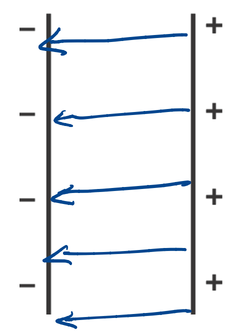
PHYS 115 Exam 1
Autumn 2024

1. b
2. b
3. e
4. a
5. b
6. c
7. d
8. c
9. a
10. a
11. a

II. Free response problems 12-16: Show work or explain reasoning for full credit.
Two square parallel plates are oppositely charged as shown to the right. Each plate is 1.0 cm x 1.0 cm; the separation is initially 1.0 mm; and the charge on each plate is $\pm 8.85 \times 10^{\cancel{-11}\,-12}$ C.

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



2 pts setup equations that can get ans. for example $E = \frac{Q}{\epsilon_0 A}$

1 pt ans. N/C

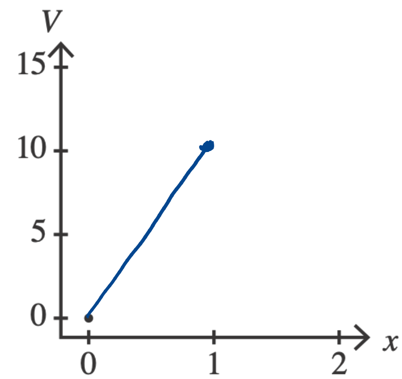
2 pts Electric field lines from pos to neg, parallel, evenly spaced.

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

3 pts for equations that can get answer e.g. $E = \frac{\Delta V_c}{d}$

2 pts ans 10V

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.

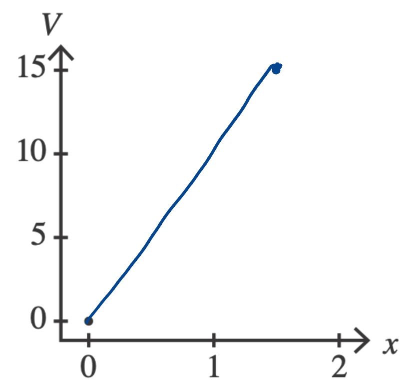


Linear btwn zero and voltage calculated in question 13, at 1 mm.

3pts linear to correct values

2pts spanning 0-1 mm

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.



Same slope as in prev. question

Linear from 0-1.5 mm

Ending at 15 V

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.

$U = \frac{1}{2}C(\Delta V)^2$; $C = \frac{Q}{\Delta V}$; $U = \frac{1}{2}Q\Delta V$; Q is constant

so energy stored increases by 1.5x

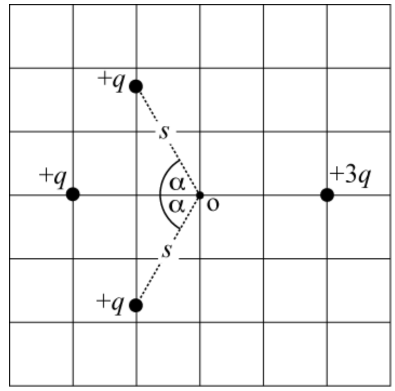
3pts setting up equations/calc. that could get answer; 2pts ans.

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

Print UW Net ID____@uw.edu

I. [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 α with the horizontal x-axis.



1. [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.

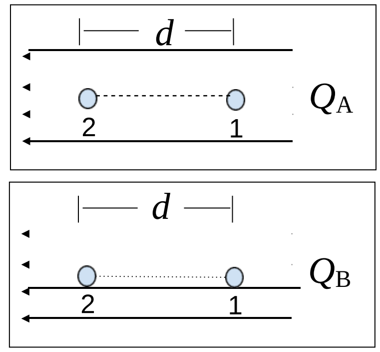
Answer: The net force is to the left.

Each +q point charge would exert a repulsive force of magnitude $F_o = kq^2/s^2$ on the +q at the origin. The force by the center +q charge is entirely to the right. The forces by the upper and lower +q charges have x and y components, each of which is less than F_o. The y-components of the forces cancel. The x-components add but is smaller than three times the force by the +q.

The magnitude of the force by the +3q charge would be equal to $3F_0$, since the +3q charge is three times larger than the +q charges and the same distance to the origin. The leftward force on the $+q_o$ charge at the origin is larger in magnitude than the rightward force. The net force on the point charge at the origin is therefore to the left.

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.)



2. [5 pts] Is the value of $V_2 - V_1$ positive, negative, or zero? Explain.

Negative:

Explanation: When released from rest, a positive point charge moves from high potential to low so $V_1 < V_2$ and $V_2 - V_1 < 0$.

or

Consider the system of all charges. Then there is no work done on the system and $W = \Delta E = \Delta K + \Delta U$. The charge moves the left and speeds up so $\Delta K > 0$ so $\Delta U < 0$.

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.

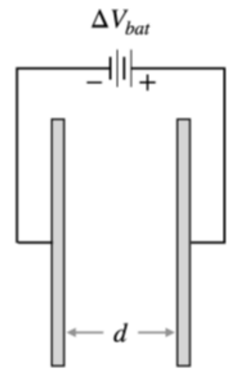
3. [5 pts] Is the magnitude of the electric field strength in which particle A is present *greater than*, *less than*, or *equal to* magnitude of the electric field strength in which particle B is present? Explain.

Answer: $E_A < E_B$

Explanation: When released from rest, a positive point charge gains energy equal to $\Delta U = q\,\Delta V = q\,Ed$. This equals the change in kinetic energy $-\Delta U = \Delta K = 1/2\, mv^2$ since the initial speed is zero.

As $qEd = 1/2\, mv^2$, doubling the mass alone would reduce the speed by $1/\sqrt{2}$. In order to reduce by more the electric field would need to be reduced by ½ as well.

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.

4. [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:

Answer: B

We know that $|\Delta V| = Qd/e_o A$. If Q remains the same but ΔV increases by a factor of 2 then d/A has to increase by a factor of 2. That can happen if d remains the same but A decreases by a factor of 2.