Homework No. 02 (Spring 2025)

PHYS 205B-002: UNIVERSITY PHYSICS

School of Physics and Applied Physics, Southern Illinois University–Carbondale
Due date: Tuesday, 2025 Jan 28, 4:00 PM, 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 this homework is a measure of how much extra work you need to put in to master the associated concepts. Solutions should be the last resource.

- Links to solutions are provided.

- Variations of homework problems and additional problems with hyperlinks to old exams are available in Lecture Notes. These serve as practice problems.

- Describe your thought process in detail and organize it clearly. Make sure your answer has units and right number of significant digits.

- After completion, scan the pages as a single PDF file, and submit the file on D2L (under Assesments → Assignments). You can replace your PDF file as many times as you like, only the last file is graded. The deadline has an (undisclosed) buffer period, so do not hesitate to try submissions after the deadline.

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.

   [**Solution**]

3. (**10 points.**) Draw the electric field lines for a configuration consisting of two positive charges with unequal charge on them.
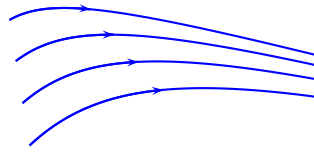
Figure 1: Problem 2

(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, $q_1 = +1.00\,\mu$C and $q_2 = -8.00\,\mu$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?
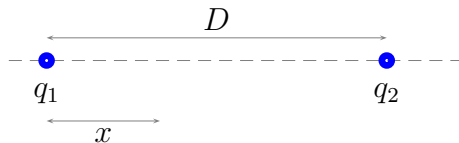

Figure 2: Problem 4

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

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

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

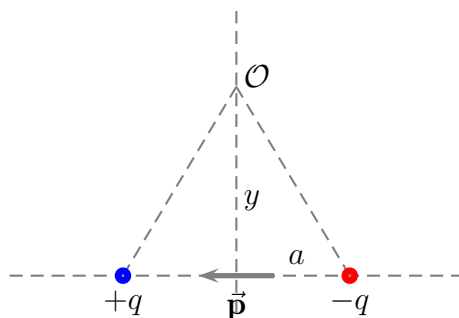(c) Calculate the magnitude and direction of the force on a charge $Q = +7.0\,\mu$C when placed at $\mathcal{O}$.

Figure 3: Problem 5

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.
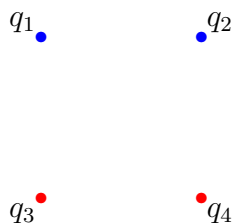

Figure 4: Problem 6

[**Solution**]

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 electric field of 1.0×10^3 N/C. Let the electron beam be aligned parallel to the plates. The electrons enter the plates with a speed of 4.0×10^6 m/s. The horizontal distance of the plates is $x = 5.0$ cm and the beam gets deflected vertically by a distance y. Refer Figure 5.

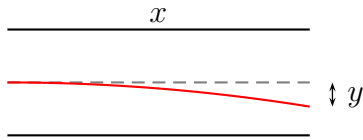(a) What is magnitude and direction of the acceleration experienced by an electron due to the electric field?

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

(b) 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 Δt. Determine the ratio v_e/v_p. Which of them gains higher speed? Which of them has a higher kinetic energy?

[**Solution**]