

**PHYS 1402**  
**General Physics II**

**EXPERIMENT 2**  
**CAPACITORS IN SERIES AND PARALLEL**

**I. OBJECTIVE:**

The objective of this experiment is to measure the equivalent capacitance of several capacitors connected in series and parallel. First the individual capacitances and their equivalent will be measured. Then we will charge the capacitors by connecting the combination to a battery and then measuring the voltage across each capacitor. This will allow us to calculate the charge on the capacitors and then calculate the equivalent capacitance using the equation  $C = Q/V$ .

**II. INTRODUCTION:**

A capacitor consists of two conducting objects (plates) separated by a nonconducting medium (dielectric). Figure (1) shows a capacitor connected to a battery. The capacitance of this capacitor is defined as the ratio of the magnitude of the charge on one of the conducting plates to the potential difference across them.

$$C = Q/V \tag{1}$$

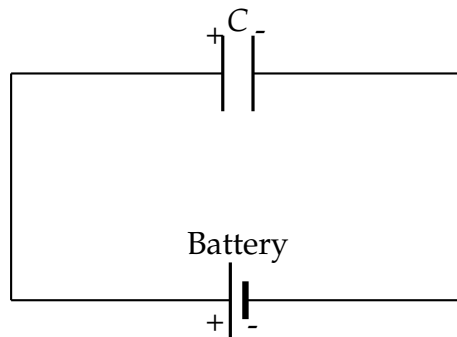


Figure 1: Capacitor Connected to a Battery

Capacitors may be combined in series or parallel. Figure (2a) shows three capacitors connected in series and connected to a battery. Figure (2b) shows three capacitors connected in parallel and connected to a battery. Note the polarity in each case. Theoretically the equivalent capacitance for the series connection is given by

$$\frac{1}{C_{eq}} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3} \tag{2}$$

and that for the parallel connection is given by

$$C_{eq} = C_1 + C_2 + C_3. \tag{3}$$

### III. APPARATUS:

3 capacitors of different values, 6-volt battery, voltmeter, capacitance meter and connecting wires (leads).

### IV. EXPERIMENTAL PROCEDURE:

1. Make sure that each capacitor is discharged ( $V=0$ ) by connecting a wire lead across the capacitor for about 30 seconds.
2. Use the capacitance meter to measure the capacitance of each capacitor. Record the values in your data table.
3. Make sure each capacitor is still discharged by repeating step (1) here.
4. Wire the capacitors in series as shown in Fig (2a) (**but do not connect them to the battery**). Pay close attention to the polarity of the capacitors and the way they are connected. The capacitors used in this experiment are electrolytic capacitors and the polarity of the plates is important. Make sure the ends of the lead wires do not come in contact with each other.

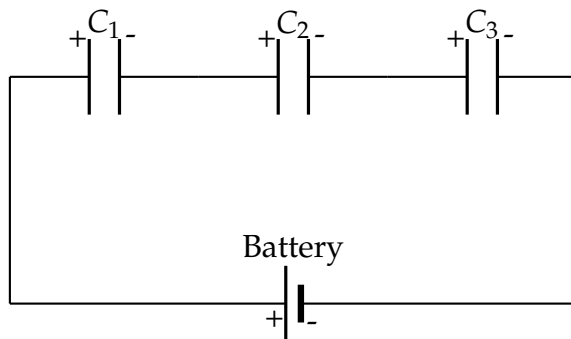


Figure (2a): Capacitors in Series

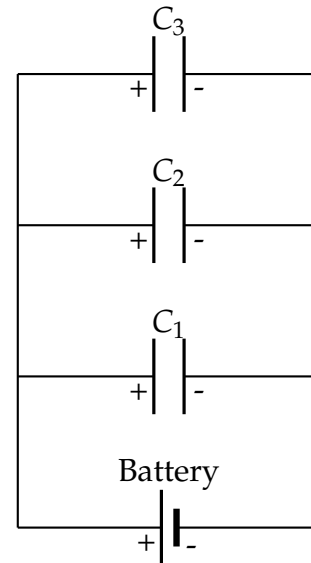


Figure (2b): Capacitors in Parallel

5. Using a capacitance meter, measure the capacitance of the series combination (connect the meter to the free ends). This is  $C_{eq,measured}$ .
6. Connect the battery to the series combination of capacitors.
7. Measure the voltage across each capacitor and the battery voltage and record these values in your data table. You are finished with the series combination.

8. Disconnect the capacitors, discharge each capacitor as you did before and wire the circuit in parallel as shown in Fig. (2b) (**but do not connect them to the battery**).
9. Using a capacitance meter, measure the capacitance of the parallel combination. This is  $C_{eq,measured}$ .
10. Connect the battery to the parallel combination of capacitors.
11. Measure the voltage across each capacitor and the voltage across the battery and record in your data table.
12. Show your data to the instructor or the lab assistant to make sure your data are OK. If so, you are finished with the experimental procedure.

## V. ANALYSIS:

### Series connection:

1. For each case calculate the charge on each capacitor using the relation  $Q_i = C_i V_i$  where  $i=1, 2, 3$ .
2. The values of the charges should be the same within the limits of experimental error. Find the average value of the charge

$$Q_{ave} = \frac{1}{3} (Q_1 + Q_2 + Q_3) \quad (4)$$

This is the charge on the equivalent capacitor.

3. Calculate the experimental equivalent capacitance  $C_{eq} = Q_{ave} / V_{batt}$  and record it in the data table.
4. Use eq. (2) to calculate the equivalent capacitance predicted by theory,  $C_{eq,predicted}$  and record it in the data table.
5. Calculate the percent difference between the equivalent capacitance predicted by theory and the measured equivalent capacitance

$$\% \text{ difference} = \frac{|C_{eq,measured} - C_{eq,predicted}|}{\frac{1}{2} (C_{eq,measured} + C_{eq,predicted})} \times 100 \quad (5)$$

6. Calculate the percent difference between the equivalent capacitance predicted by theory and the experimental equivalent capacitance,  $C_{eq}$ .

**Parallel connection:**

1. For each case calculate the charge on each capacitor.
2. Calculate the total charge,  $Q_{\text{total}} = Q_1 + Q_2 + Q_3$ .
3. Calculate the experimental equivalent capacitance  $C_{\text{eq}} = Q_{\text{total}}/V_{\text{batt}}$  and record it in the data table.
4. Use eq. (3) to calculate the equivalent capacitance predicted by theory,  $C_{\text{eq,predicted}}$  and record it in the data table.
5. Calculate the percent difference between the equivalent capacitance predicted by theory and the measured equivalent capacitance

$$\% \text{ difference} = \frac{|C_{\text{eq,measured}} - C_{\text{eq,predicted}}|}{\frac{1}{2}(C_{\text{eq,measured}} + C_{\text{eq,predicted}})} \times 100 \quad (6)$$

6. Calculate the percent difference between the equivalent capacitance predicted by theory and the experimental equivalent capacitance,  $C_{\text{eq}}$ .
7. Write a conclusion summarizing your results. Comment on the success of this experiment. Explain any percent differences larger than 10%. Is your result consistent with theoretical predictions? What do you think are the two most important sources of error?

**VII. QUESTIONS:**

1. For each connection, calculate the amount of energy stored in each of the three capacitors. Add up these energies to get the total energy stored in each of the series and parallel connections.
2. Calculate the amount of energy stored in the equivalent capacitance and show that this energy is equal to the sum of the energies stored in the individual capacitors for the series and parallel connections.
3. Which way should capacitors be connected to give you the largest amount of energy stored.

**Experiment (2) Data Table**

**SERIES CONNECTION**

Capacitance $C$ (mF)	Voltage $V$ (Volts)	Charge $Q$ (mC)
$C_{eq} = \frac{Q_{ave}}{V_{batt}} =$	$V_{batt} =$	$Q_{ave} =$
$C_{eq,measured} =$		
$C_{eq,predicted} =$		

**PARALLEL CONNECTION**

$C_{eq} = \frac{Q_{total}}{V_{batt}} =$	$V_{batt} =$	$Q_{total} =$
$C_{eq,measured} =$		
$C_{eq,predicted} =$		