Homework No. 01B (Fall 2023)

PHYS 205B: UNIVERSITY PHYSICS

School of Physics and Applied Physics, Southern Illinois University–Carbondale

Due date: Tuesday, 2023 Sep 5, 9:30 AM, on D2L

Instructions

- You are encouraged to use any of the resources to complete this homework. However, the extent to which you depend on resources while doing homework is usually a measure of how much extra work you need to put in to master the associated concepts. Solutions should be the last resource.
- Describe your thought process in detail and organize it clearly. Make sure your answer has units and the right number of significant digits.
- After completion, scan the pages as a single PDF file, and submit the file on D2L (under Assessments → Assignments).

Problems

1. (**10 points.**) Draw the electric field lines for a configuration consisting of two positive charges with unequal charge on them.

   (a) The direction of the electric field at a point in space is determined by the tangent to the electric field line passing through the point. What characteristic of the field lines represents the magnitude of the electric field?

   (b) Can two electric field lines intersect?

   (c) For this configuration, there are how many points where the electric field is zero.

   Solution

2. (**10 points.**) Two charges, $q_1 = +1.00\,\mu\text{C}$ and $q_2 = -8.00\,\mu\text{C}$ are a distance D apart. Refer Figure 1. As a multiple of distance D, at what coordinate x on the line connecting the two charges is the total electric field zero?

   Solution

3. (**10 points.**) The electric dipole moment of a configuration consisting of two equal and opposite point charges, separated by a distance d, is defined to be

$$\vec{\mathbf{p}} = q\vec{\mathbf{d}}, \tag{1}$$

   where $\vec{\mathbf{d}}$ points from the negative to the positive charge and $d = |\vec{\mathbf{d}}|$. Let $d = 2a$. Given $q = 1.0\,\mu\text{C}$, $d = 2.00\,\text{cm}$, and $y = 5.00\,\text{cm}$.

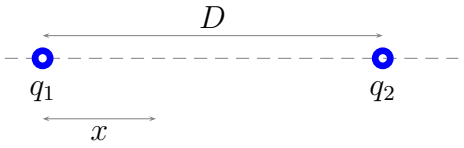

Figure 1: Problem 2

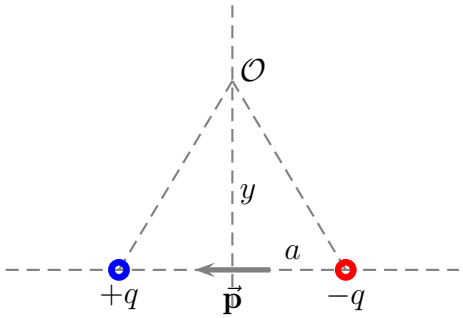

Figure 2: Problem 3

(a) Determine the magnitude and direction of the electric dipole.

(b) Determine magnitude and direction of the total electric field at $\mathcal{O}$ along a bisector of the electric dipole, a distance y away from the center of the dipole.

(c) Calculate the magnitude and direction of the force on a charge $Q = +7.0\,\mu\text{C}$ when placed at $\mathcal{O}$.

Solution

4. (**10 points.**) Watch the following YouTube video by Science Marshall

https://youtu.be/ysaUfsJyer0

on how a Cathode Ray Tube works.

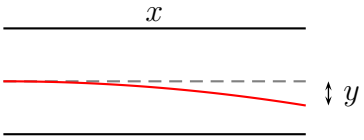

Figure 3: Deflection of an electron beam in a cathode ray tube.

The deflection plates of a cathode ray tube has an electric field of $1.0 \times 10^3\,\text{N/C}$. Let the electron beam be aligned parallel to the plates. The electrons enter the plates with a

speed of $4.0 \times 10^6\,\text{m/s}$. The horizontal distance of the plates is $x = 5.0\,\text{cm}$ and the beam gets deflected vertically by a distance y. Refer Figure 3.

(a) What is magnitude and direction of the acceleration experienced by an electron due to the electric field?

(b) How much time does an electron take to pass the distance x in the plates.

(c) Calculate the deflection y in centimeters.

Solution

5. (**10 points.**) An electron and a proton are each placed at rest in a uniform electric field. The particles accelerate to respective speeds v_e and v_p after being released simultaneously. Determine the ratio v_e/v_p. Which of them gains higher speed? Which of them has a higher kinetic energy?

   Solution

6. (**10 points.**) An electron and a proton are released from rest in a uniform electric field. The particles travel distances x_e and x_p in a time Δt. Determine the ratio x_e/x_p.

   Solution [Refer Problem 6.]

7. (**10 points.**) An electron and a proton are released from rest in a uniform electric field. The particles accelerate at a_e and a_p Determine the ratio a_e/a_p.

   Solution