

# Superposition and Symmetry

## 1 Overview

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In previous activities, only one charge was responsible for creating the electric field. When there are more charges, superposition can be used to find the total electric field by summing  $\vec{\mathbf{E}}$  due to each charge. Superposition can also be used to find the total electric force on a charge due to two or more charges.

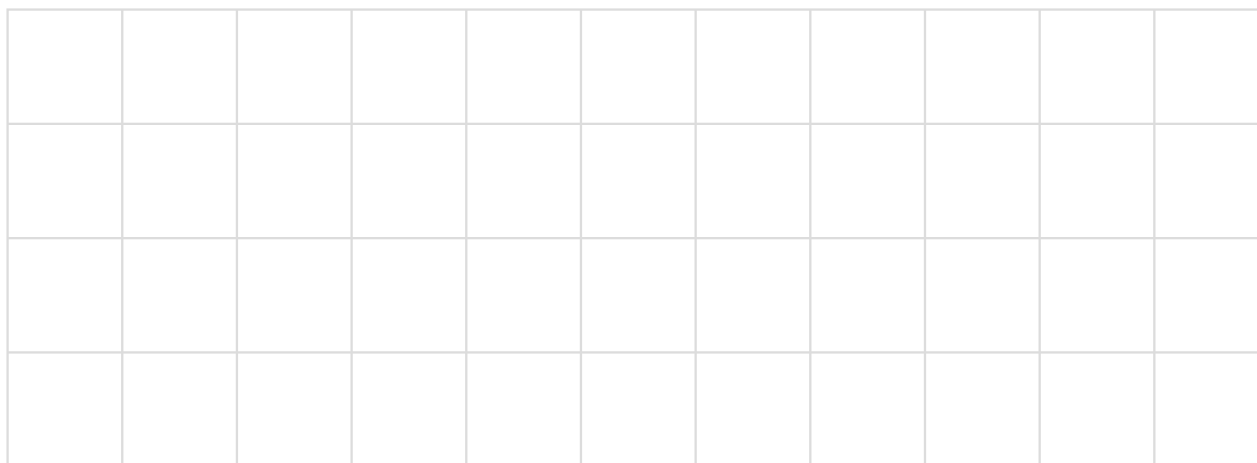
Superposition problems are often simplified by recognizing a symmetry. For example, if we want to know the electric field at the origin due to charges  $+q$  at  $(x, y) = (\pm a, 0)$ , we can state the answer is zero without computing the fields due to each charge – we know they will be equal and opposite.

## 2 Problem

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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  $q$  is a positive number.

1. Draw this charge configuration below.



2. Why does it not make sense to ask what the electric *force* is at the origin?

In the following,

3. Find the electric field at the origin due to  $q_1$ . Write your answer in the form  $\vec{\mathbf{E}}_1 = E_{x1}\hat{\mathbf{i}} + E_{y1}\hat{\mathbf{j}}$ .
4. Find the electric field at the origin due to  $q_2$ . Write your answer in the form  $\vec{\mathbf{E}}_2 = E_{x2}\hat{\mathbf{i}} + E_{y2}\hat{\mathbf{j}}$ .

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

6. Find the total electric field at the origin by adding  $\vec{\mathbf{E}}_1$ ,  $\vec{\mathbf{E}}_2$ , and  $\vec{\mathbf{E}}_3$ . Write your answer in the form  $\vec{\mathbf{E}} = E_x\hat{\mathbf{i}} + E_y\hat{\mathbf{j}}$ .

7. Will your answers to 3.–6. change if the problem had asked for the electric field at a different position? If so, which answers?

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

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