Student handout Write a formula for the electrostatic potential due to a point charge.

1 Instructor's Guide

1.1 Prerequisite Knowledge

Students will usually have seen the electrostatic potential due to a point charge in their introductory course, but may have trouble recalling it.

1.2 Whole-Class Conversations

As students try to remember the formula, many will conflate potential, potential energy, force, and electric field. Their answers may have some aspects of each of these. We use this question to get the iconic equation into the students' working memory in preparation for subsequent activities. This question also be used to help student disambiguate these different physical quantities.

1.2.1 Correct answers you're likely to see

$$V = \frac{kq}{r}$$

$$V = \frac{1}{4\pi\epsilon_0}\frac{q}{r}$$

You may want to discuss which constants to use in which contexts, e.g. k is short and easy to write, but may be conflated with other uses of k in a give problem whereas $\frac{1}{4\pi\epsilon_0}$ assumes you are working in a particular system of units.

1.2.2 Incorrect answers you're likely to see

- Two charges instead of one

$$\cancel{V = \frac{kq_1q_2}{r}}$$

- Distance squared in the denominator

$$\cancel{V = \frac{kq}{r^2}}$$

- Vector values

$$\cancel{V = \frac{kq\,\hat{r}}{r}}$$

Possible follow-up questions to help with the disambiguation:

- Which function is the derivative of the other: $1/r$ or $1/r^2$?

- Which physical quantity (potential or electric field, potential energy or force) is the derivative of the other?
- What is the electrostatic potential conceptually?
- Which function falls off faster: $1/r$ or $1/r^2$?
- What are the dimensions of potential? Units?
- Where is the zero of potential?

1.3 Wrap-up

- This could be a good time to refer to the (correct) expression for the potential as an *iconic equation*, which will need to be further interpreted (”unpacked”) in particular physical situations. This is where the course is going next.
- This SWBQ can also serve to help students learn about recall as a cognitive activity. While parts of the equations that students write may be incorrect, many other parts will be correct. Let the way in which you manage the class discussion model for the students how a professional goes about quickly disambiguating several different choices. And TELL the students that this is what you are doing. Deliberately invoke their metacognition.
- Many students may not know that the electrostatic potential that we are talking about in this activity is the same quantity as what a voltmeter reads, in principle, but not in practice. You may need to talk about how a voltmeter actually works, rather than idealizing it. It helps to have a voltmeter with leads as a prop. Students often want to know about the “ground” lead. We often tie a long string to it (to symbolize making a really long wire) and send the TA out of the room with the string, “headed off to infinity” while discussing the importance of setting the zero of potential. The extra minute or two of humerous byplay gives the importance of the zero of potential a chance to sink in.

We use this small whiteboard question as a transition between The Distance Formula (Star Trek) activity, where students are learning about how to describe (algebraically) the geometric distance between two points, and the Electrostatic Potential Due to a Pair of Charges (with Series) activity, where students are using these results and the superposition principle to find the electrostatic potential due to two point charges.

This activity is the initial activity in the sequence Visualizing Scalar Fields addressing the representations of scalar fields in the context of electrostatics.