Due Tues., Feb 14

2011-12 PreAP Electrostatics 14

$C = \varepsilon_0 \frac{A}{d}$ $\quad \varepsilon_0 = 8.85 \times 10^{-12}$ $\quad C = \frac{|Q|}{\Delta V}$

1. Units: Electric field is in ____; Electric force is in ____; Voltage is in ____; Charge is in ____; Capacitance is in ____ or ____.

   1. C is in Farads or coulombs/volts

2. You find a parallel plate capacitor. Its capacitance is not written on it. So you decide to find out what it can do. You pull out your handy volt/charge meter and a variable voltage supply.

   A. You discharge the capacitor. How?

   A. Connect with a wire

   B. What is the voltage of the discharged capacitor?

   C. What is the charge on one of the plates when discharged?

   D. You then hook up the voltage supply, set to 6 volts. You connect it to the capacitor for only 2 seconds. What is the voltage of the capacitor, approximately?

   2D: less than 6V

   E. You reattach the 6V supply. When will the capacitor stop charging?

   2E: when $V_{cap} = 6V$

   F. When it is fully charged to 6V you read that −3C of charge has been pushed to the negative plate. What is the charge on the positive plate?

   2F: $|Q+| = |Q-|$ (always)

   G. What is the capacitance of the capacitor?

   G: 3C/6V = 0.5 F

   H. You then up the power supply to 10 volts. What is the final voltage across the plates of the capacitor?

   H: 10 volts

   I. When fully charged the negative plate then read −5C. What is the capacitance of the capacitor?

   I: 5C/10V = 0.5 F

   J. How did the increase of voltage change the capacitance of the capacitor?

   J. Didn't change it.

   K. What does an increase of voltage change for a capacitor?

   K. Amount of Q

   L. You up the power supply to its maximum voltage. You read −7.5C. What is the capacitance of the capacitor?

   M. What is the maximum voltage of your power supply?

3. On another day you find a different parallel plate capacitor, but you don't have your voltage/charge meter. Instead you have a micrometer (reads very small distances) and a ruler.

   A. You measure one side of one of the square plates at 25 cm. What is the area of the plate?

   A. $A = \ell \times w = (.25)^2 = .0625 m^2$

   B. The micrometer reads 12 μm between the plates. What will you use for d?

   B. 12×10^{-6} m

   C. Now that you have measured the physical dimensions of the capacitor, what is its capacitance?

   C. $C = \varepsilon_0 \frac{A}{d} = \varepsilon_0 \frac{.0625}{12 \times 10^{-6}}$

   $C = 4.61 \times 10^{-8} F$

   D. If the distance between the plates of the capacitor was half as much, what is its new capacitance?

   D. 2 times

   E. By halving the plate distance you _____ the capacitance.

OK—now you should see the difference between the two equations.

4. A 9 V battery is hooked up to a 1 F capacitor.

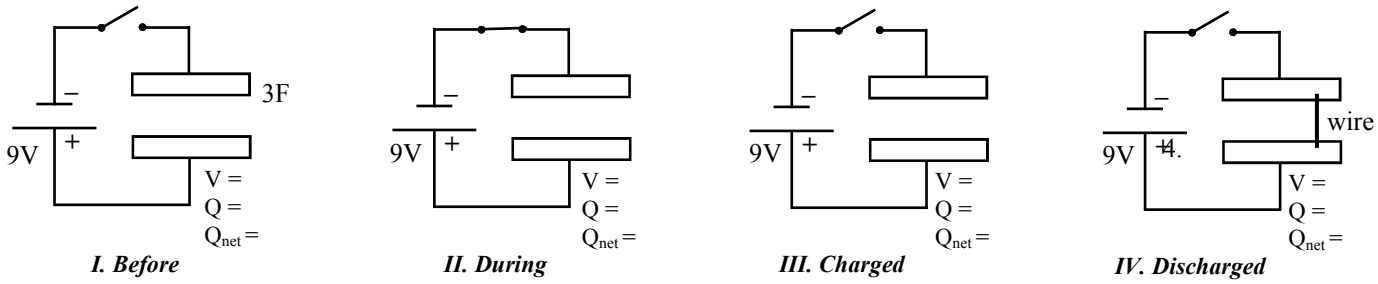
   A. How much charge can it hold?

   4A: 1F = 1C per volt OR 1F = 1C/V mult by volts

   B. How much charge can a 2 F capacitor hold for the same potential (voltage)?

   C. So, a bigger capacitor can hold _____ charge for the same voltage.

5. A. On the diagrams below draw what occurs on the capacitor plates. Be correct as for which plate is positive.
   B. For each of the stages, give V, Q, and Qnet. If you can't completely calculate, give < or >.



I. Before ***II. During*** ***III. Charged*** ***IV. Discharged***

6. A neutral 3 pF (pico farad) capacitor (pico = $\times 10^{-12}$) is placed in a circuit, but the switch is not closed.

   A. What is the charge on one of the plates beforehand?

   A 12 V battery is then connected and charges the capacitor.

   B. What is the total charge on the capacitor when it is fully charged?

   C. What is the final voltage across the capacitor?

   D. What charge will be gained by the positive plate?

   E. What charge will be gained by the negative plate?

   F. How much potential energy is stored?

   G. If the voltage were doubled, how much charge could it hold?

   H. How would the capacitance change if the voltage were doubled?

   I. When the capacitor is discharged, what happens (talk + and − charges and voltage).

B. 36pC

D. 3.6E−11C

7. Solve the capacitance equation for Q.
8. Write the PE for a capacitor without Q in it.
9. Solve the capacitance equation for V.
10. Write the PE for a capacitor without V in it.
11. A 3F capacitor is charged to 2 V. Calculate the potential energy stored.

7. C = Q/V so Q = CV
8. PE = ½CV(V) = ½CV^2
9. V = Q/C
10. PE = ½Q^2/C
11. Use one of the above equations.

12. A 6F capacitor has 15C of charge on one plate. Calculate its potential energy.

A-Day Due Tues., Jan 25
B-Day: Due Wed., Jan 26

2011 PreAP Electrostatics 6

1. Units: Electric field is in N/C; Electric force is in N; Voltage is in V; Charge is in C; Capacitance is in F or C/V.
2. You find a parallel plate capacitor. Its capacitance is not written on it. So you decide to find out what it can do. You pull out your handy volt/charge meter and a variable voltage supply.
   A. You discharge the capacitor. How? connecting the ends (or with a wire)
   B. What is the voltage of the discharged capacitor? 0 V
   C. What is the charge on one of the plates when discharged? 0 C
   D. You then hook up the voltage supply, set to 6 volts. You connect it to the capacitor for only 2 seconds. What is the voltage of the capacitor, approximately? less than 6V
   E. You reattach the 6V supply. When will the capacitor stop charging? when $V_{cap} = 6V$
   F. When it is fully charged to 6V you read that −3C of charge has been pushed to the negative plate. What is the charge on the positive plate? +3C
   G. What is the capacitance of the capacitor? $C = \frac{Q}{V} = 3C/6V = 0.5\ F$ -2w
   H. You then up the power supply to 10 volts. What is the final voltage across the plates of the capacitor? 10 V
   I. When fully charged the negative plate then read −5C. What is the capacitance of the capacitor? 0.5 F, still $\frac{5C}{10V} = 0.5\ F$ -2w
   J. How did the increase of voltage change the capacitance of the capacitor? It didn't
   K. What does and increase of voltage change for a capacitor? the charge (Q)
   L. You up the power supply to its maximum voltage. You read −7.5C. What is the capacitance of the capacitor? 0.5 F
   M. What is the maximum voltage of your power supply? $.5 = \frac{7.5}{V}$ $V = \frac{7.5}{.5} = 15$ volts -2w

   2D: less than 6V
   2E: when $V_{cap} = 6V$
   2F: $|Q+| = |Q-|$ (always)
   G: $3C/6V = 0.5\ F$
   H: 10 volts
   I: $5C/10V = 0.5\ F$

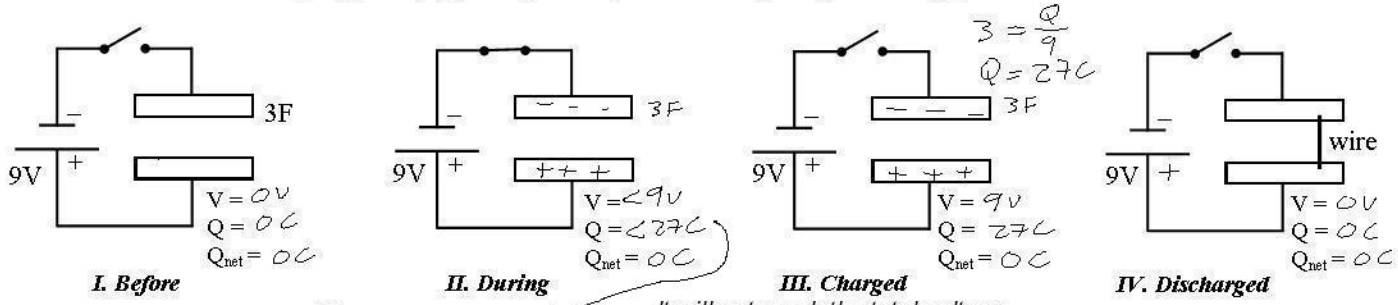
3. On another day you find a different parallel plate capacitor, but you don't have your voltage/charge meter. Instead you have a micrometer (reads very small distances) and a ruler.
   A. You measure one side of one of the square plates at 25 cm. What is the area of the plate? $(.25)^2 = .0625\ m^2$ -2w
   B. The micrometer reads 12 μm between the plates. What will you use for d? $12 \times 10^{-6} m$
   C. Now that you have measured the physical dimensions of the capacitor, what is its capacitance? $C = \varepsilon_0 \frac{A}{d} = 8.85 \times 10^{-12} \frac{(.0625)}{12 \times 10^{-6}} = 4.61 \times 10^{-8}\ F$ -2w
   D. If the distance between the plates of the capacitor was half as much, what is its new capacitance? $\times 2 = 9.22 \times 10^{-8}\ F$ (C doubled) -2w
   E. By halving the plate distance you doubled the capacitance.

   A. $A = \ell \times w = (.25)^2 = .0625 m^2$
   B. 12×10^{-6} m
   C. $C = \varepsilon_0 \frac{A}{d} = \varepsilon_0 \frac{.0625}{12 \times 10^{-6}}$
   $C = 4.61 \times 10^{-8} F$

OK—now you should see the difference between the two equations.

4. A 9 V battery is hooked up to a 1 F capacitor.
   A. How much charge can it hold? $1 \frac{C}{V}\ 9V = 9\ C$ -2w
   B. How much charge can a 2 F capacitor hold for the same potential (voltage)? 18 C
   C. So, a bigger capacitor can hold more charge for the same voltage.

5. A. On the diagrams below draw what occurs on the capacitor plates. Be correct as for which plate is positive.
   B. For each of the stages, give V, Q, and Qnet. If you can't completely calculate, give < or >.



use $C = Q/V$ for total: $Q = 9V(3F) = 27C$

It will not reach the total voltage until it is completely charged.

6. A neutral 3 pF (pico farad) capacitor (pico = $\times 10^{-12}$) is placed in a circuit, but the switch is not closed.

   A. What is the charge on one of the plates beforehand? 0 C

   A 12 V battery is then connected and charges the capacitor.

   B. What is the total charge on the capacitor when it is fully charged? 0 C → sorry or → B. 36pC

   C. What is the final voltage across the capacitor? 12V $C = \frac{Q}{V}$

   D. What charge will be gained by the positive plate? 3.6×10^{-11} C $Q = CV$ $(3 \times 10^{-12})(12) = 3.6 \times 10^{-11}$ C

   E. What charge will be gained by the negative plate? -3.6×10^{-11} C D. 3.6E−11C

   F. How much potential energy is stored? $\frac{1}{2}(Q)(12) = 2.16 \times 10^{-10}$ J

   G. If the voltage were doubled, how much charge could it hold? twice $= 7.2 \times 10^{-11}$ C

   H. How would the capacitance change if the voltage were doubled? won't

   I. When the capacitor is discharged, what happens (talk + and − charges and voltage).
   negs go back to + plate. each plate is neutral. V = 0 volts

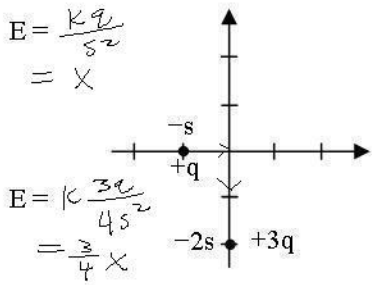
$C = Q/V$ $PE = \frac{1}{2}QV$

7. Solve the capacitance equation for Q. $Q = CV$
8. Write the PE for a capacitor without Q in it. $PE = \frac{1}{2}CV^2$
9. Solve the capacitance equation for V. $V = Q/C$
10. Write the PE for a capacitor without V in it. $PE = \frac{1}{2}Q^2/C$
11. A 3F capacitor is charged to 2 V. Calculate the potential energy stored.
    $PE = \frac{1}{2}(3)(2)^2 = 6$ J −2w

7. C = Q/V so Q = CV
8. PE = ½CV(V) = ½CV²
9. V = Q/C
10. PE = ½Q²/C
11. Use one of the above equations.

12. A 6F capacitor has 15C of charge on one plate. Calculate its potential energy.
    $\frac{1}{2}\frac{(15)^2}{6} = 18.75$ J −2w

13. Two charges are placed near the origin, as shown.



   A. Write an expression for each of the individual electric fields.
   see diagram

   B. Write an expression for the Enet at the origin.
   $\sqrt{X^2 + \frac{9X^2}{16}} = \sqrt{\frac{16X^2}{16} + \frac{9X^2}{16}} = \sqrt{\frac{25}{16}X^2}$ 1st Q
   pyth. th.
   $= 5X/4 = \frac{5}{4}\frac{kq}{s^2}$ N/C

   C. A 3rd charge of −q is placed at the origin. What force does it feel?
   E is $\frac{N}{C}(C) = N$ so $F = qE = q\left(\frac{5}{4}\right)\frac{kq}{s^2} = \frac{5}{4}\frac{kq^2}{s^2}$ N

   D. Toward what quadrant would it move?
   3rd Q (opp. electric field)