Student handout

Each of you is a point charge.

1. Make a linear charge density.
2. How would you measure the value of the density?
3. Answer the same questions for surface and volume charge densities.

0.1 Introduction

Tell the students that they each represent a point charge. Do NOT specify that they are each the same charge unless they ask. Then initiate a conversation with the whole class by asking the prompts listed in "Student Conversations," below. Be flexible about the order of the prompts, responding to the ideas brought up by the students.

Note: It helps if the instructor stands on a chair or table so they are high enough to see all the students.

0.2 Student Conversations

1. Start with the prompt: "Make a constant linear charge density."
   - Students usually line up in a straight line. An excellent follow-up question is: "Does a linear charge density need to be arranged in a straight line?" Answer: "No, a linear charge density just means that the charges are distributed in one dimension, which may be along a curve."
   - A few students may interpret the word linear to mean that the number of charges in each interval is *increasing* linearly. This is an excellent opportunity to discuss the two different common uses of the term "linear" - as "one-dimensional" and as "$y = mx$". Specify that in this context, we are choosing the first definition.
2. A next question might be: "Make a non-uniform linear charge density?"
   - You can then discuss what "uniform" means. You may now need to specify that you intend for them to represent equal charges.
   - Discuss that if they represented masses instead of charges, then it might be more appropriate to have them represent unequal masses. (Avoid fat shaming!!) For number density, of course, all students are equal.
3. At some point, typically about now, the idea of idealization should come up. What do we mean by a continuous distribution of charges described by a charge density? Discuss how to approximate the charge density by holding up a 2 meter stick at various places along the curve the students have formed and count how many students fall into the 2 meter range. Introduce the symbol $\lambda(u)$ and discuss the dimensions of linear charge density.
4. The next question might be: "Make a surface charge density."

- Sometimes students will spread themselves around the room, sometimes they will line up two-by-two. You can ask the students whether their distribution needs to be flat and whether it needs to be uniform.
- Introduce the symbol $\sigma(x, y)$ and, if appropriate to the level of the class, introduce the symbol $\sigma(u, v)$ and lightly introduce the idea of parameterization.
- Discuss the meaning of surface charge density, i.e. the number of students that fit into a square meter. Demonstrate the geometry of a square meter with meter sticks surrounding the students and describe the dimensions of surface charge density.

5. The final question might be: "Make a volume charge density." Be alert, some students may want to jump up onto unsafe furniture.

0.3 Wrap-up

The instructor can wrap up by making an organized table of the notations used to describe the various types of charge densities (λ, σ, and ρ) and their dimensions. If there is time, get the students to help generate the table.