1 Overview

This activity covers topics in Section 21.3-4 of Young and Freedman 2015, 14th Edition.

Electric Force

Coulomb's Law in compact form is

$$\mathbf{F}_{1 \text{ on } 2} = kq_1q_2\frac{\hat{\mathbf{r}}}{r^2}$$

where $\hat{\mathbf{r}}$ is the unit vector that points from the position of q_1 to q_2 and r is the distance between q_1 and q_2.

Electric Field

The electric field vector, $\mathbf{E}$ is a quantity that we assign to a point in space. Given this quantity, we can compute the force on a charge Q will experience if it is placed at that point in space using the equation $\mathbf{F} = Q\mathbf{E}$.

To find $\mathbf{E}$ at any point in space, compute the force $\mathbf{F}$ due to all other charges on a hypothetical (or "test") charge q_o at point where you want to know $\mathbf{E}$. To find $\mathbf{E}$ at that point, divide $\mathbf{F}$ by q_o.

$$\mathbf{E} = \frac{\mathbf{F}}{q_o}$$

2 Example

Charge q_1 is at $(x, y) = (-a, -a)$.

Find the electric field at $(x, y) = (a, a)$ in the form $\mathbf{E} = E_x \hat{\mathbf{x}} + E_y \hat{\mathbf{y}}$.

Solution

According to the perscription given, to find the electric field at a point in space, we put a hypothetical "test" charge q_o at that point, compute the force on it due to all other charges, and then use

$$\mathbf{E} = \frac{\mathbf{F}}{q_o}$$

The force a charge q_1 at $(x, y) = (-a, -a)$ exerts on a charge q_2 at $(x, y) = (a, a)$ was computed in a previous activity. We can use the answer after replacement of q_2 with q_o. The result is

$$\mathbf{F} = k \frac{q_1 q_o}{8a^2} \left[\frac{1}{\sqrt{2}} \hat{\mathbf{x}} + \frac{1}{\sqrt{2}} \hat{\mathbf{y}} \right]$$

The electric field is then

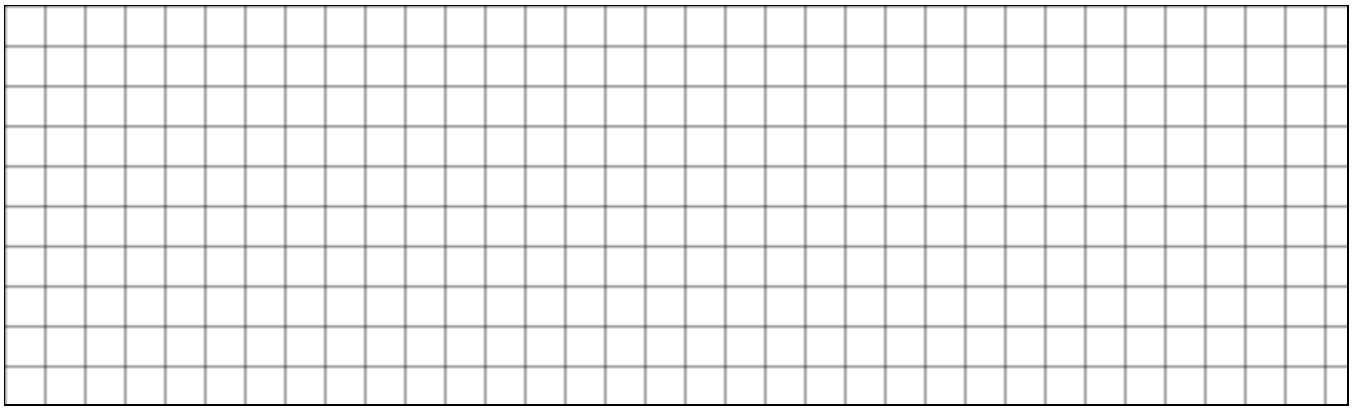
$$\mathbf{E} = \frac{\mathbf{F}}{q_o} = k \frac{q_1}{8a^2} \left[\frac{1}{\sqrt{2}} \hat{\mathbf{x}} + \frac{1}{\sqrt{2}} \hat{\mathbf{y}} \right]$$

3 Problem

In the previous example, there was only one charge responsible for creating the electric field $\mathbf{E}$. To find the electric field when there are more charges, superposition can be used.

Charge $q_1 = +q$ is at $(x, y) = (a, 0)$, charge $q_2 = +q$ is at $(x, y) = (-a, 0)$, and charge $q_3 = -q$ is at $(x, y) = (0, a)$. Assume that the quantity associated with q is positive.

1. Draw this charge configuration on the provided graph paper.



In the following,

2. Find the electric field at the origin due to q_1. Write your answer in the form $\mathbf{E}_1 = E_{x1}\hat{\mathbf{x}} + E_{y1}\hat{\mathbf{y}}$.

3. Find the electric field at the origin due to q_2. Write your answer in the form $\mathbf{E}_2 = E_{x2}\hat{\mathbf{x}} + E_{y2}\hat{\mathbf{y}}$.

4. Find the electric field at the origin due to q_3. Write your answer in the form $\mathbf{E}_3 = E_{x3}\hat{\mathbf{x}} + E_{y3}\hat{\mathbf{y}}$.

5. Find the electric field at the origin. Write your answer in the form $\mathbf{E} = E_x\hat{\mathbf{x}} + E_y\hat{\mathbf{y}}$.

6. Will your answers to 2.-5. change if the problem had asked for the electric field at a different position? If so, which answers?

7. Find the electric field at the origin if charge $q_1 = 2q$ (instead of q).