Experiment # 1

PARALLEL PLATE CAPACITOR

OBJECTIVE

To verify the relationship between the voltage, the electric field and the spacing of a parallel plate capacitor.

EQUIPMENT

- 1. Capacitor plate (two).
- 2. Electric field meter (1 KV/m = 1 mA).
- 3. Power supply *DC* 12*V* and 250*V* (variable).
- 4. Multi-meters (two).
- 5. Plastic ruler (100 *cm*).
- 6. Plastic and wooden sheets.

INTRODUCTION

Assume one of the capacitor plates is placed in the y-z plane while the other is parallel to it at distance d as shown in Figure 1. The effect of the boundary disturbance due to the finite extent of the plates is negligible. In this case, the electric field intensity $\overline{\mathbf{E}}$ is uniform and directed in x-direction. Since the field is irrotational ($\overline{E} = -\overline{\nabla}V = \overline{0}$), it can be represented as the gradient of a scalar field V

$$\overline{E} = -\overline{\nabla}V = -\frac{\partial V}{\partial x} \tag{1}$$

which can be expressed as the quotient of differences

$$\overline{E} = -\frac{V_1 - V_o}{x_1 - x_o} = -\frac{V_A}{d}$$
 (2)

where V_A is the applied voltage and d is the distance between the plates. The potential of a point at position x in the space between the plates is obtained by integrating the following equation

$$\frac{\partial V}{\partial x} = \frac{V_A}{d} \tag{3}$$

to give

$$V(x) = \frac{V_A}{d} x \tag{4}$$

EXPERIMENTAL SETUP AND PROCEDURE

- 1. The experimental setup is as shown in Figure 2. Adjust the plate spacing to d=10 cm. The electric field meter should be zero-balanced with a voltage of zero.
- 2. Measure the electric field strength at various voltages ranging from 0 to 250 Volts for d=10 cm and summarize the results in a table. Choose a suitable voltage step to produce a smooth curve.
- 3. Plot a graph of the data of step (2). On the same graph paper, plot the theoretical graph based on equation (2) and compare the theoretical and experimental graphs.
- 4. Adjust the potential V_A to 200V. Measure the electric field strength as the plate separation is varied from d=2 cm to d=12 cm. Summarize your results in a table.
- 5. Plot a graph of the data of step (4). On the same graph paper, plot the theoretical graph based on equation (2) and compare the theoretical and experimental graphs.
- 6. With a different medium (sheet) inserted between the plates, measure the electric field strength at various voltages ranging from 0 to 30*V*. The separation between the plates is fixed at *d*=1 cm. Repeat for all sheets.

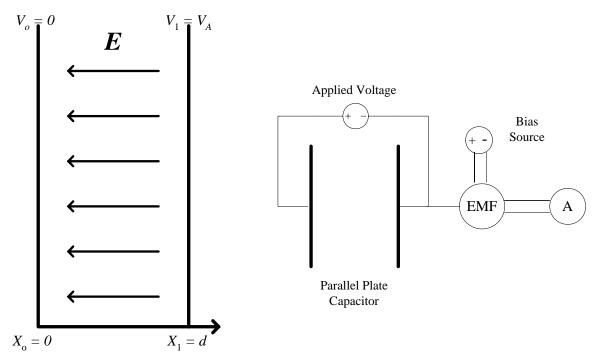


Figure 1: A parallel plate capacitor placed in the yz-plane

Figure 2: Experimental set-up

Calibration → _____

Table 1: Electric field variation with Voltage (d = 10cm)

Voltage (Volts)	Current, 'I', (mA)	Experimental Electric Field Strength 'E' (V/m)	Theoretical 'E' from Eq(2) E=V/d
0			
25			
50			
75			
100			
125			
150			
175			
200			
225			
250			

Table 2: Electric field variation with Plate Separation "d" (V = 200 Volts)

Plate Separation, 'd' (cm)	Current, 'I', (mA)	Experimental Electric Field Strength 'E' (V/m)	Theoretical 'E' from Eq(2) E=V/d
2			
4			
6			
8			
10			
12			

Table 3: Electric field variation with Voltage when Plastic Sheet is used (d = 1 cm)

Voltage (Volts)	Current, 'I', (mA)	Experimental Electric Field Strength 'E' (V/m)
0		
5		
10		
15		
20		
25		
30		

Table 4: Electric field variation with Voltage when Wooden Sheet is used (d=1cm)

Voltage (Volts)	Current, 'I', (mA)	Experimental Electric Field Strength 'E' (V/m)
0		
5		
10		
15		
20		
25		
30		

QUESTIONS FOR DISCUSSION

- 1. What are the assumptions and simplifications in this experiment? Discuss their effects on the experimental results.
- 2. Plot theoretical relation between the potential and distance (equation 4) inside a parallel plate capacitor with d=10 cm and $V_A=100$ V.