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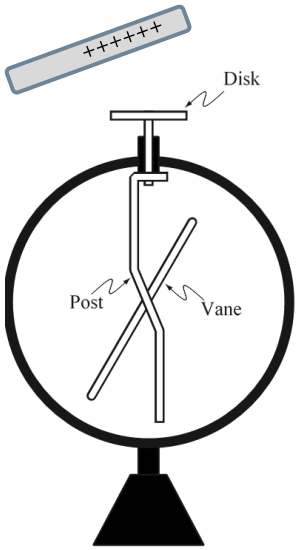
I. Multiple choice [5 pts each]: choose the most correct answer.

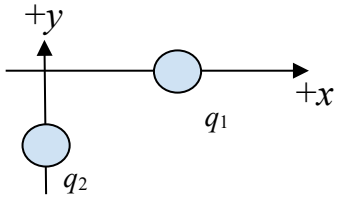


1. An electroscope is initially uncharged, when a positively charged rod is brought near the upper disk *but does not touch it.* Describe the charge distribution within the electroscope.
   a) The electroscope is neutral everywhere
   b) The electroscope is neutral, but with negative charges on the disk and positive charges on the post and vane.
   c) The electroscope is negative everywhere
   d) The electroscope is positive everywhere
   e) The disk and post are negative and the vane is positive

2. If the electric force is so much stronger than the gravitational force, why does gravitation dominate on the scale of the solar system and beyond?
   a) The electric force is a short range force
   b) Matter in bulk is neutral
   c) The electric force doesn't act on most objects
   d) The speed of the particles affects the electric force
   e) None of these

3. A point charge of $q_1 = +3.0$ nC and another point charge q of unknown charge are separated by a distance of 3.2 mm. If the force between them is found to be of a magnitude 3.6 N what is the unknown charge?
   a) -1.27×10^{-4} C
   b) -4.27×10^{-4} C
   c) $+1.27 \times 10^{-4}$ C
   d) $+4.27 \times 10^{-4}$ C
   e) Not enough information

4. A charge $q_1 = +2.0\ \mu$C is a distance of +3.0 mm from the origin on the x-axis. Another charge $q_2 = +3.0\ \mu$C is a distance of -2.0 mm from the origin along the y-axis. A third charge $Q = -1.5$ nC is at the origin. What is the magnitude of the force on Q from the other charges?
   a) 10.6 N
   b) 3.6 N
   c) 3.6×10^{-3} N
   d) 1.8×10^{-3} N
   e) None of these



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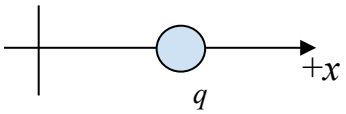
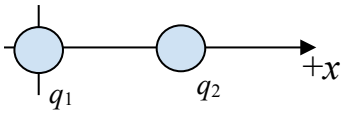
5. A point charge q = -3.5 μC is at x = 4.0 mm. What is the electric field from this charge at x = 3.6 mm?



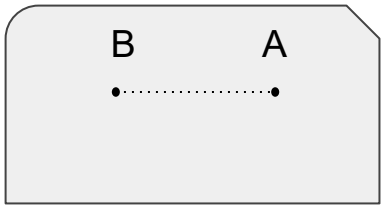
a) 0 N/C
b) 1.97 x10^{11} N/C to the right
c) 1.97 x10^{11} N/C to the left
d) 3.97 x10^{11} N/C to the right
e) 3.97 x10^{11} N/C to the left

6. Charge q_1 =+5 C is at the origin and charge q_2 = -3 C is at x =1.5 mm. In what regions is it possible for the electric field to equal zero?



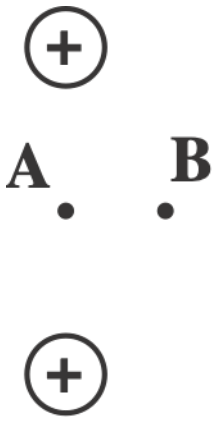
a) 0 < x < 1.5 mm only
b) x < 0 only
c) x > 1.5 mm only
d) x > 1.5 mm and x < 0
e) None of these

7. The conductor below is placed in a uniform electric field of 3.5 N/C to the right, and sits for a time. The potential at point A inside the conductor is then measured to be 3.0 V. What is the potential at point B if the separation distance is 2.0 m between them?



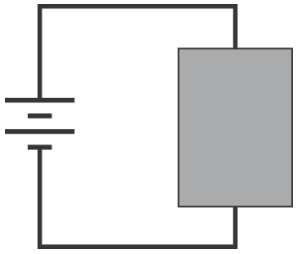
a. V_B =10 V
b. V_B = -4.0 V
c. V_B = 0 V
d. V_B = 3 V
e. None of these

8. Two positive charges +Q are oriented as shown at right. Which statement accurately describes the potential and electric field?

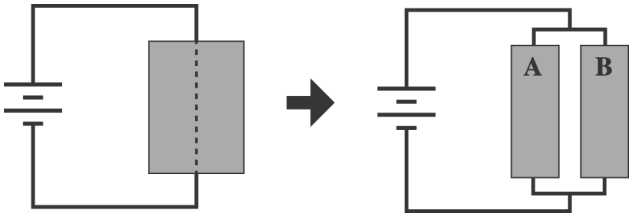


a) The potential at A is greater than the potential at B; so the electric field at A is greater than the electric field at B.
b) Both the electric field and potential are both greater at point B than point A.
c) The potential at A is greater than the potential at B; but the electric field at B is greater than the electric field at A.
d) The electric field and potential is zero at point A.

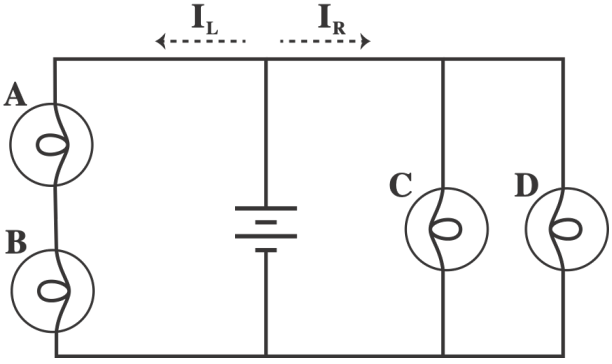
9. The circuit on the right contains a 10 V battery and a 5 Ω resistor. What is the current?
   a) 2 Amps in the clockwise direction
   b) 2 Amps in the counter-clockwise direction
   c) 0.5 Amp in the clockwise direction
   d) 2.5 Amps in the counter-clockwise direction



10. The resistor in the previous question is now carefully sliced in two length-wise (as shown below) to make two resistors that have the original length but half the width. What is the current in the resistors?
    a) 1 Amp in each resistor
    b) 2 Amps in each resistor
    c) 4 Amps in each resistor
    d) 2 Amps in resistor A and zero current in resistor B
    e) It depends on the shape of the resistor, so not enough information is given



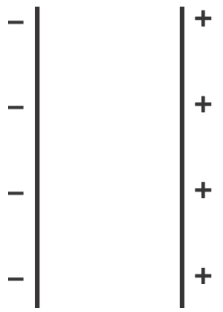
11. In the circuit below the current from the battery splits and travels into the left and right arms of the circuit (I_L & I_R). Describe the currents and relative brightness (power) of the four identical lightbulbs in this circuit.
    a) The current in the left branch is 1/4 the current in the right branch. C & D are the same brightness and 4 times as bright as A & B.
    b) The current in the left branch is equal to the current in the right branch, so A & B are the same brightness and twice as bright as C & D.
    c) The current in the right branch is twice the current in the left branch, so all the bulbs are the same brightness.
    d) There is not enough information given to determine the currents and relative brightnesses.



II. [25 pts] Free response problems 12-16: Show work or explain reasoning for full credit.

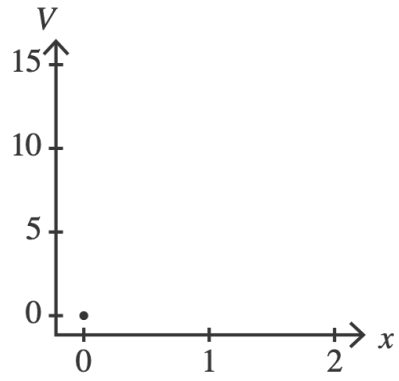
Two square parallel plates are oppositely charged as shown below. Each plate is 1.0 cm x 1.0 cm; the separation is initially 1.0 mm; and the charge on each plate is $\pm 8.85 \times 10^{-11}$ C.

12. [5 pts] Calculate the magnitude of the Electric field inside the capacitor, and draw the Electric Field Lines on the capacitor diagram.

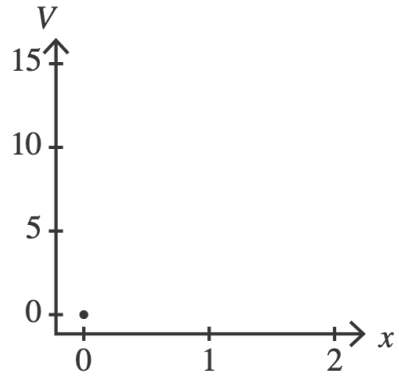


13. [5 pts] Calculate the potential difference ΔV across the capacitor.

14. [5 pts] If we define the left-hand plate to be at zero voltage and at zero position x (as shown by the dot), draw the voltage vs. position graph (ΔV vs. x in mm) within the capacitor on the axes provided.



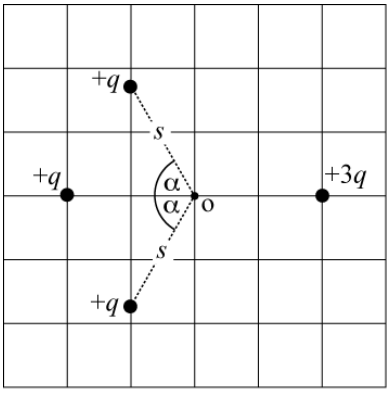
15. [5 pts] Keeping the charge on each plate constant, the plates are now pulled apart so they are separated by 1.5 mm. Draw the voltage vs. position graph (ΔV vs. x in mm) within the capacitor on the axes provided.



16. [5 pts] Did the energy stored in the capacitor increase or decrease as the plates were moved apart? Calculate the ratio of final to initial stored energy.

III. [20 pts] Tutorial Free Response problems 17-20. Show work or explain reasoning where indicated.

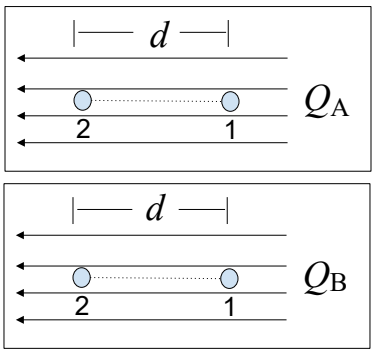
Four charges, one with charge +3q and the others with charge +q, are fixed a distance s away from the origin, o, as shown at right. The top and bottom charges each make an angle ***a*** with the horizontal x-axis.



17. [5 pts] A positive point charge, $+q_o$ is now placed at the origin, o. On the diagram, indicate the direction of the net force on the test charge $+q_o$. Explain.

The next two questions are based on the situation below:

Two particles with the ***same*** positive charge, Q_A and Q_B are released from rest at point 1 in separate uniform electric fields that point in the negative x-direction. There is no interaction between the two charges. Both charges move through a distance d to the left. (Ignore any gravitational forces.)



18. [5 pts] Is the value of $V_2 - V_1$ positive, negative, or zero? Explain.

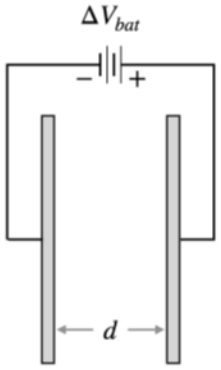
It is known that the mass of Q_A is twice as large as the mass of Q_B. When both charges have moved from point 1 to point 2, the speed of Q_A is measured to be ½ the speed of Q_B.

19. [5 pts] Is the magnitude of the electric field strength in which particle A is present *greater than, less than,* or *equal to* magnitude of the electric field strength in which particle B is present? Explain.

Consider the following two cases in which a battery is connected to a parallel plate capacitor and then disconnected:

In Case 1, a 5 V battery is used.

In Case 2, a 10 V battery is used.



It is found that the charge stored on the two capacitors is the same.

20. [5 pts] In what way could the capacitors differ? Assume all characteristics of the capacitors other than the changes described are the same.

    A. The capacitor in Case 2 could have half the distance between the plates.

    B. The capacitor in Case 2 could have half the area of the plates.

    C. The capacitor in Case 2 could have half the distance **and** half the area.

    D. It is not possible for the two capacitors to store the same charge.

Explain your answer for full credit: