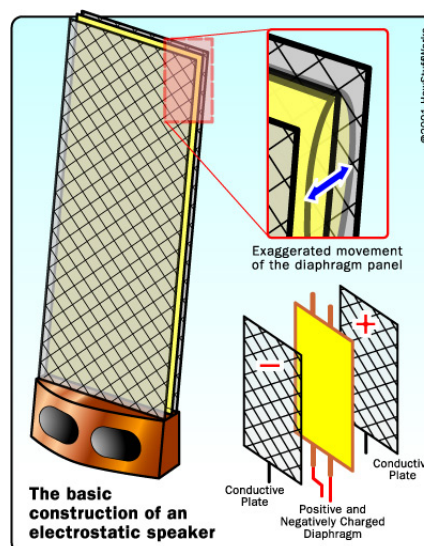


University of Calgary
Department of Physics and Astronomy
PHYS 259, Winter 2021

Lab 2: Electric Fields of Charge Configurations

The electric field is a rather abstract concept when you first learn about it, but it turns out to be a useful tool for situations where you are dealing with more than two point charges – that is, almost everything in real life. Instead of studying interactions between pairs of charges and adding them up (which can become quite cumbersome), you consider a property of space, generated by the source charge(s): the electric field. A technical application is the electrostatic speaker. While most loudspeakers produce sound with magnetic fields that cause a diaphragm to vibrate, these speakers use an electric field generated by oppositely charged grids, and a diaphragm that fluctuates in this field due to its time-varying charge. (Image from electronics.howstuffworks.com, where you can find more information)



Goals:

To understand how electric fields and forces are related, and how electric fields are represented graphically. To understand what the electric field of a distribution of point charges looks like by using superposition. To practice calculating the electric field of a distribution of point charges.

Preparation:

Halliday, Resnick, and Walker, “Fundamentals of Physics” 10th edition, Wiley: 22.1–22.3, and 22.6. Complete the pre-lab before coming to the lab.

Equipment:

Electric Fields from Point Charges applet

http://www.compadre.org/Physlets/electromagnetism/illustration23_2.cfm

Pre-Lab Assignment

In this pre-lab assignment, you will answer some preliminary questions related to the preparatory textbook reading (sections 22.1–22.3, and 22.6). There is no at-home experiment to do and no equipment needed to complete it. Part of the pre-lab assignment involves watching the introductory video posted to D2L before attending your lab section, but you should be able to answer the following questions without having first watched the video. This video will be available on D2L by the afternoon of Friday January 22.

Question 1: Consider a set of source charges that create a net electric field $\vec{E}$ at a particular location in space. If another point charge q is placed at this location, what is the electric force $\vec{F}$ that acts on this point charge?

The electric field is a vector and hence has a direction associated with it. Consider separately two isolated point charges: one is positive and one is negative.

Question 2: Does the electric field produced by the positive charge point toward or away from the charge? Explain this based on the force that a nearby positive test charge would experience.

Question 3: Does the electric field produced by the negative charge point toward or away from the charge? Explain this based on the force that a nearby positive test charge would experience.

Question 4: What is the principle of superposition and how is it used to find the net electric field of a distribution of point charges? If you need a refresher, the principle of superposition is discussed on page 615 of the textbook.

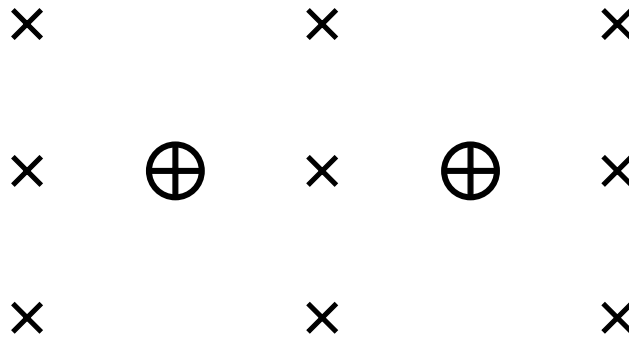
Question 5: The electric field of a distribution of charges is often represented pictorially by electric field lines. Can these electric field lines ever cross? Use the principle of superposition to justify your answer. You might find it useful to draw a diagram to help explain.

End of Pre-Lab Assignment

Submit your pre-lab assignment to the appropriate dropbox for your lab section on D2L by 5:00 PM **the day before your scheduled lab section**. Please see the instructions posted to D2L about submitting pre-lab assignments.

1 The Electric Field of a Configuration of Point Charges

Question 6: At each point indicated by an $\times$, draw the individual electric field vectors due to the two positive charges, labelling which is which. In a different colour, draw the **net** electric field vector at each point $\times$.



Open the following url: http://www.compadre.org/Physlets/electromagnetism/illustration23_2.cfm

Question 7: Set up the configuration of two positive charges shown below and sketch the electric field lines into the diagram provided. Are these field lines consistent with your prediction in Question 1?



Question 8: Now add another charge halfway between the two, as in the diagram below, and sketch the electric field lines.



Question 9: Now add two more charges into the two gaps, as in the diagram below, and sketch the electric field lines.



Question 10: What do you notice about the electric field above and below the line of charges as the number of charges increases?

Question 11: What would you expect the electric field to look like for a string of positive charges without any spacing? Sketch this in the diagram below and verify using the applet.



B:

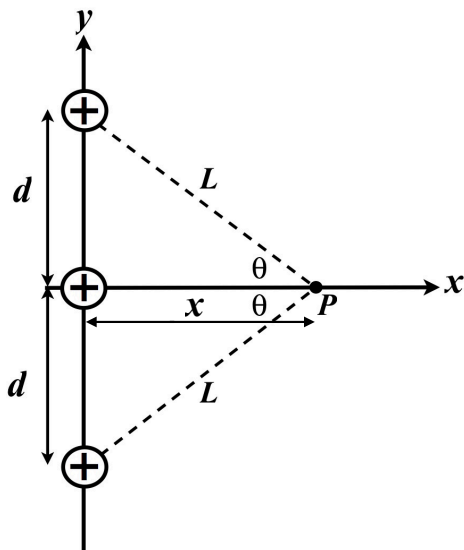
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CHECKPOINT 1: Before moving on to the next part, discuss your results as a group, then have your TA evaluate your answers.

2 Using Symmetry to Calculate Electric Fields

Question 12: The figure below shows three equal positive point charges q equally spaced on the y -axis. Calculate the electric field $\vec{E}(x)$ at the point P marked on the positive x -axis by following the steps below:



a) For each of the three charges, draw and label the corresponding individual electric field vectors at point P .

b) Make an argument based on the symmetry of the problem why some components cancel and others add. The ones that cancel we can simply ignore.

c) Write down expressions for $\sin \theta$ and $\cos \theta$ in terms of d and x .

d) For each of the three charges, write down the magnitude of the electric field it produces at point P in terms of q , x , d , and any relevant constants.

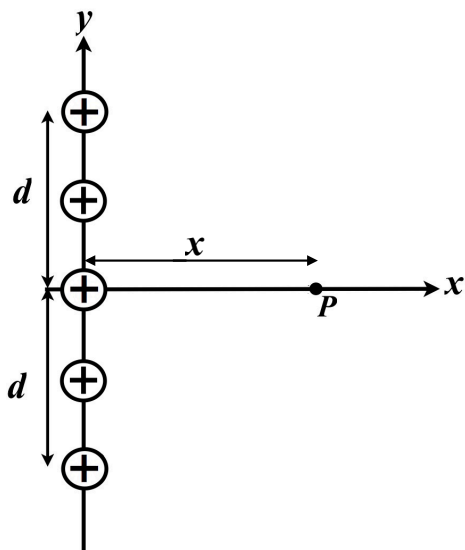
e) For each of the three charges, write down the x -component of the electric field it produces at point P in terms of q , x , d , and any relevant constants. Why don't you need to calculate the y -components?

f) Use these results to calculate the net electric field at point P . In what direction does it point?

g) If point P is very far away from the charges, what do you expect the electric field to be (in terms of q , x , d , and any relevant constants) and why? Use mathematical techniques to verify your prediction by considering $x \gg d$ in your answer to part (f).

h) If point P is very close to the middle charge, what do you expect the electric field to be (in terms of q , x , d , and any relevant constants) and why? Use mathematical techniques to verify your prediction by considering $x \ll d$ (but $x \neq 0$) in your result for part (f).

i) Write down what the electric field at point P is for the string of five identical equally-spaced charges q shown in the diagram below. Hint: you do need to do any additional calculations, but you should justify your answer.



B:

A:



Last Checkpoint! Before being dismissed from the lab, discuss your results as a group, then have your TA evaluate your answers.