

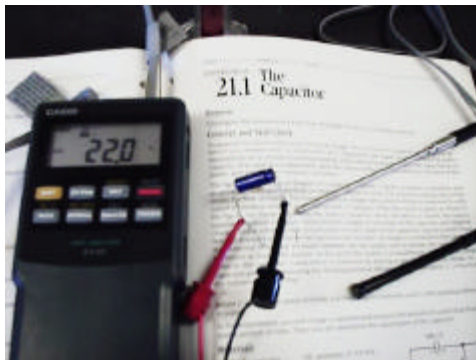
Escaping Electricity

Math / Physics / General Science

Middle / High

Exponential Regressions / Data Collection / Basic Electronics

Introduction: A capacitor is a small electronics device used to store electrical charges. The first capacitor was designed and constructed by a Dutch physicist named Pieter van Musschenbroek in 1746 at the University of Leyden. This early device, called the Leyden Jar, set the pattern for all capacitors to follow. The Leyden Jar was a glass jar with metal foil on the inside and metal foil on the outside. A conductive rod ran through the middle, attached to the inner foil by a chain and held in place by wooden lid. Draining electrons from the inner foil through the conductive rod by the use of an electrostatics machine charged the jar. As electrons left the inner foil, the inner foil became positively charged. Free electrons, induced by the positive inner foil, flowed from a ground wire to the outer foil, thus creating a stored electric potential.



Like the Leyden Jar, all capacitors are a system of conductors (metal foil) separated by an insulator (glass). In today's electronics, capacitors come in many shapes and sizes with varying abilities to hold electrical charges. Capacitors are used to protect sensitive electrical components found in things like TVs and computers from unwanted electrical pulses. They also can be used to release stored energy when it is needed.

A resistor is a small electrical component used to control the flow of electricity within a device. You can think of resistance as the ability of material to resist the flow of electrons through it. It is like friction for electrons. The greater the resistance, the fewer electrons pass through it. Precisely, resistance is defined by the ration of the applied voltage (V) to the resulting current (I).

$$R = V / I$$

Objectives: Students will be able to...

1. Collect data by following an experimental procedure.
2. Input data in a graphing calculator.
3. Compare results.
4. Draw conclusions.
5. Make predictions.
6. Discuss the uses capacitors and resistors in real electronics.

Related Key Words:

capacitor	electric potential energy	current
ohms	farad	conservation of energy
resistor	capacitance	charging by induction

Materials: 100k OHM Resistor (Radio Shack Cat. No. 271-1347)
 220 MFD Electrolytic Capacitor (Radio Shack Cat. No. 272-1017)
 9 VOLT Battery
 CASIO CFX9850-G COLOR GRAPHING CALCULATOR
 CASIO EA-100 CASIO Data Collector (CDA)
 Voltage Probe (Included with the CDA)
 Link Cord (Included with the CDA)
 Resistor Color Code Guide (available at Radio Shack)

Purpose: This activity demonstrates how voltage is discharged from a capacitor through a resistor by using the CASIO DATA COLLECTOR (CDA).

STEP 1-- With the CDA turned off, insert the Voltage Probe into the Channel One port on the top of the CDA and turn on the CDA.

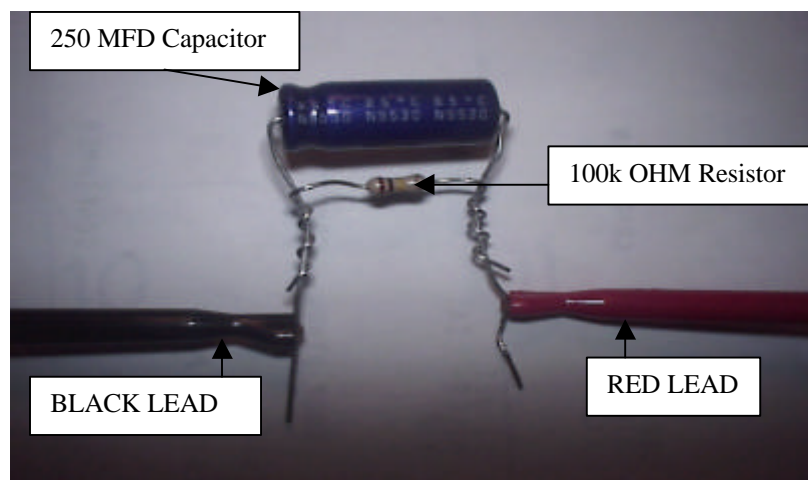
STEP 2-- Press the Yellow SHIFT key followed by the mode key on the CDA. This enables you to set up the parameters of the experiment. The first thing that appears is a choice to set the time between when the data points can be collected. To view these different times press the DATALOG key to scroll through the times; these range from 10 m-sec to 60 seconds. There is also a choice of .000, this allows you to record a data point whenever you press the trigger key, and this is not dependent on time. **Set this parameter for 1 sec and press the TRIGGER key to fix the setting.**

STEP 3-- The next parameter you will need to set is the total number of samples you will be collecting. By pressing the DATALOG key you will scroll through the values, these vary from 10 to 200, **set the parameter to 50 and press the TRIGGER key to fix the choice.**

STEP 4-- The last parameter you will need to set is the time setting. This setting has three choices. The first choice is ZERO (0); this is used for real time data collecting and should only be used in conjunction with a program in the calculator. The second choice is ONE (1), **this is the choice that you should use whenever you are collecting data and the CDA does not have to be collected to the calculator.** This will give you the time readings in relative time. The third choice is two (2); this is the absolute time setting and is also used in conjunction with a program from the calculator.

STEP 5-- At this point you should have either a voltage reading or three dashes [---] on your CDA. If you do not repeat steps 1-4. If you do have a reading and the word "READY" appears on the left side of the screen.

STEP 6-- At this time connect the resistor to the capacitor as shown in the photo.



NOTICE: The resistor leads are wrapped around the leads of the capacitor. Make sure that the leads do not go all the way down to the end of the leads. Also, make sure that the indented part of the capacitor is on the same side as the dark band of the resistor. Connect the black lead from the Voltage Probe to the capacitor lead from the

indented part of the capacitor. Connect the red lead from the Voltage Probe to the other lead. The RED and BLACK leads should be connected below the resistor, as shown in the picture. Next, touch the 9-VOLT battery to the leads of the capacitor. The NEGATIVE terminal of the battery should be touched to the lead with the black lead and the POSITIVE terminal of the battery should be touched to the red lead. Notice, that the screen of the CDA reads about 9 volts, and immediately begin to drop. Place the battery to the capacitor again and press the TRIGGER key of the CDA at the same time. At this point, the word “sampling” will be flashing on the left side of the screen; this will last for about 50 seconds. Hold the capacitor as still as possible, making sure not to touch the metal leads, until the word “DONE” appears on the screen. You have now collected one voltage reading every second for 50 seconds, and it is stored in the CDA. To repeat the experiment using the same parameters press the SHIFT RESTART key. (NOTE: This will delete the data from the previous sampling.)

STEP 7--

This section can be used with either the cfx-9850G or the fx-7400G by manually entering the data recorded in the EA-100 into the STAT MENU on the calculators.

To view the data that has been collected in the EA-100 press the DATALOG key on the EA-100. This will scroll you through the data samples. You will need to record these samples as the “Y” value and the TIME as the “X” values. Now you can have your students graph these data points on a piece of graph paper.

Dave Barron of Casio, Inc developed this activity.

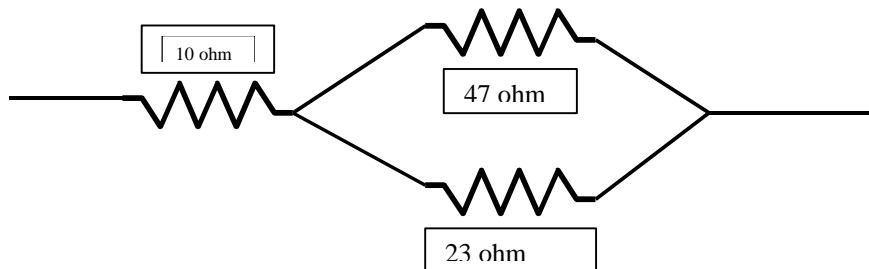
Questions and Problems:

Level 1: Answer the following questions in complete, well-structured sentences.

1. Explain the function of resistors in electronics?
2. Explain the function of capacitors in electronics?
3. What dangers might capacitors hold for people who work with electronics?
4. How do you read the resistance of a resistor?
5. Describe the shape of the curve the data makes?

Level 2:

1. What is the function of the resistor in this experiment?
2. Looking at the data, what is the voltage 3 seconds after the experiment begins?
3. Should the voltage of the capacitor ever reach zero? Explain.
4. Discuss the relationship between resistance, voltage and current.
5. Using Krichoff’s Rules, determine the equivalent resistance of the following circuit:



Extension: Predict how the curve, the rate of “escaping electricity”, would change if we increased the size of the capacitor? How would it change if we increased the size of the resistor? Have students research the topic of superconductivity.

FYI: Radio Shack sells small dial-a-grams to determine the resistance of a resistor based on the color coding.