Course and Section_______ Names ___________________________

Date___________________ ___________________________

ELECTRIC FIELD SIMULATION

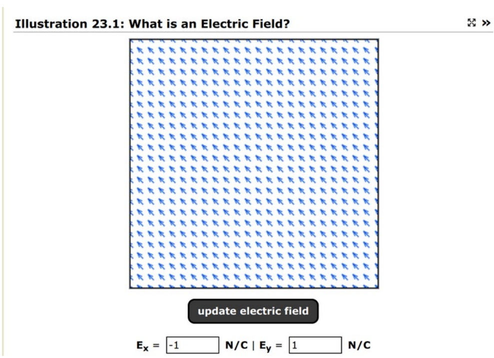
Introduction

In class you learned that all charged objects create an electric field. These fields are vector quantities, that is they contain both a direction and a magnitude. In this online simulation you will explore further the properties of electric fields, both the direction and magnitude.

Submit your answers using Blackboard.

1 – Vector proprieties of *E*

To gain some familiarity with the vector nature of electric fields open the simulation (https://www.compadre.org/Physlets/electromagnetism/illustration23_1.cfm)



This simulation will display an electric field in two dimensions. There are two input boxes where you can put a number, or more generally a function, to set the value of the x or y components of the electric field. Once you click the update electric field button the simulation will display the field. At anytime you can calculate the magnitude of the electric field as,

$$|E| = \sqrt{E_x^2 + E_y^2}$$

1. Set $E_x = -1$, $E_y = 0$ what direction does the field point?
2. Set $E_x = 0$, $E_y = -1$ what direction does the field point?
3. Set $E_x = -1$, $E_y = 1$ what direction does the field point? Answer in degree from the *x*-axis.
4. Let $E_x = 1$, $E_y = 2$ what is the magnitude of the electric field? (N/C)

Set $E_x = 0$, $E_y = -y$. What you see is not the electric field of a point charge.

5. Does the magnitude of this electric field change as you move up along the positive y axis?

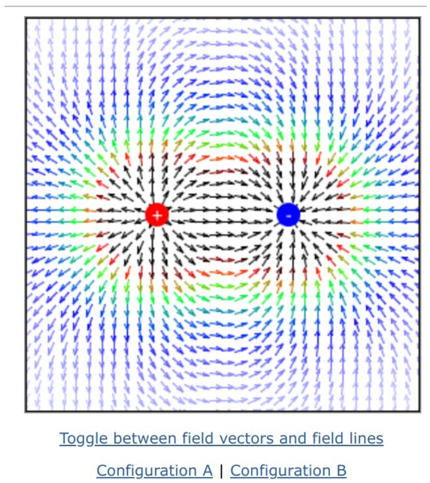
6. Is the sign of the charge distribution positive?

If the source has a opposite charge than in question 6, which would be the corresponding components of the electric field?
7. E_x =
8. E_y =

2 – Field/Line Representation of Vector Fields

In the previous problem we created a uniform electric field point in a certain direction. Now lets explore the fields created by point particles.

Open the simulation (https://www.compadre.org/physlets/electromagnetism/illustration23_3.cfm?) and select configuration *A*. In this configuration you can move around two charges so you can observe the changes in the electric field vectors.



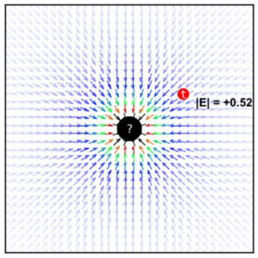
9. Can you move only one charge in such a way that none of the vectors changes?

Now change to configuration *B*.
10. Which of the charges are negative ?
11. Can you arrange the charges such that there is at least one point where the total electric field *E* is zero? (Do not place the charges directly on top of each other)

Click *toggle between field vectors and field lines* you should now see electric field lines instead of vectors.
12. Which charge has the smallest positive charge?
13. Which charge has the smallest negative charge? (i.e. the least negative)

3 – Find the Unknown Charge

The strength or magnitude of an electric field is determined by the amount of charges which generate that field. Open the simulation (https://www.compadre.org/physlets/electromagnetism/prob23_1.cfm?)



This simulation displays in the center an unknown charge distribution (it's not a point particle). The red dot can be clicked with the mouse and moved around. This dot represents a test charge. When the red dot is moved the simulation will display the magnitude of the electric field at the location of the test charge. When you click an hold on the red dot the bottom left hand corner will display a yellow box with coordinates for the location of the red dot given in cm. The value of the magnitude of the electric field is given in N/C.
The electric field in this situation can be written as,

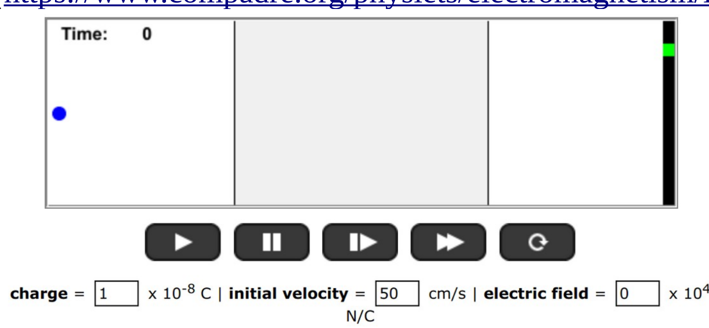
$$E = k\frac{q}{r^2}, \; r = \sqrt{(x^2 + y^2)}$$

where k is the Coulomb constant.
14. What is the value of the unknown charge distribution? (pC) p-pico 10^{-12}
15. What is the origin of this charge distribution?

The smallest unit of charge is the fundamental charge $e = 1.602 \times 10^{-19}$ C.
16. Calculate the number of fundamental charges that are needed to produce the observed field. Enter your answer in terms of millions of charges.

4 – Motion of a Charge in an Electric Field

Not only do charges create electric fields but they are also influenced by an external electric fields. In this simulation we will explore the effect an external electric field has on the motion of a charge.
Open the simulation (https://www.compadre.org/physlets/electromagnetism/illustration23_4.cfm?)



The simulation displays a region where a uniform electric field can be created. When the play button is pressed a charged particle will be released with a specified velocity. You have 3 boxes where you can change the charge on the particle, the initial velocity and the electric field strength.

Set the charge to 10^{-8} C, the initial velocity to v = 20 cm/s and E = 0 .
17. How does the charged particle move?

Set the electric field to $E = -1\times10^4$ N/C.
18. How does the charged particle move?
19. For what value of E will the charge hit the green dot on the right side of the screen? (kN/C)

Change the initial velocity to v = 35 cm/s
20. Does the charge still hit the green dot?
21. Set $E = -1\times10^4$ N/C and v = 35 cm/s fixed for what value of the charge will the charged particle hit the green dot? (nC) n-nano=10^{-9}

5 – Data Analysis: find the charge Q

Suppose we have a sphere of radius R sitting on your desk with an unknown amount of charge Q. The electric field outside the sphere at distances r from the center of the sphere is

$$E=k\frac{Q}{r^2} \qquad r>R$$

A device is use to take measurements of the electric. Suppose we take measurements of the electric field at different r as follow

E (N/C)	20448.3	10462.3	4520.31	3166.76	2215.24	1967.09	1553.89	1036.67	958.77
r (m)	1	1.5	2	2.5	3	3.5	4	4.5	5

Calculate $1/r^2$ for each of the given values of r

$1/r^2$ (m)									

Make a plot of E vs $1/r^2$

22. What is the value of the slope? (Nm^2/C)
23. Using the value of the slope, find Q (μC)
24. How many electrons (excess or deficit) would it take to create this amount of charge? (Answer in trillions)