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**PHYS 1220-02 Group Work Sheet**  
**Capacitance**

Permittivity of free space  $\epsilon_0$   $8.854 \times 10^{-12} \text{ C}^2/(\text{N} \cdot \text{m}^2)$

1. We will use the ideal field of a hypothetical infinite plane of charge to develop our understanding of capacitance.
  - a. What is the magnitude and direction of the electric field around an infinite plane bearing an area charge density (coulombs per square meter) of  $+\sigma$ ?
  - b. What is the magnitude and direction of the electric field around an infinite plane of bearing an area charge density of  $-\sigma$ ?
  - c. Two infinite charged planes are parallel to each other. One has an area charge density of  $+\sigma$ , while the other has an area charge density of  $-\sigma$ .
    - i. What is the magnitude and direction of the electric field between the planes?
    - ii. What is the magnitude and direction of the electric field beyond the positive plane?
    - iii. What is the magnitude and direction of the electric field beyond the negative plane?
2. Two planar, parallel conducting sheets of area  $A$  face each other, separated by a small distance  $d$ . One bears charge  $+Q$  and the other bears charge  $-Q$ .
  - a. What are the surface charge densities of the two plates?
  - b. What is the magnitude of the electric field between the plates, in terms of the given quantities  $A$ ,  $d$ , and  $Q$  and any necessary constants?
  - c. What is the electric potential difference  $V$  between the plates, in terms of the given quantities  $A$ ,  $d$ , and  $Q$  and any necessary constants?

- d. Derive a formula for the charge magnitude  $Q$  in terms of voltage  $V$ .
  
  - e. What type of mathematical function is  $Q(V)$ ?
3. A capacitor with capacitance  $C$  is charged to an initial voltage  $V$ .
- a. How much work  $dW$  would it take to transfer a small increment of charge  $+dq$  from the negative plate of the capacitor to the positive plate?
  
  - b. By what amount  $\Delta V$  would the voltage of the capacitor change if a substantial increment of charge  $+\Delta Q$  is transferred from the negative plate to the positive plate?
4. A capacitor with capacitance  $C$  is initially uncharged, with both plates at the same potential. How much work would it take to transfer a substantial increment of charge  $+Q$  from one plate to the other?

5. Two different capacitors, one with capacitance  $C_1$  and the other with capacitance  $C_2$ , are charged to the same voltage  $V$ .
  - a. What is the charge on each individual capacitor?
  
  - b. What is the total charge on the two capacitors?
  
  - c. What is the energy stored in each individual capacitor?
  
  - d. What is the total energy stored in the two capacitors?
  
6. Two different capacitors, one with capacitance  $C_1$  and the other with capacitance  $C_2$ , are given the same charge  $Q$ .
  - a. What is the voltage of each individual capacitor?
  
  - b. What is the total voltage of the two capacitors?
  
  - c. What is the energy stored in each individual capacitor?
  
  - d. What is the total energy stored in the two capacitors?

