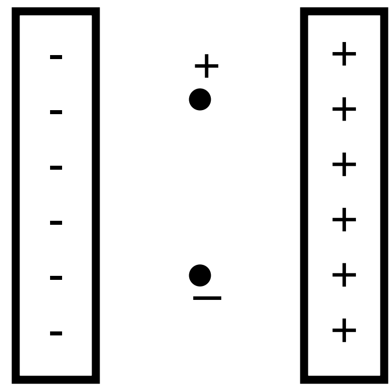
PHY132 Practicals Day 8
Student Guide

Summer 2009

Concepts of this Module

- The electric field inside a capacitor
- Potential and kinetic energy of charged particles inside a capacitor
- Charging and discharging capacitors
- RC circuits

EM Mod. 5 - Activity 1



Positive and negative test charges are placed inside a parallel plate capacitor as shown. These test charges interact only with the capacitor. Their presence does not alter the field of the capacitor, nor do they interact with each other.

A. An enlarged version of the diagram shown to the right is provided at the end of this module. Tear off the page and staple it into your lab notebook. Use a **black** pen or pencil to draw the electric field vectors due to the capacitor inside the capacitor on that enlarged version.
B. Use a **red** pen or pencil (if available) to draw the forces acting on the two charges.
C. Pick a point of your choosing for the zero of potential energy. Label it “U = 0” on the diagram.
D. Is the potential energy of the positive point charge positive, negative, or zero? Explain.
E. In which direction (right, left, up, or down) does the potential energy of the positive charge decrease? Explain.
F. In which direction will the positive charge move if it is released from rest? Use the concept of energy to explain your answer.
G. Does your answer to part F agree with the force vector that you drew in part B?
H. Repeat steps D to G for the negative point charge.

EM Mod.5. Activity 3 - Measuring Capacitance

The unit of capacitance is the Farad, F, named after Michael Faraday. One Farad is equal to one Coulomb/Volt. As you will demonstrate shortly, one Farad is a very large capacitance for a conventional capacitor (see discussion in Appendix). Thus actual capacitances are often expressed in smaller units with alternate notation:

microfarad: $10^{-6} = 1\ \mu F$
nanofarad: $10^{-9} = 1$ nF
picofarad: $10^{-12} = 1$ pF

Typically, there are several types of capacitors used in electronic circuits, including disk capacitors, foil capacitors, electrolytic capacitors, and so on. You might want to examine some typical capacitors. To do this, you'll need:

- 4 capacitors (assorted collection)

To complete this activity, you will need to construct a parallel plate capacitor and use a multimeter to measure capacitance. You will use the following items:

- 2 pieces of thin aluminum sheet or aluminum foil, 15 cm × 15 cm
- 1 textbook
- 1 multimeter with capacitance-measuring capability
- 2 insulated wires
- 1 ruler
- 1 Vernier caliper

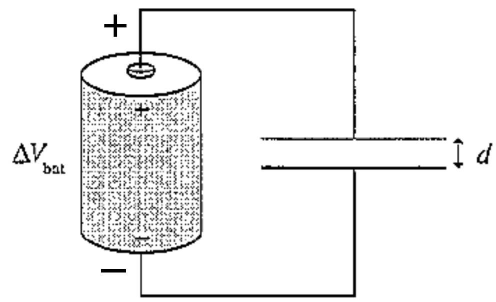
You can make a parallel plate capacitor out of two rectangular sheets of aluminum foil separated by pieces of paper. A textbook works well as the separator for the foil since you can slip the two foil sheets between any number of sheets of paper and weight the book down with something heavy and non-conducting like another massive textbook. You can then use your digital multimeter in its capacitance mode for the measurements. Note: Insert the wires into the capacitance slots of your multimeter as "probes". When you measure the capacitance of your "parallel plates", be sure that the aluminum sheets arranged carefully so they don't touch each other and "short out".

A. Devise a way to measure how the capacitance depends on the foil area and on the separation between the foil sheets. (i) First, hold the area constant and do a series of measurements while varying the separation. (ii) Then hold the separation constant and do a series of measurements while varying the area. In both cases, be sure to record the dimensions of the foil so you can calculate its area, and record the distance between the foil sheets. Take at least five data points in each case. Describe your methods and then create a data table with proper units and display a graph of the results for each case.

B. Can straight lines be drawn through the data in your graphs? If not, you should make a guess at the functional relationship that your data set represents and create a model that matches the data. Draw a corresponding graph and compare it with your graph in part A for each case. Be sure to label your graph axes properly. Can you explain your results based on physical reasoning?

C. Use the ohmmeter to measure the resistance of a page in your textbook. What is its resistance? Can current flow through the pages of your book?

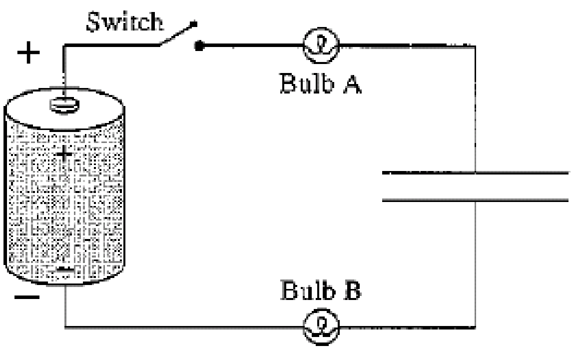
EM Mod.5. Activity 4



A parallel plate capacitor with plate separation *d* is connected to a battery that has potential difference ΔV_{bat}, as shown. Without breaking any of the connections, insulating handles are use to increase the plate separation to *2d*.

A. Does the potential difference ΔV_C across the capacitor change as the separation increases? If so, by what factor? If not, why not?
B. Does the capacitance *C* change? If so, by what factor? If not, why not?
C. Does the capacitor charge *Q* change? If so, by what factor? If not, why not?
D. As the plates are being pulled apart, does current flow clockwise, counterclockwise, or not at all? Explain.

EM Mod.5. Activity 5 [If you have time]



Light bulbs can be used to indicate current flow in a circuit. The brightness of a bulb increases with increasing current passing through it. The figure shows a battery, a switch, two light bulbs, and a capacitor that is initially uncharged.

A. Immediately after the switch is closed, are either or both bulbs glowing? Explain.
B. If both bulbs are glowing, which is brighter? Or are they equally bright? Explain.
C. For any bulb (A or B or both) that lights up immediately after the switch is closed, does its brightness increase with time, decrease with time, or remain unchanged? Explain.

Last revision to this write-up: July 23, 2009 by Jason Harlow.

The EM-Mod.5 Guide Sheet was written in December 2007 by Kimberly Strong, Dept. of Physics, Univ. of Toronto. The activities are based on Randall D. Knight, **Student Workbook** (Pearson, 2004) and Priscilla W. Laws, **Workshop Physics Activity Guide, Module 4: Electricity and Magnetism** (John Wiley & Sons, 2004).

Enlarged version of the diagram in Activity 1