge vs. voltage for the process of charging a capacitor.

2. How can the capacitance of the capacitor and the quantity of energy stored by the capacitor be determined from such a plot?

3. Carry out this analysis and record your findings. Print the plot.