Electric Field of a Point Charge

Objectives

Calculating and displaying the 3D electric field of one or more source charges at multiple observation locations is best done with a computer. The electric field is related to the electric force by

$$\vec{E} = \vec{F}_e/q = \frac{1}{4\pi\epsilon_0}\frac{q_1}{|\vec{r}|^2}\hat{r}. \tag{1}$$

Before doing this activity you should have completed activity VP01, Introduction to 3D Computational Modeling, and you should have studied part of Section 13.9 of the *Matter & Interactions 4e* textbook (p. 535 and the top of p. 536), which discusses how to calculate electric fields in 3D.

After completing this activity you should be able to:

- Write a VPython program to calculate the electric field of a point charge at a particular observation location
- Create and scale an `arrow` to represent the net electric field at a particular observation location

1 Electric Field of a Point Charge

Beginning with the shell script complete the following tasks.

⇒ A particle with charge +3 nC is located at the origin. Create a sphere at the appropriate location to represent the particle.

⇒ Consider an observation location $\langle 10, 0, 0\rangle$ nm. Create a green arrow to represent the vector $\vec{r}$ from source to observation location. You may need to adjust the radius of your sphere to make both objects visible. In calculating $\vec{r}$ make sure to use symbolic names such as "`mycharge.pos`"–don't retype numbers.

⇒ How far away is the observation location from the source charge? What is the magnitude of the the vector $\vec{r}$?

⇒ Write additional code to calculate the electric field at the observation location.

⇒ Create an orange arrow, with its tail at the observation location, to represent the electric field at that location. Set the axis of the arrow to the electric field times a scale factor. Try a scale factor of about 3e-16. If you need to review scale factors, watch the brief video at http://vpython.org/video05.html

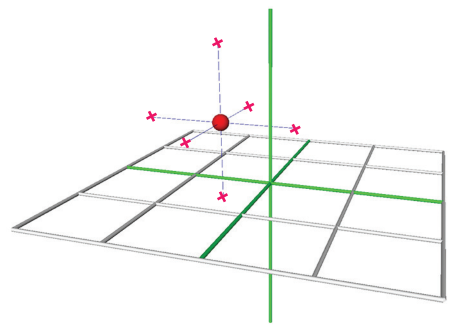
⇒ Check to make sure that the direction of the electric field is correct.

Show your work to the instructor before continuing.

2 Additional Observation Locations

It is possible to repeat this calculation at multiple observation locations simply by copying and pasting code. In the next part, we will learn a better way to do this. For now, unless you already know how to use lists in VPython, it's fine to copy and paste code to do the following:

⇒ Repeat the steps above, for 5 more observation locations. Each observation location should be 10 nm away from the source charge, in either the $\pm x$, $\pm y$, or $\pm z$ direction, as indicated by the red "x"s in the diagram below. Your program should display a green arrow representing the vector $\vec{r}$ to each location, and an orange arrow representing the electric field at that location.



Show your work to the instructor before continuing.

⇒ Without changing the observation locations, move the location of the source charge to $\langle 6, 0, 0\rangle$ nm. Do all of your arrows change appropriately?

⇒ Optional: Adjust the arrows by setting `shaftwidth` when you create each arrow so all green arrows and all orange arrows have the same size shafts. Consult the VPython help (accessible from the pulldown Help menu in VIDLE) for more information.

3 Part II: Many Observations on a Circle

Now lets consider observations of the electric field in a circle in the $x - y$ plane. Following the discussion on p. 537, lets recreate displays similar to Fig. 13.51 using a while loop.

⇒ Starting with the source charge at the origin, plot 12 arrows indicating the electric field at a radius of 10 nm

⇒ Move the source charge to $\langle -5, 0, 0\rangle$ nm, and replot.

Show your work to the instructor before continuing.

⇒ Send vpython scripts, with question answers embedded as comments, from all portions of this lab to me at pstancil@uga.edu.