Online laboratory assignment 1 – Coulomb's law

Purpose: to study the attractive and repulsive force between electric charges.

Introduction

Coulomb's Law describes the magnitude of the electrostatic force that exists between two charged particles (a and b)

$$|\vec{F}_{ab}| = k\frac{|q_a q_b|}{r^2}$$

where $\vec{F}_{ab}$ is the force exerted by particle a on particle b. The charges are q_a and q_b, and the distance between the two charges is r. The Coulomb constant can also be written in terms of the electric permittivity,

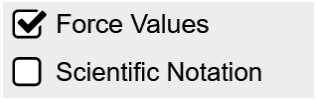
$$k = \frac{1}{4\pi\epsilon_0}$$

When the two charges are alike (both positive or both negative), then the force is repulsive and directed away. When the two charges are opposite (one positive and one negative), then the force is attractive and directed towards each other. This lab looks at the dependence of the Coulomb force on charges and separation distance. It uses these dependencies to determine the electric permittivity, ϵ_0.

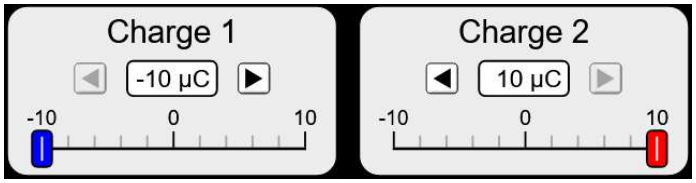
Laboratory assignment

Part 1: Direction of the force vector

1. Run the "Coulomb's law" PhET simulation.
2. Select the "Macro scale" option.
3. Make sure that the "Force values" box is checked and the "Scientific notation" box is uncheck.



4. Set the left charge (q_1) to −10 μC and the right charge (q_2) to 10 μC.



5. Based on the direction of the arrows above the charges, is the force attractive or repulsive?

_____.

6. Set both charges to be −10 μC.
7. Based on the direction of the arrows above the charges, is the force attractive or repulsive?

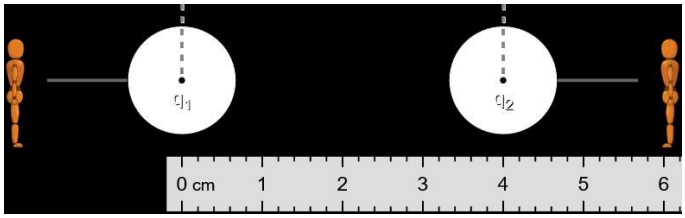
_____.

8. Set both charges to be 10 μC.
9. Based on the direction of the arrows above the charges, is the force attractive or repulsive?

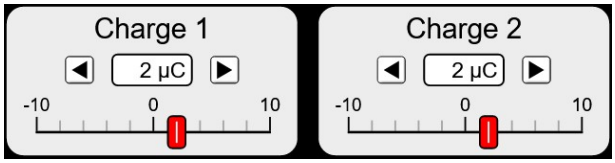
_____.

Part 2: Electric force's dependence on the magnitude of a charge

10. Drag the left person so that the left spherical charge is centered at 0 cm, and drag the right person so that the right spherical charge is centered at 4 cm.



11. Change both charges (q_1 and q_2) to be 2 μC.

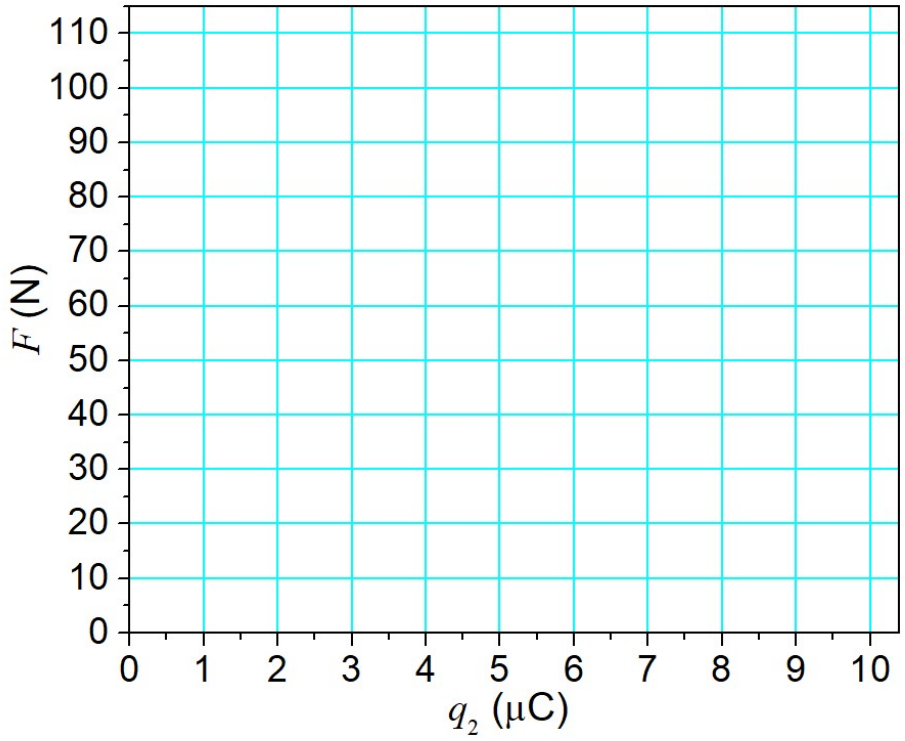


12. Write down the displayed force magnitude in Table I.
13. Change the value of q_2 and write down the displayed force magnitudes to fill in the remainder of Table I.

Table I: Magnitude of electric force by varying one charge.

q_1 (μC)	2	2	2	2	2
q_2 (μC)	2	4	6	8	10
F (N)					

14. Plot the data from Table I in the below graph.

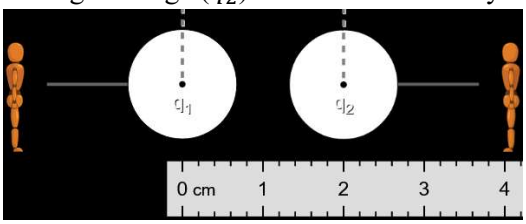


15. How does the electric force depend on one of the charges (linear, quadratic, inverse, inverse square, exponential, etc.)?

_____.

Part 3: Electric force's dependence on the distance of separation

16. Change the position of the right charge (q_2) so that it is now only 2 cm from the left charge (q_1).

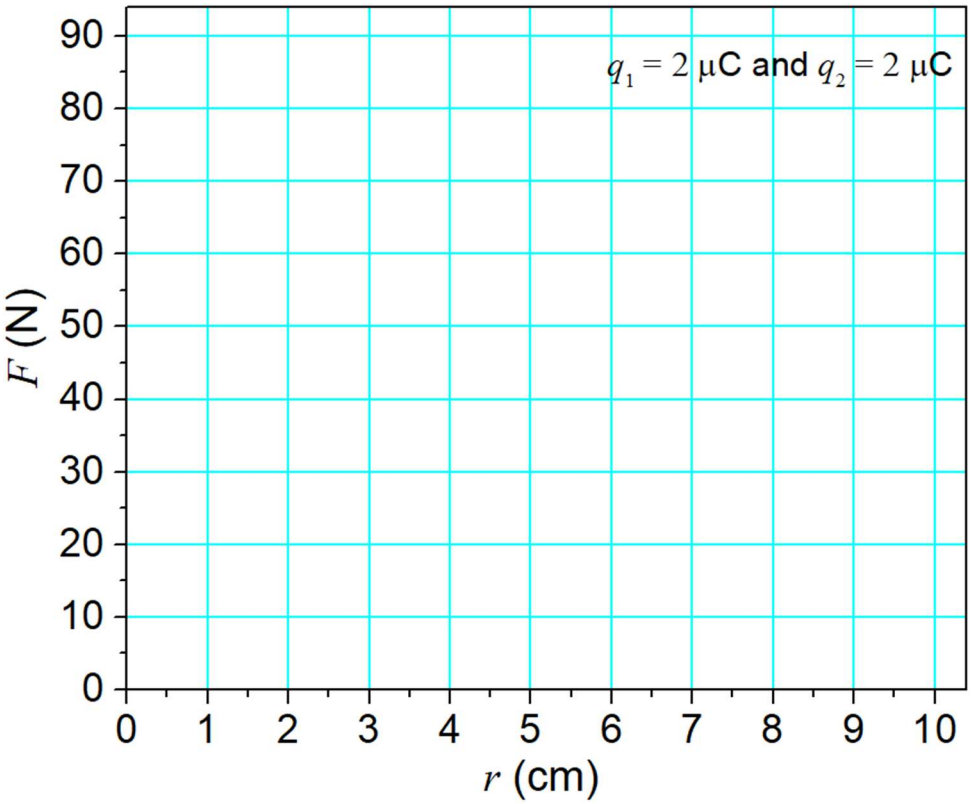


17. Set both charges to be 2 μC.
18. Write down the magnitude of the electric force in Table II.
19. Repeat the measurement for all other distances given for the measurements of the electric field in Table II.
20. Complete Table II by determining the percent differences between the measured and approximated values of the electric field magnitude.

Table II: Magnitude of force for varying separation distance r between charges $q_1 = q_2 = 2$ μC.

r (cm)	2	4	6	8	10
F (N)					

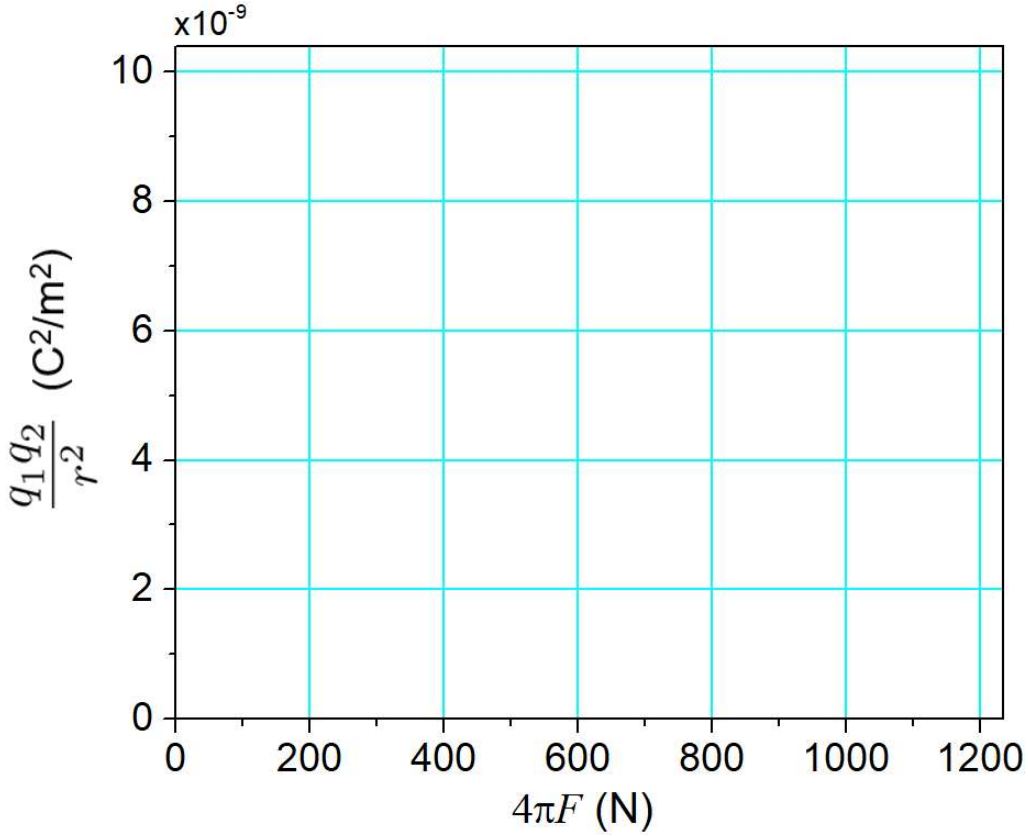
21. Plot the data from Table II in the below graph.



22. How does the electric force depend on the distance of separation between the charges (linear, quadratic, inverse, inverse square, exponential, etc.)?

_____.

23. Using the data from Table II calculate and plot the parameters in the below graph (use the SI units requested)



24. Determine the slope of the graph and use it to determine the electric permittivity of free space with uncertainty and the proper units.

$\epsilon_0 =$ _____ ± _____.

25. Calculate the % difference of the estimated value with respect to $8.854\times10^{-12}\ N^{-1}m^{-2}C^2$.

% diff = _____.

26. Write a conclusion to this laboratory assignment.

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