Electrostatic Field for Ring of Charge

Instructor Guide

Keywords: Upper-division, E and M, Electric Field, Symmetry, Ring

Brief overview of the activity

In this activity, students work in small groups to find the electric field everywhere in space due to a charged ring.

This activity brings together student understanding of:

1. Electric Field
2. Spherical and cylindrical coordinates
3. Superposition
4. Integration as "chopping and adding"
5. Understanding of which variables are variable and which are held constant during integration
6. Linear charge density
7. 3-dimensioinal geometric reasoning

Student prerequisite skills

This activity was designed to be used following the electrostatic potential - ring activity. If this activity is being used on its own, the instructor should look at the electric potential activity to understand the types of things students will encounter with this ring problem. Students will need understandings of:

1. The prerequisites addressed in the electrostatic potential - ring activity.
2. Which variables are variable and which are held constant during integration. `Link to helping students understand what is variable are what is held constant`.
3. Electric field

Props

- Hula hoop or other thin ring
- Balls to represent point charges
- Coordinate system (e.g. with straws or Tinkertoys)
- Poster-sized whiteboards
- markers
- whiteboards around room. `Link to room set-up`.

The activity - Allow 30 minutes.

Overview

Students should be assigned to work in groups of three and given the following instructions using the visual of a hula hoop or other large ring: "This is a ring with total charge Q and radius R. Find the electrical field due to this ring in all space." Students do their work collectively with markers on a poster-sized sheet of whiteboard at their tables. `Link to worked solution resulting in an elliptic integral`.

What the students will be challenged by and how to facilitate their learning

This description assumes students have already completed the `Electrostatic Potential - Ring` activity. This activity expands upon and reinforces the concepts from the previous activity. If students thoroughly understood parts of the previous activity, they may find this activity fairly easy. On the other hand, if they received a lot of help during the previous activity and had a weaker understanding, this will help them to understand those previous concepts. The instructor can help "tweak" and extend the understanding of the strongest students and can make sure the weaker students are truly understanding the essential concepts

1. Students will need to consider the vector nature of the field. The scalar field in the previous example of electrical potential requires different geometric arguments and different symmetry considerations than the electric field. Thinking about these differences helps students more clearly understand the differences between electrical potential and electric field. Prior to this activity, we had a lecture about the vector nature of electric fields that goes beyond the $V = \frac{kq}{r^2}$ from earlier courses. `Link to helping students understand electric field vectors`.
2. As in the previous activity, this activity also gives students the opportunity to use curvilinear coordinates and rectangular coordinates in combination to create an elliptic integral. For a description of the issues involved, see the electrostatic potential - ring activity, item 5 under "what students will be challenged by and how to facilitate their learning." For a worked solution to the electric field problem see the `link to the worked solution resulting in an elliptic integral`.

Debriefing, Whole-Class Discussion, Wrap-up and Follow-up

- Discuss-
- Maple-Link to Maple worksheet
- Suggested homework -