Online Lab: Capacitance

Name: Date:

Instructor: Section:

Theory:

A capacitor is used to store charge. A capacitor can be made with any two conductors kept insulated from each other. If the conductors are connected to a potential difference, V, as in for example the opposite terminals of a battery, then the two conductors are charged with equal but opposite amount of charge Q, which is then referred to as the "charge in the capacitor."

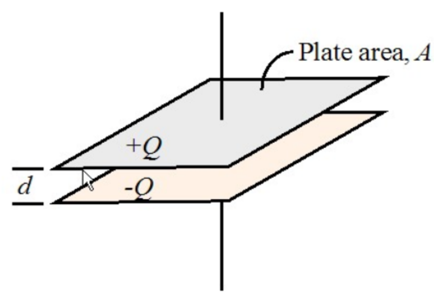
$$C = \frac{Q}{V}$$

Rearranging gives:

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

The simplest form of a capacitor consists of two parallel conducting plates, each with area A, separated by a distance d. The charge is uniformly distributed on the surface of the plates. The capacitance of the parallel-plate capacitor is given by:

$$C = \kappa\epsilon_0 \mathrm{A/d}$$



Where κ is the dielectric constant of the insulating material between the plates ($\kappa = 1$ for a vacuum; other values are measured experimentally and can be found in tables), and ϵ_0 is the permittivity constant, of universal value $\epsilon_0 = 8.85 \text{ x } 10^{-12}$ F/m. The SI unit of capacitance is the Farad (F).

When the capacitor is connected to the battery, charge builds up in the capacitor. The potential difference on the plates is related to the electric field as:

$$V = Ed \qquad or \qquad E = V/d$$

Potential energy (Stored energy) in a charged capacitor is stored in the electric field between plates:

$$U \;=\; \frac{1}{2}QV \;=\; \frac{1}{2}CV^2$$

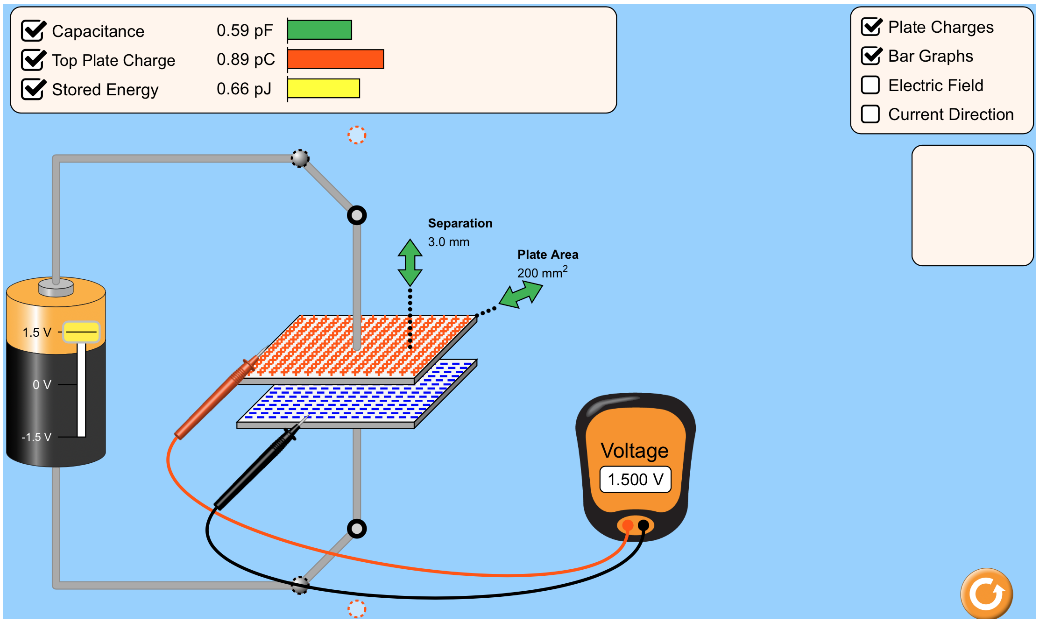
When the capacitor is disconnected from the circuit, the charge on the plates remains constant.

Capacitor Basics:

1. Go to the following website:
   https://phet.colorado.edu/sims/html/capacitor-lab-basics/latest/capacitor-lab-basics_en.html

2. Click Capacitance on the PHeT simulation.

3. **SET** the battery Voltage to 1.5 V, **CHECK** the Top Plate Charge and Stored Energy boxes in the upper left, **CHECK** Plate Charges and Bar Graphs boxes in the upper right and connect the Voltmeter to the plates so your display resembles the graph below.



4. Use the simulation to complete the table below.
   CLICK and **DRAG** the green arrows to adjust the values for separation and plate area.

Table 1: Capacitor Basics

Separation (mm)	**Plate Area** (mm^2)	**Capacitance (pF)**	**Plate Charge (pC)**	**Stored Energy (pJ)**
6 mm	200 mm^2			
6 mm	400 mm^2			
3 mm	200 mm^2			

1. When the plate area was doubled and plate separation held constant, what happens to the Capacitance?

2. When the plate separation was halved and plate area held constant, what happens to the Capacitance?

Effect of the Plate Separation

1. Click the **Reset** Button on the bottom right of the PHeT simulation.
2. **CHECK** Plate Charges and Bar Graphs boxes in the upper right and **CHECK** the Top Plate Charge and Stored Energy boxes in the upper left. **SET** the Plate Area to 200 mm^2, the Plate Separation to 10.0 mm and the Battery Voltage to 1.5 V.
3. Connect the capacitor to the battery to charge the capacitor. Connect the voltmeter across the capacitor by placing the red on the top plate and black on bottom. Make sure the voltage on the voltmeter is equal to the voltage of the battery. Disconnect the charged capacitor from battery.
4. Measure and Record each quantity given in Table 2.

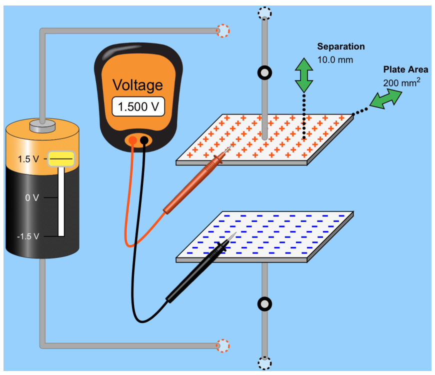


Table 2: Effect of the Plate Separation

Plate Separation (mm)	Plate Area (mm^2)	Capacitance C (pF)	Stored Energy U (pJ)	Plate Charge Q (pC)	Electric Voltage V (V)
10 mm	200 mm^2				
8 mm	200 mm^2				
6 mm	200 mm^2				
4 mm	200 mm^2				
2 mm	200 mm^2				

1. Describe what happen with each quantity below when the plates are moved closer together. **Select One: Increases, Decreases, Stays the Same**

   (a) Capacitance, C:

   (b) Charge, Q:

   (c) Voltage, V:

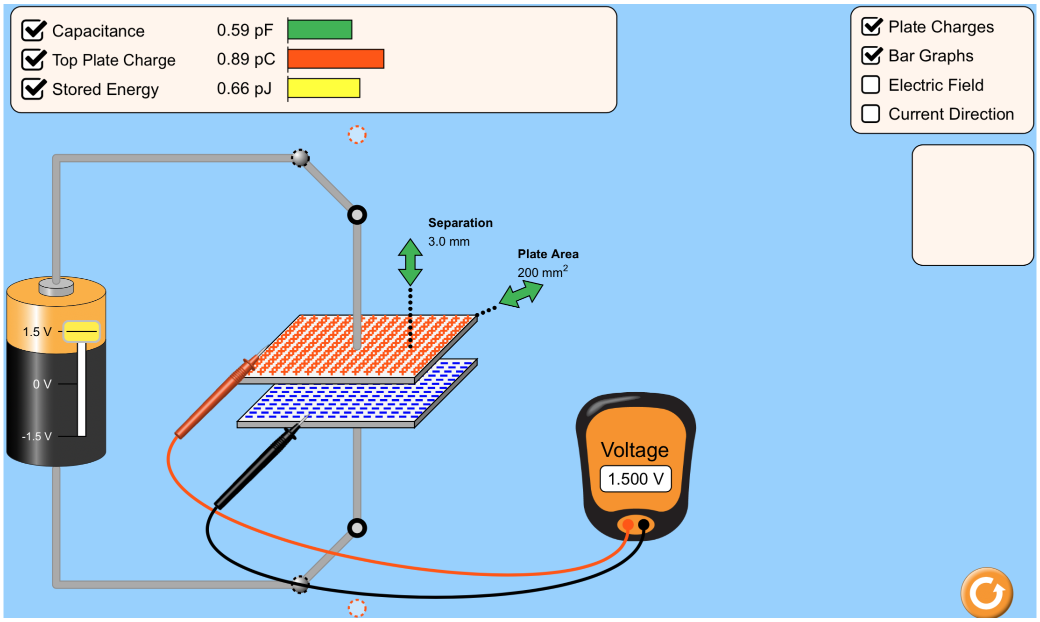
   (d) Potential Energy, U:

Capacitance, Charge and Voltage: Q = CV

1. Click the **Reset** Button on the bottom right of the PHeT simulation.

2. **CHECK** Plate Charges and Bar Graphs boxes in the upper right so your display resembles the graph below.

3. **SET** the Plate Area to 200 mm^2 and the Separation to 4.0 mm.



4. Connect the voltmeter across the capacitor by placing the red on the top plate and black on bottom. If the voltmeter reads a negative, switch the red and black.

5. Set the battery Voltage to 0.25 V. Record the measured plate charge, Q.

6. Repeat Step 5 for each Voltage in Table 3.

Table 3: Charge and Voltage

Voltage (V)	**Plate Charge (pC)**
0.25 V	
0.50 V	
0.75 V	
1.00 V	
1.25 V	
1.50 V	

Conclusions

1. Write a formula that describes how Capacitance, Charge and Voltage are related?

2. Write a formula that describes how Stored Energy, Capacitance and Voltage are related?

3. What are the ways the capacitance of a capacitor can be increased?

4. When increasing the voltage of the battery what happens to the charge on the plates of the capacitor?

5. **Create a graph of Charge, Q on they y-axis versus Voltage, V on the x-axis using your data results in Table 3. Upload it with this Lab Report in D2L.**
   Measure the slope of the line using any method you are comfortable with.
   Record the slope here. What is the physical meaning of the slope?

6. **Take a photo or scan a copy showing ALL calculations performed during this lab and upload it with this Lab Report in D2L.**