PHYS 202L **Capacitors** Name:\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  
  
In this lab you will go through few activities with capacitors. Conclusion is not required.  
  
A) Go to the following simulation and click play: <https://phet.colorado.edu/en/simulation/capacitor-lab>

1. Introduction tab is the default start. What you see is a parallel plate capacitor, connected to a battery, whose voltage is set to zero.
2. Increase the voltage to +1.5 V, all the way up, and describe what happens?
3. Click “Electric Field lines” under View, electric field lines between the capacitor plates will be displayed. Sketch the field lines below.   
   
4. Capacitance, *C* is defined as charge, *q* per voltage, *V*. .   
   Stored energy is given by,   
   Turn on the capacitance meter, record the capacitance value, and calculate the charge, *q* on the capacitor plate and the energy stored. Use the voltage already set, 1.5 V. Turn on the Plate charge and Stored Energy and record these simulation values also below.

Voltage = V = \_\_\_\_\_\_\_\_\_\_\_\_\_ Capacitance = C =\_\_\_\_\_\_\_\_\_\_\_\_\_

|  |  |  |
| --- | --- | --- |
|  | Calculated Value | Simulation Value |
| Plate Charge, *q* |  |  |
| Stored Energy |  |  |

B. In the simulation click the “Dielectric” tab.

1. What you see is a parallel plate capacitor and a dielectric. The voltage of the battery is set to zero.
2. Click “Capacitance” under “meters” to display the capacitance value. The influence of the dielectric constant (*κ*) on the capacitance can be found by moving the dielectric in between the capacitor plates. The Plate Area and Separation can also be varied to see their effects on the capacitance. 

Determine how the capacitance, *C* depends on the following:

1. Dielectric constant, *κ*: Directly proportional or Inversely proportional
2. Plate Area, *A*: Directly proportional or Inversely proportional
3. Separation of the plates, *d*: Directly proportional or Inversely proportional
4. Express the capacitance, *C* in terms of the above variables (assume a proportionality constant of ε0): \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
5. Move the dielectric completely inside the capacitor plates and record the capacitance, Plate Area, and Separation values. Use the above equation and calculate a value for the dielectric constant. Assume ε0 = 8.85 x 10-12 C2/(N.m2).

**C.** To investigate various combinations of capacitors and determine the equivalent (total) capacitance.    
  
**Theory:**

|  |  |  |
| --- | --- | --- |
| Combination | Diagram | Formula to calculate |
| Series |  |  |
| Parallel |  |  |

**Procedure:**In the simulation click the “Multiple Capacitors” tab.

1. Click “2 in Series” under “Circuits”. Set the capacitors, C1= 1.0 and C2= 2.0. Calculate the equivalent (total) capacitance. Click “Total Capacitance” under “Meters” and complete the first row of the data table for equivalent capacitance below.
2. Click “3 in Series” under “Circuits”. Set the capacitors, C1= 1.0, C2= 2.0, and C3= 3.0 . Calculate the equivalent (total) capacitance. Click “Total Capacitance” under “Meters” and complete the second row of the data table for equivalent capacitance below.
3. Click “2 in Parallel” under “Circuits”. Set the capacitors, C1= 1.0 and C2= 2.0. Calculate the equivalent (total) capacitance. Click “Total Capacitance” under “Meters” and complete the third row of the data table for equivalent capacitance below.
4. Click “3 in Parallel” under “Circuits”. Set the capacitors, C1= 1.0, C2= 2.0, and C3= 3.0 . Calculate the equivalent (total) capacitance. Click “Total Capacitance” under “Meters” and complete the fourth row of the data table for equivalent capacitance below.
5. Repeat the above for other circuits and complete the data table for equivalent capacitance below.

DATA TABLE: Equivalent (total) capacitance

C1= 1.0 C2= 2.0 C3= 3.0

|  |  |  |  |
| --- | --- | --- | --- |
| Circuit | Circuit Diagram | Total Capacitance ( | |
| Calculated value | Simulation value |
| 2 in Series |  |  |  |
| 3 in Series |  |  |  |
| 2 in Parallel |  |  |  |
| 3 in Parallel |  |  |  |
| 2 in Series + 1 in Parallel |  |  |  |
| 2 in Parallel + 1 in Series |  |  |  |

D. In the simulation under “Multiple Capacitors” tab, click “Reset All”.

1. Click “3 in Series” under “Circuits”. Set the capacitors, C1= 1.0, C2= 2.0, and C3= 3.0 . Increase the voltage to +1.5 V, all the way up. Observe the charge in each of the capacitors, are they the same?\_\_\_\_\_\_\_\_\_\_

This means when capacitors with different capacitances are in series, each of them will carry the same charge. This will be very useful during problem solving with capacitors.

1. Click “Voltmeter” and measure the voltage across each of the capacitors as shown below.



|  |  |  |  |
| --- | --- | --- | --- |
|  | Capacitance, C () | Voltage, V (volt) | Charge = CV ( |
| C1 |  |  |  |
| C2 |  |  |  |
| C3 |  |  |  |

1. Is the charge same on each of the capacitor? \_\_\_\_\_\_\_\_\_\_\_
2. Click “Stored Charge” and record the simulation value:\_\_\_\_\_\_\_\_\_\_
3. Is the total voltage same as the battery voltage, 1.5V?\_\_\_\_\_\_\_\_\_\_\_

This is expected since the battery is connected across all three capacitors and they all share the battery voltage.

E. In the simulation under “Multiple Capacitors” tab, click “Reset All”.

1. Click “3 in Parallel” under “Circuits”. Set the capacitors, C1= 1.0, C2= 2.0, and C3= 3.0 . Increase the voltage to +1.5 V, all the way up. Observe the charge in each of the capacitors, are they the same or different?\_\_\_\_\_\_\_\_\_\_\_\_
2. Click “Voltmeter” and measure the voltage across each of the capacitors as shown below.   
   

|  |  |  |  |
| --- | --- | --- | --- |
|  | Capacitance, C () | Voltage, V (volt) | Charge = CV ( |
| C1 |  |  |  |
| C2 |  |  |  |
| C3 |  |  |  |

1. Is the voltage same on each of the capacitor? \_\_\_\_\_\_\_\_\_\_\_  
   This is expected because the capacitors are in parallel across the battery, and each gets the same voltage.
2. Click “Stored Charge” and record the simulation value:\_\_\_\_\_\_\_\_\_\_
3. How is the above “Stored Charge” relates to the charges on each of the capacitor?

F. In the simulation under “Multiple Capacitors” tab, click “Reset All”.

1. Click “2 in Series +1Parallel” under “Circuits”. Set the capacitors:

C1= 1.0, C2= 2.0, and C3= 3.0 . Increase the voltage to +1.5 V, all the way up.  


1. Observe the charge in each of the capacitors, and describe it below:
2. The voltage across C3 can be found easily, since it is connected across the battery. What is the voltage across C3 = \_\_\_\_\_\_\_\_\_\_\_  
   Measured value with the voltmeter =\_\_\_\_\_\_\_\_\_\_

Charge on capacitor C3 = \_\_\_\_\_\_\_\_\_\_\_

1. Since capacitors C1 and C2 are in series, they carry the same charge as of the equivalent capacitor of C1 and C2, which will have the entire battery voltage.   
   To find this charge,   
   a. First, find the equivalent capacitance of C1 and C2.

b. Use the battery voltage and the above equivalent capacitance to find the charge.

c. Use the above charge with the capacitance of C1 to find the voltage for C1 and the capacitance of C2 to find the voltage for C2.

d. Measured values of the voltages with the voltmeter:  
Voltage for C1 = \_\_\_\_\_\_\_\_\_\_Voltage for C2 = \_\_\_\_\_\_\_\_\_\_\_\_\_\_