

## Homework No. 02 (Fall 2024)

### PHYS 205B: UNIVERSITY PHYSICS

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

Due date: Tuesday, 2024 Sep 3, 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.
- Additional problems, with hyperlinks to exams, are available in [Lecture Notes](#).
- After completion, scan the pages as a single PDF file, and submit the file on D2L (under Assessments → Assignments).

### Problems

1. (**5 points.**) A positive charge  $q = +1.0 \text{ nC}$  is positioned on the  $y$  axis at  $y = +2.0 \text{ cm}$ . Determine the magnitude of the electric field due to this charge on the  $x$  axis at  $x = +2.0 \text{ cm}$ .

[\[Solution\]](#)

2. (**5 points.**) A positive charge is placed in the electric field described by the electric field lines in Figure 1. Where should it be placed so that it experiences the largest magnitude of force.

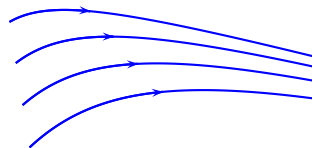


Figure 1: Problem 2

[\[Solution\]](#)

3. (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**

4. (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 2. As a multiple of distance  $D$ , at what coordinate  $x$  on the line connecting the two charges is the total electric field zero?

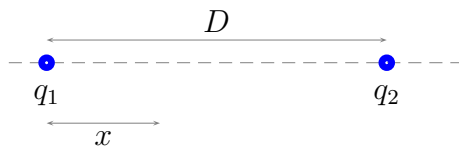


Figure 2: Problem 4

**Solution**

5. (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

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

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

- (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**

6. (10 points.) Four charges  $q_1 = +q$ ,  $q_2 = +q$ ,  $q_3 = -q$ , and  $q_4 = -q$ , are placed at the corners of a square of side  $L$ , such that  $q_1$  and  $q_4$  are at diagonally opposite corners. Refer Figure 4. Calculate the magnitude and direction of the total electric field at the center of the square.

[Solution]

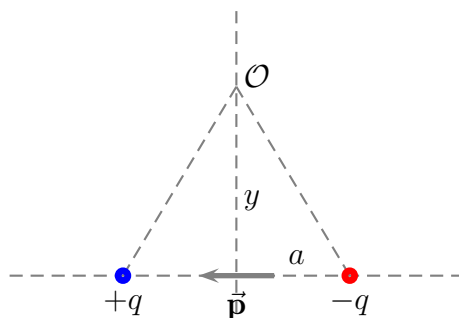


Figure 3: Problem 5

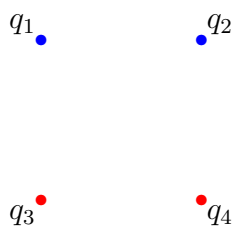


Figure 4: Problem 6

7. (10 points.) Watch the following YouTube video by Science Marshall

<https://youtu.be/ysaUfsJyer0>

on how a Cathode Ray Tube works. The deflection plates of a cathode ray tube has an

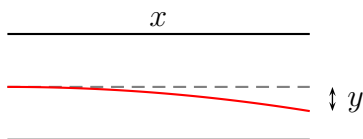


Figure 5: Deflection of an electron beam in a cathode ray tube.

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 5.

- What is magnitude and direction of the acceleration experienced by an electron due to the electric field?
- How much time does an electron take to pass the distance  $x$  in the plates.

(c) Calculate the deflection  $y$  in centimeters.

[Solution]

8. (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  $v_p$  in a time  $\Delta t$ . Determine the ratio  $v_e/v_p$ . Which of them gains higher speed? Which of them has a higher kinetic energy?

[Solution]