PHYSICS C

LAB 11

PARALLEL PLATE CAPACITOR

OVERVIEW

A capacitor consists of two conducting electrodes separated by an insulator and is used to store electric charge. If a voltage is applied to the capacitor, one electrode becomes negatively charged and the other becomes positively charged. For a given capacitor of capacitance, C, the amount of charge, Q, that is acquired by each electrode is proportional to the potential difference, V, as given by:

$$Q = CV$$

The unit of capacitance is the farad, which is equal to one coulomb per volt. A **parallel plate capacitor** consists of two large plates of area, A, separated by an air gap of distance, d. Its capacitance then given by:

$$C = \frac{\varepsilon_0 A}{d}$$

where ε_0 is the premittivity of free space. In this experiment you will quantitatively investigate the relationship between separation distance and voltage using a variable, parallel plate capacitor with a fixed charge.

1. First, you will set up the parallel plate capacitor apparatus.

2. Next, you will place a fixed charge on the capacitor plates.

3. You will then use an electrometer to measure the voltage across the plates as the separation distance between the plates is increased.

4. Finally, you will draw conclusions about the relationship between the voltage across the plates and the separation distance.

TIME REQUIREMENTS

This lab activity requires one 50-minute class period.

LAB EQUIPMENT AND MATERIALS

A list of equipment and materials needed to perform this lab is given below.

Equipment	Amount Needed
Basic variable capacitor (e.g., PASCO ES-9079)	1
DC power supply 0-18VDC 0-5A (e.g., PASCO SE-9720)	1
Basic electrometer (e.g., PASCO ES-9078)	1
Materials	**Amount Needed**
Graph paper, linear	1 sheet

LAB PROCEDURE

Hints for a successful lab:

⇒ In dry weather keep body movement to a minimum because stray static charge on your body can adversely affect the charge on the parallel plate capacitor. Ground yourself before making a measurement.

⇒ Be sure the moveable plate is connected to ground.

⇒ It is very important that the plates are parallel to each other. Rough handling can make them out of alignment. Horizontal and vertical adjustment screws are available on the back of each plate.

Set up parallel plate capacitor and electrometer:

1. Place the parallel plate capacitor, electrometer and DC power supply on the table top. Be sure the power supply is turned off and the voltage control turned down to zero.

2. Set the plate spacing of the capacitor to 0.5 cm.

3. Connect the low-capacitance test cable that came with the electrometer (with BNC connector and leads) to the electrometer input.

4. Connect the ground lead of the test cable to the moveable plate of the capacitor and the other lead to the fixed plate of the capacitor.

5. Connect the grounding cable that came with the electrometer to the ground connection of the electrometer and the (-) terminal of the power supply.

6. Connect a wire lead with an aligator clip to the (+) terminal of the power supply.

7. The circuit of the apparatus now should be like the schematic diagram shown in Figure 1.

8. Connect the clip end of the (+) lead from the power supply to the terminal on the fixed plate of the capacitor.

9. Turn on the electrometer and set it to the 30 VDC scale. Press the zero button to remove excess charges from the electrometer.

10. Turn on the power supply and turn up the voltage to 15.0 V. Use the reading on the electrometer to set the voltage, not the meter on the power supply.

11. Unclip the (+) power supply wire lead from the terminal on the fixed plate of the capacitor.

Make voltage measurements at different plate separations:

1. Press the zero button on the electrometer.

2. Charge the capacitor to 15.0 V by momentarily touching the (+) lead from the power supply to the terminal on the fixed plate of the capacitor.

3. Increase the separation distance between the capacitor plates slightly (≤0.5 cm increase at first; larger increases okay as the separation becomes >5 cm).

4. Read the voltage on the electrometer and record the value on the data worksheet.

5. Repeat procedure steps 3 and 4 several times until the capacitor plates are separated by ~10 cm.

6. Run a second trial by repeating procedure steps 1-5.

7. Turn off the power supply and electrometer.

Cleanup lab:

1. Disconnect all wire leads and cables.

2. Carefully put away the parallel plate apparatus

3. Put away the power supply and electrometer.

LAB REPORT / ANALYSIS QUESTIONS

Provide answers to the following questions, using complete sentences.

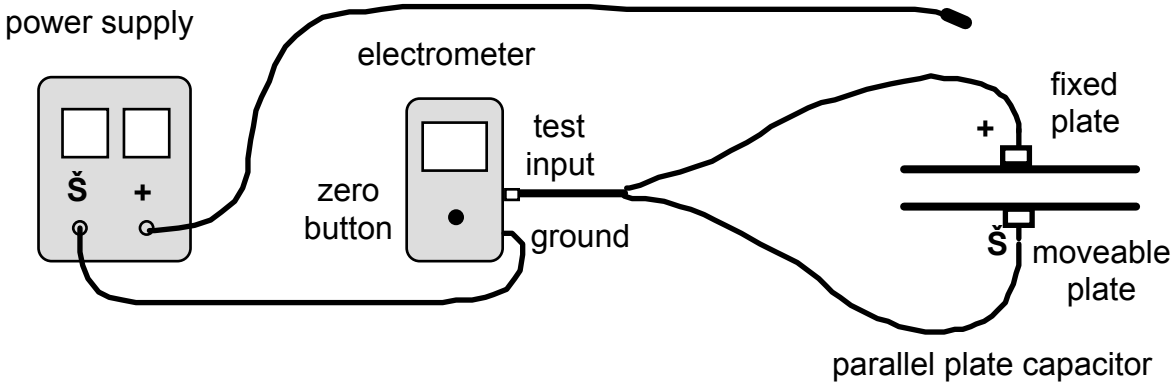
1. Calculate $1/V$ and $1/d$ for your experimental values of V and d and record them on the data worksheet.

2. Make a plot of capacitor voltage, V in volts (y-axis) vs. separation distance, d (x-axis) on linear graph paper. Plot the data for each trial on the same plot. What happens to the voltage as the separation distance increases?

3. Make a plot of $1/V$ (y-axis) vs. $1/d$ (x-axis) on linear graph paper. Plot the data for each trial on the same plot. What is the relationship between these two values?

4. The a line fitted to the data points in the previous plot ($1/V$ vs. $1/d$) should go through the origin. What experimental condition might prevent the line from going through origin?

Fig. 1. Schematic diagram of parallel plate capacitor apparatus.



DATA WORKSHEET

Voltage across plates V (V)	Plate separation d (cm)	Plate separation d (m)	$1/V$ (1/V)	$1/d$ (1/m)