Online laboratory assignment 3 - Capacitors

Purpose: to investigate the charge, voltage, and capacitance relationship of parallel plate capacitors

Introduction

A capacitor is an energy storage device commonly used in electric circuits. When an emf source is connected to a capacitor, the two separated conductive surfaces become oppositely charged with equal magnitudes of charge q. As the plates charge an electric field grows between the plates, as does a voltage difference V across the plates. The energy provided by the source of emf is stored in the electric field between the capacitor's charged conductors.

When connected in a single loop, the series resistance R determines the maximum amount of current $I = dQ/dt$ that can travel through the circuit, where the resistance affects the charging and discharging time of a capacitor. The capacitance is defined as the ratio of the charge held on a capacitor plate to the voltage across the plates, or the parallel combination

$$C = \frac{Q}{V}$$

where the capacitance depends on the capacitor's geometry and dimensions. The energy stored a capacitor is given by

$$U = \frac{1}{2}QV$$

Although the above equation relates the capacitance to the charge on the capacitor plates and voltage across the capacitor plates, the capacitance is simply a result of the geometry of the capacitor and materials used between the capacitor plate. For a parallel plate capacitor with no material between the plates, the capacitance is given by

$$C = \frac{\epsilon_0 A}{d}$$

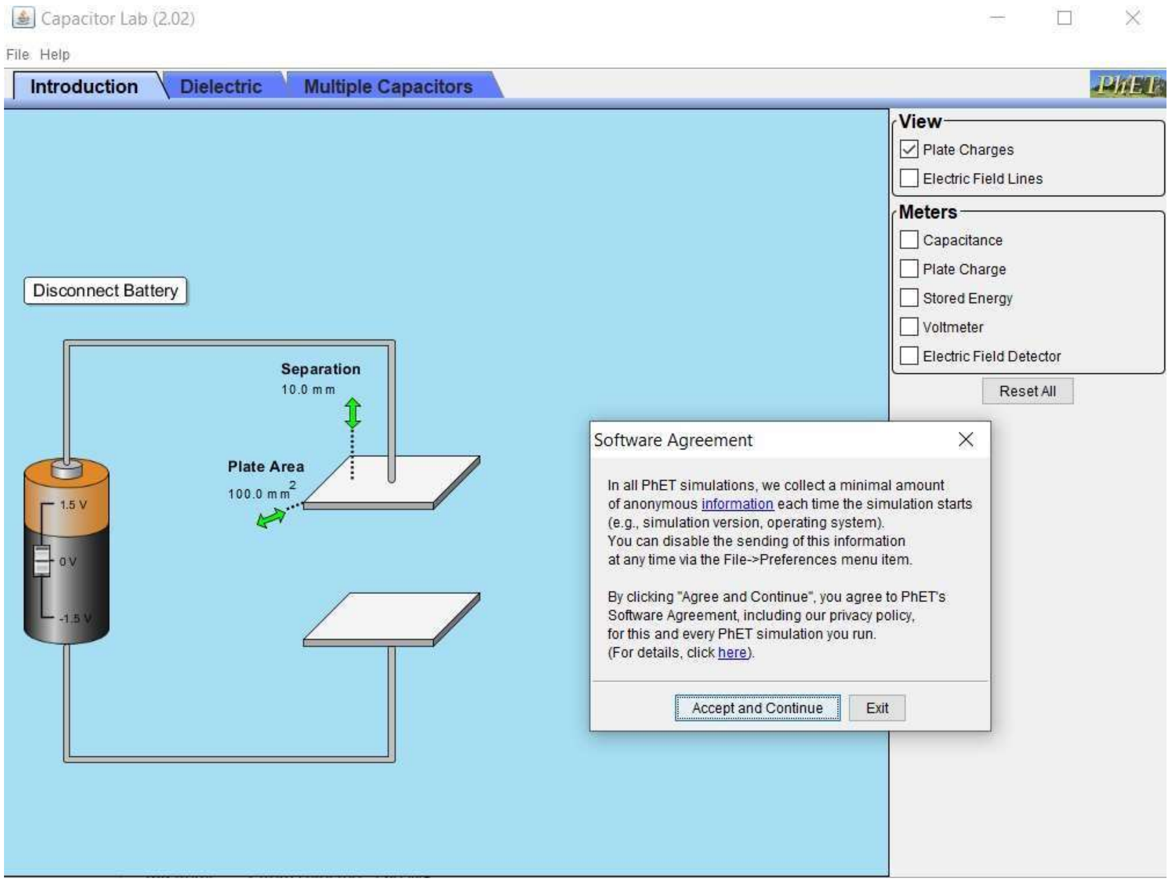
where ϵ = 8.854 × 10 F/m is the permittivity of free space, A is the area of a plate, and d is the distance of separation between the plates. When the space between the plates is filled with a dielectric, the capacitance of the parallel plate capacitor is given by

$$C = \frac{K\epsilon_0 A}{d}$$

where K is the relative permittivity of the material.

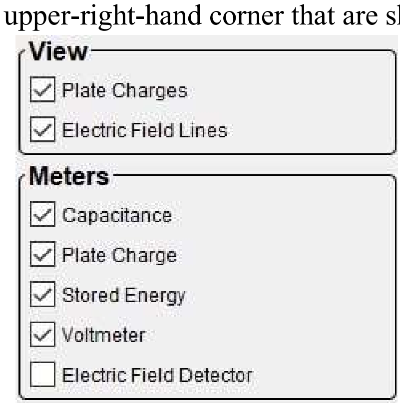
Laboratory assignment

1. Run the "Capacitor lab" PhET simulation.
2. If you choose to download a .jar file and run the program offline, then you may see an image show up when the file begins to run. If so, then click "Accept and Continue."

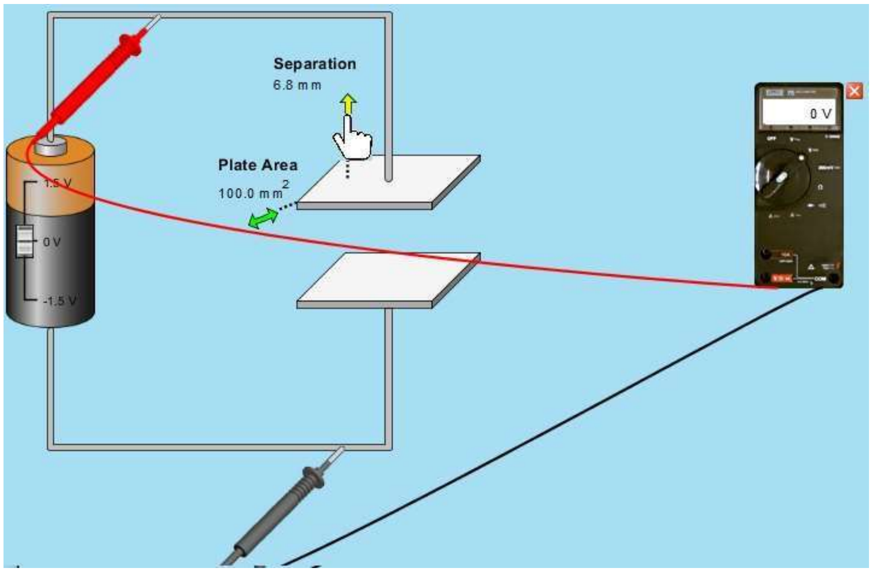


Part I: Capacitance and dimensions

3. Next, check all the boxes in the upper-right-hand corner that are shown in the below image.



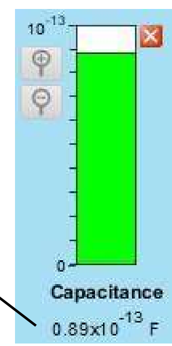
4. Drag the probes to touch the wires on each side of the capacitor as shown below. You can change the dimensions of the capacitor by clicking and dragging the green arrows (it will turn yellow as shown when you hover over it).



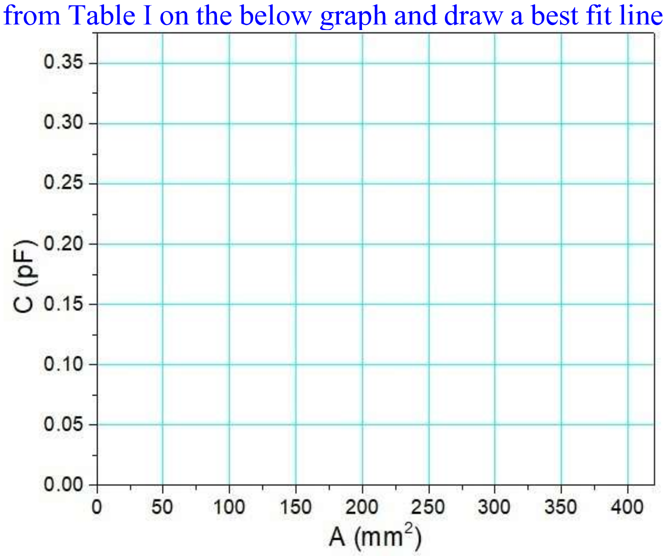
5. Start with a separation distance of 10.0 mm. Only change the area. Record the values of the capacitance (number below green scale) for given areas in Table I. Note, you may not get the exact values for the areas, but try to get as close as you can with dragging the area arrow. Also note that you can change the bar graph scales with the zoom in (+) and zoom out (-) buttons.

Table I: Capacitance vs. Area for d = 10.0 mm

Area (mm^2)	Capacitance (pF)
100.0	
176.5	
249.2	
324.9	
400.0	



6. Place your data points from Table I on the below graph and draw a best fit line or curve.



7. Does the capacitance increase or decrease with increasing area? Is it linear? Explain.

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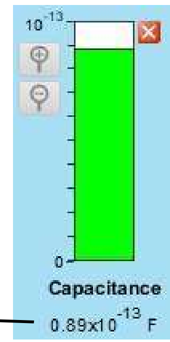
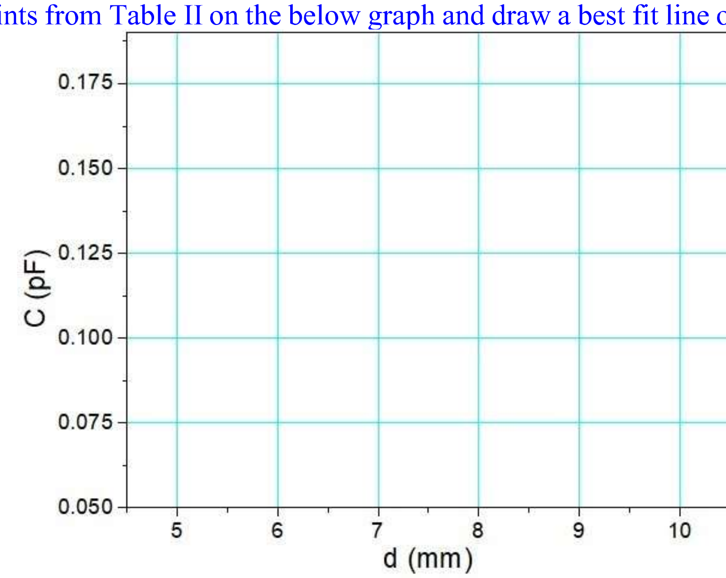
8. Start with an area of 100.0 mm^2. Only change the distance of separation. Record the values of the capacitance (number below green scale) for given separation distances in Table II.

Table II: Capacitance vs. d for A = 100.0 mm^2

d (mm^2)	Capacitance (pF)
5.0	
6.2	
7.5	
8.8	
10.0	



9. Place your data points from Table II on the below graph and draw a best fit line or curve.



10. Does the capacitance increase or decrease with increasing d? Is it linear? Explain.

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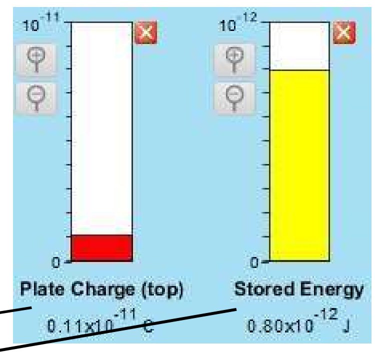
Part II: Charge and energy

11. For this part, set d = 5.0 mm and A = 400.0 mm^2.
12. You can adjust the battery voltage with the sliding scale and the voltmeter will read out the voltage across the capacitor plates if you connected the probes correctly. See below.

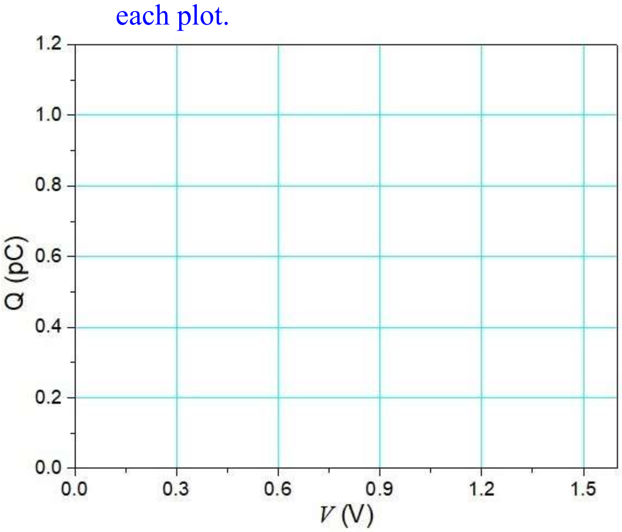
13. Set the voltage values as close as you can to those listed in Table III and fill in the blanks.

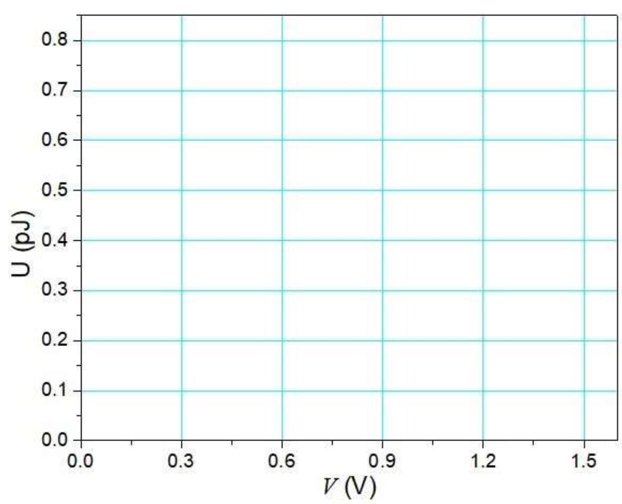
Table III: Charge and energy as a function of voltage.

Voltage (V)	Charge (pC)	Stored energy (pJ)
0		
0.300		
0.600		
0.900		
1.20		
1.50		



14. Place your data points from Table III on the below graphs and draw a best fit line or curve for each plot.





15. Estimate the slope for the Q vs. V graph to the right with uncertainty and correct units.

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16. Explain below what the slope of the Q vs. V graphs represents.

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17. Write a short conclusion to the laboratory below.

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