PH 221 Homework Assignment Chapter on Capacitors – 25 Problems Total

1. How much charge flows from a $6.00\ \mathrm{V}$ battery when it is connected to a $7.50\ \mu\mathrm{F}$ capacitor?

Solution for Problem 1

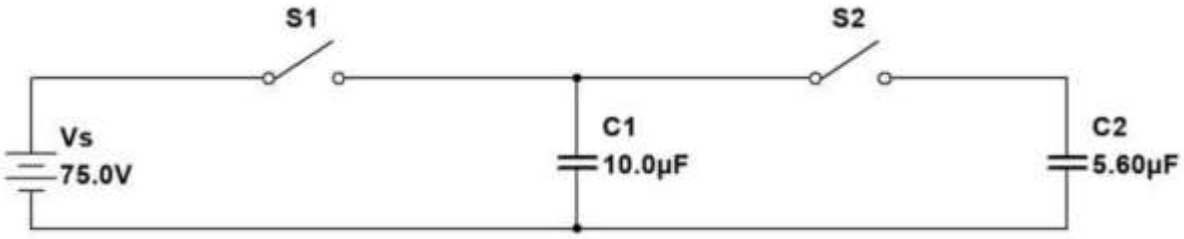
2. Two short sections of wire are parallel. One wire carries a charge of $+1.80\ \mathrm{x}\ 10^{-10}\ \mathrm{C}$, while the other wire carries $-1.80\ \mathrm{x}\ 10^{-10}\ \mathrm{C}$. The potential difference between the two wires is measured to be $16.8\ \mathrm{V}$. What is the effective capacitance between the wires?

Solution for Problem 2

3. The voltage across a capacitor is decreased from $108.\ \mathrm{V}$ to $48.0\ \mathrm{V}$. The charge on the capacitor decreases by $37.2\ \mu\mathrm{C}$. What is the capacitance of the capacitor?

Solution for Problem 3

4. As shown in the circuit below, a capacitor $(\mathrm{C}_1 = 10.0\ \mu\mathrm{F})$ is initially uncharged. It is connected to a batter $(\mathrm{V}_\mathrm{S} = 75.0\ \mathrm{V})$ when switch (S_1) is closed. After the capacitor is fully charged, switch (S_1) is opened. Capacitor $(\mathrm{C}_2 = 5.60\ \mu\mathrm{F})$ is initially uncharged. Switch (S_2) is now closed. The circuit is allowed to equilibrate.



(a) What is the voltage on Capacitor (C_1)?

(b) What is the voltage on Capacitor (C_2)?

(c) What is the charge on Capacitor (C_1)?

(d) What is the charge on Capacitor (C_2)?

Solution for Problem 4

5. A $7.75\ \mu\text{F}$ capacitor is attached to a $375.\ \text{V}$ power source. A $4.34\ \mu\text{F}$ capacitor is attached to a $715.\ \text{V}$ power source. Both capacitors are then removed from their power supplies.

(a) What is the charge on the $7.75\ \mu\text{F}$ capacitor?

(b) What is the charge on the $4.34\ \mu\text{F}$ capacitor?

(c) The two capacitors are connected in parallel (i.e. positive plate connected to positive plate and negative plate connected to negative plate). What is the voltage across the parallel combination?

(d) What is the charge on the $7.75\ \mu\text{F}$ capacitor?

(e) What is the charge on the $4.34\ \mu\text{F}$ capacitor?

(f) If instead of combining the two fully charged capacitors in parallel as indicated in part (c), combine them in series (connect the negative plate of the $7.75\ \mu\text{F}$ capacitor is to the positive plate of the $4.34\ \mu\text{F}$ capacitor). What is the voltage across the series combination? (For polarity assume the positive plate of the $7.75\ \mu\text{F}$ capacitor is positive and the negative plate of the $4.34\ \mu\text{F}$ capacitor is the negative (or lower voltage) side.)

(g) What is the voltage across the $7.75\ \mu\text{F}$ capacitor?

(h) What is the voltage across the $4.34\ \mu\text{F}$ capacitor?

Solution for Problem 5

6. One type of computer Random Access Memory (RAM) is called Dynamic RAM (DRAM) and is essentially a small capacitor. If the capacitor is fully charged, it represents a binary digit "1". If the capacitor is not charged or it is not charged "enough", it represents a binary digit of "0". Assume the capacitor used in a particular DRAM has a capacitance of $20.\text{x}\ 10^{-15}\text{F} = 20.\ \text{fF}$ (f stands for prefix "femto"). Assume the fully charged DRAM capacitor has a voltage of $3.3\ \text{V}$ across it. Assume the charge leaks off the capacitor at a rate of $3.1\ \text{x}\ 10^{-11}\ {}^{\text{C}}/_{\text{S}}$.

(a) When the capacitor is fully charged, how many excess electrons are on the negative plate of the capacitor?

(b) How long would it take the capacitor drop its fully charged value of $3.3\ \text{V}$ to a level of $1.7\ \text{V}$? This would make its binary state confusing. Refreshes are needed to keep this from happening.

Solution for Problem 6

7. You want to construct a parallel plate capacitor with a capacitance of $10.0\ \mathrm{mF}$. Assume the air gap between the two plates is $2.40\ \mathrm{x}\ 10^{-4}\ \mathrm{m}$. What surface area will the plates need?

Solution for Problem 7

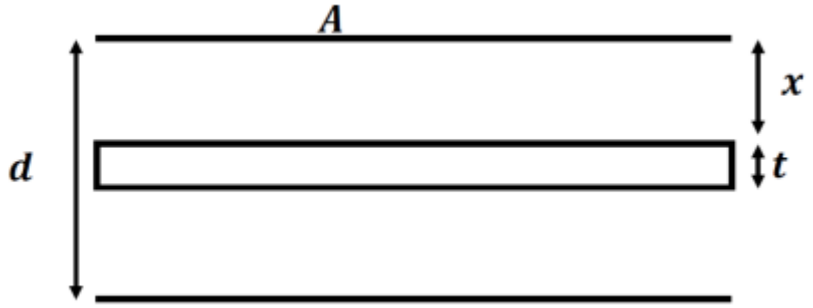
8. For dry air, if the electric field exceeds a value of about $3.00\ \mathrm{x}\ 10^{6}\ {}^{\mathrm{V}}/_{\mathrm{m}}$, the charges will move through the air creating a spark similar to a lightning bolt. How much charge can be placed on the plates of a parallel capacitor before the charge arcs between the two plates. Consider the case when the plate area is $1.60\ \mathrm{x}\ 10^{-3}\ \mathrm{m}^2$?

Solution for Problem 8

9. A potential difference of $5.67\ \mathrm{x}\ 10^{3}\ \mathrm{V}$ is desired between two plates which area of $2.35\ \mathrm{x}\ 10^{-3}\ \mathrm{m}^2$. Assume the plates each have a charge of magnitude $8.92\ \mathrm{x}\ 10^{-8}\ \mathrm{C}$. How far apart should the plates be spaced?

Solution for Problem 9

10. Consider a large parallel plate capacitor with plate area (A) and separated by a distance (d). A metal plate with the same area as the capacitor but has a thickness of (t) is placed in between the two plates as shown below. Clearly before the metal plate is inserted in between the capacitor plates, the capacitance is $\mathrm{C}_0 = \frac{\varepsilon_0 \mathrm{A}}{\mathrm{d}}$.



(a) What is the capacitance after the metal plate is inserted?

(b) Consider the thickness of the inserted plate to be a fraction of the separation of the original plates (i.e. $\mathrm{t} = \mathrm{pd}$, where p is a fraction or percentage). What is the ratio of the new capacitance to the original capacitance?

Solution for Problem 10

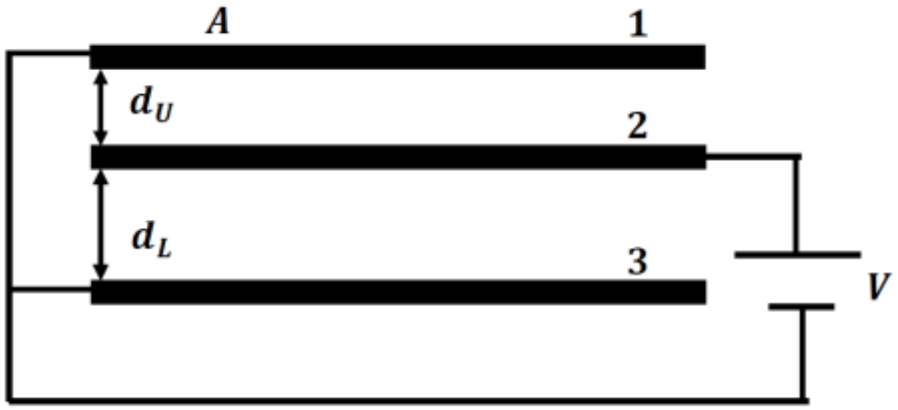
11. Consider you have five $2.34\ \mathrm{mF}$ capacitors. What is the total capacitance if these capacitors are wired:

(a) In Parallel?

(b) In Series?

Solution for Problem 11

12. Three conducting plates all have the same area (A) as shown below. They are connected to each other as shown and a voltage (V) is applied as indicated.



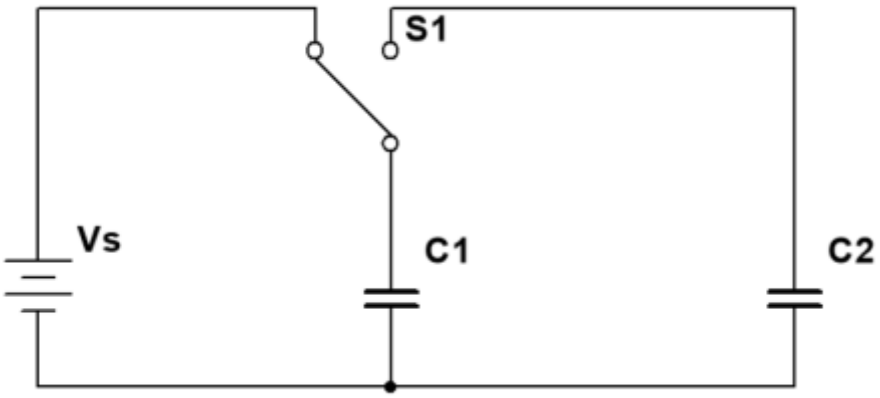
(a) Are these plates wired as two capacitors in series or in parallel?

(b) Determine the capacitance of the combination in terms of $\mathrm{A}, \mathrm{d_U}, \mathrm{and}\ \mathrm{d_L}$. Assume both $\mathrm{d_U}\ \mathrm{and}\ \mathrm{d_L} << \sqrt{\mathrm{A}}$.

(c) Assume plate 2 can be moved vertically thus $\mathrm{d_U}\ \mathrm{and}\ \mathrm{d_L}$ can be changed. Find minimum value of the capacitance.

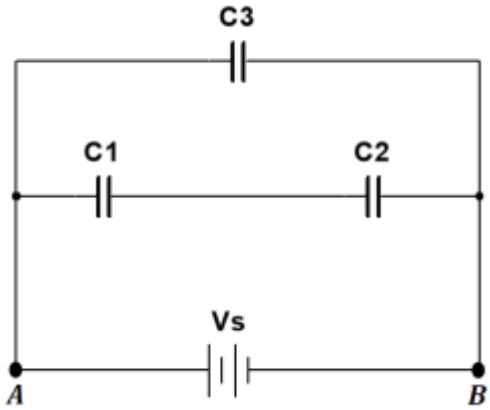
Solution for Problem 12

13. The circuit below shows a capacitor (C_1) is initially connected to a power source with a voltage (V_S). The capacitor is allowed to fully charge. Then the switch (S_1) is thrown and the second capacitor (C_2). A long time after the switch is thrown, what is the charge on each capacitor?



Solution for Problem 13

14.

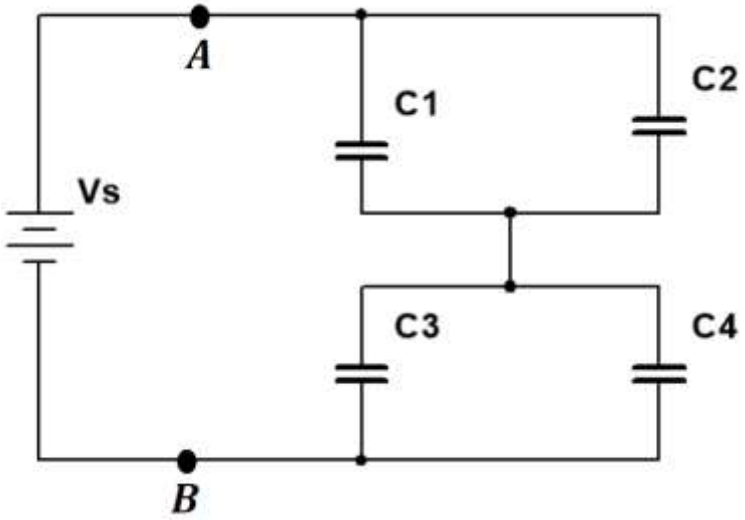


(a) What is the equivalent capacitance between points A and B for the circuit shown above?

(b) Assuming the capacitors are fully charged, what is the charge on capacitor (C_2)

Solution for Problem 14

15.



(a) Determine the equivalent capacitance between points A and B.

(b) Determine the charge on capacitor C_1.

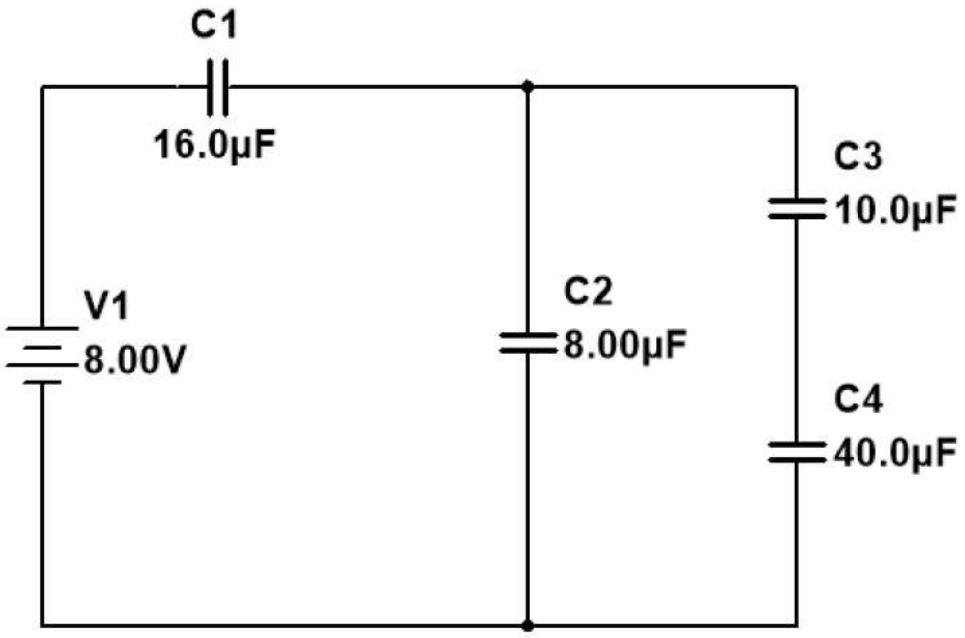
(c) Determine the charge on capacitor C_3.

(d) Determine the voltage on capacitor C_2.

(e) Determine the voltage on capacitor C_4.

Solution for Problem 15

16.



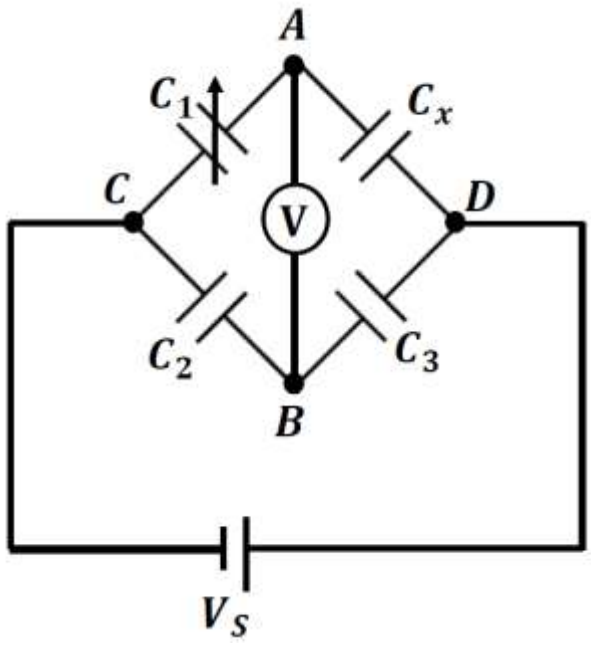
(a) Determine the total capacitance of the above circuit.

(b) Complete the table below

Capacitor	Charge on Capacitor	Voltage Across Capacitor
C_1		
C_2		
C_3		
C_4		

Solution for Problem 16

17. The circuit shown below is known as a "Capacitance Bridge". As indicated four capacitors are wired as shown and a voltage source (V_s) is wired as indicated. Two capacitors $(C_2 \text{ and } C_3)$ are known capacitances. Capacitor (C_1) is a variable capacitance and the remaining capacitor is unknown (C_x). The "Bridge" is balanced when the variable capacitance is adjusted until there is no charge movement (current) between points A and B. The voltmeter or Galvanometer would read "Zero".

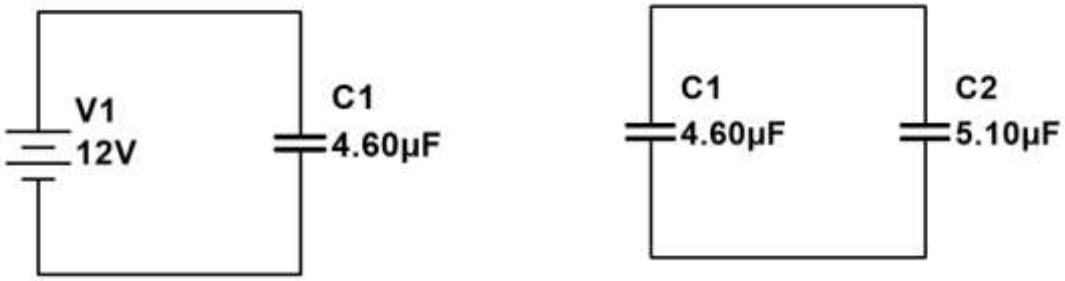


(a) Determine the expression for the unknown capacitor (C_x)?

(b) If Capacitors $(C_2 = 15.0 \text{ mF} \text{ and } C_3 = 35.0 \text{ mF})$ and the variable capacitor is tuned to $(C_1 = 17.0 \text{ mF})$ what would that make the unknown capacitor (C_x)?

Solution for Problem 17

18. As shown below, a $12.0\ \mathrm{V}$ Power Supply is attached to a capacitor $(\mathrm{C}_1 = 4.60\ \mu\mathrm{F})$. The capacitor is charged until the voltage across it is the same as the power supply $(12.0\ \mathrm{V})$. The capacitor is eventually disconnected from the power supply and now it is wired in parallel to a second capacitor $(\mathrm{C}_2 = 5.10\ \mu\mathrm{F})$.



(a) What is the total energy stored in capacitor (C_1) when it is first disconnected from the power supply before it is connected to the second capacitor?

(b) What is the total energy stored in both capacitors after they come to an equilibrium state?

(c) What is the change in energy stored between parts (a) and (b)?

Solution for Problem 18

19. Determine the force one plate of a parallel plate capacitor exerts on the other plate when they are charged.

Solution for Problem 19

20. Two uncharged capacitors $(\mathrm{C_A})$ and $(\mathrm{C_B})$ are connected in parallel and then the combination is connected to a power source with a voltage $(\mathrm{V_S})$. The capacitors are allowed to come to full charge. They now have a total stored energy $(\mathrm{U_P})$. Consider if instead the two uncharged capacitors were connected in series and then hooked up to the same power source allowed to come to full charge. The total stored energy is $(\mathrm{U_S})$. If the relationship of the stored energies is

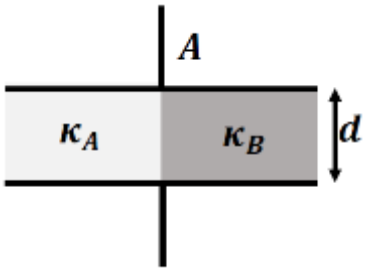
$$\mathrm{U_P} = 5\mathrm{U_S}$$

What is the ratio

$$\frac{\mathrm{C_A}}{\mathrm{C_B}}$$

Solution for Problem 20

21. Shown below is a parallel capacitor with plate area (A) and the plates are separated by a distance (d). One half of the space between the plates is filled with a dielectric with a dielectric strength of (κ_{A}). The second half is filled with a dielectric with a dielectric strength of (κ_{B}).

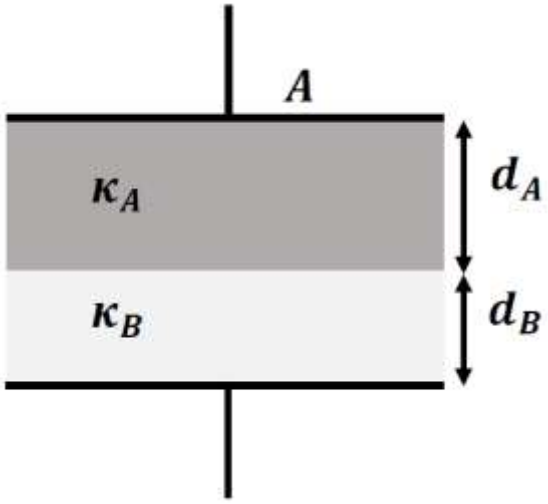


(a) Is this situation equivalent to two capacitors in Parallel or Series?

(b) Find the capacitance of this capacitor.

Solution for Problem 21

22. Shown below is a parallel capacitor with plate area (A) and the plates are separated by a distance $(\mathrm{d} = \mathrm{d_A} + \mathrm{d_B})$. One section (thickness $(\mathrm{d_A})$)of the space between the plates is filled with a dielectric with a dielectric strength of (κ_{A}). The second section (thickness $(\mathrm{d_B})$) is filled with a dielectric with a dielectric strength of (κ_{B}).



(a) Is this situation equivalent to two capacitors in Parallel or Series?

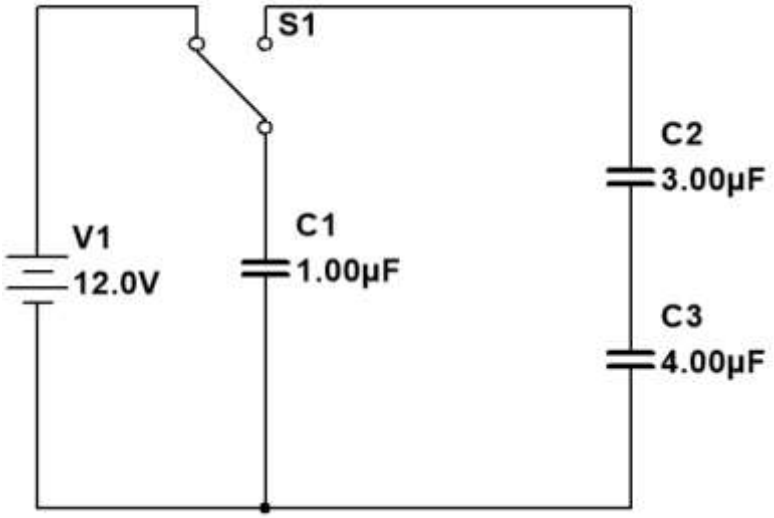
(b) Find the capacitance of this capacitor.

Solution for Problem 22

23. A cardiac defibrillator is used to shock a heart that is beating in an erratic manner. The capacitor in the device is charged to a voltage of $1000.\,\mathrm{V}$ and stores an energy of $360.\,\mathrm{J}$. What is the capacitance of the capacitor?

Solution for Problem 23

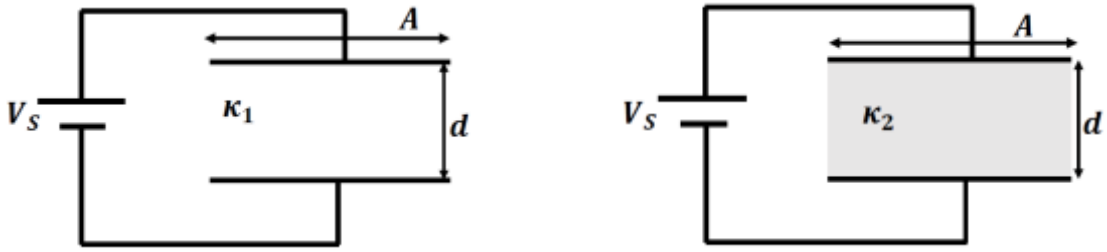
24.



Capacitor		
Before Switch is thrown	Charge on Capacitor	Voltage across Capacitor
C_1		
After Switch is thrown		
C_1		
C_2		
C_3		

Solution for Problem 24

25. A parallel plate capacitor is shown below in two conditions. The plate area is $A = 3.00\ m^2$, the spacing between the plates is $d = 4.00 \times 10^{-3}\ m$. A power source is connected as shown with a voltage $V_S = 65.0\ V$. In situation 1, the space between the plates is empty so $\kappa_1 = 1.00$. In situation 2, there is a dielectric completely filling the space between the plates with $\kappa_2 = 5.50$. Assume in both situations the voltage has fully charged the capacitor.



(a) What is the capacitance of Situation 1?

(b) What is the capacitance of Situation 2?

(c) What is the charge on the capacitor in Situation 1?

(d) What is the charge on the capacitor in Situation 2?

(e) What is the Electric field between the plates in Situation 1?

(f) What is the Electric field between the plates in Situation 2?

(g) What is the energy stored in the capacitor in Situation 1?

(h) What is the energy stored in the capacitor in Situation 2?

(i) What was the work done by the electric field as the dielectric was inserted changing Situation 1 into Situation 2?

Solution for Problem 25

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