Midterm Exam No. 01 (Spring 2025)

PHYS 205B: UNIVERSITY PHYSICS

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

Date: 2025 Feb 6

(Name) (Signature)

Instructions

1. Seating direction: On even-numbered seats in alternate rows, B, D, F, ...
2. Total time = 75 minutes.
3. There are 4 short questions and 3 homework-style problems in this exam.
4. Equation sheet is provided separately.
5. To be considered for partial credit you need to present your work in detail and organize it clearly.
6. A simple calculator (with trigonometric functions) is allowed.
7. Use of smart devices, including smart watches, is strictly prohibited. They should stay out of reach during the exam.
8. Academic misconduct will lead to a failing grade in the course.

1. (**5 points.**) What is the magnitude and direction of the total electric force on an electric dipole when it is placed in a uniform electric field?

2. (**5 points.**) Two identical conducting spheres A and B carry equal charge. They are separated by a distance much larger than their diameters. A third identical conducting sphere C is uncharged. Sphere C is first touched to A, then to B, and finally removed. As a result, what is the electrostatic force between A and B, if it was originally F.

3. (**5 points.**) A positive charge $q = +1.0\,\text{nC}$ is positioned on the y axis at $y = +1.0\,\text{cm}$. Determine the magnitude of the electric field due to this charge on the x axis at $x = +2.0\,\text{cm}$.

4. (**5 points.**) Consider a configuration consisting of two charged concentric spherical shells of radius a and b with charges Q_a and Q_b, respectively. Let us have $a < b$. Given $a = 1.0\,\text{cm}$, $b = 2a$, $Q_a = -3.5\,\text{nC}$, and $Q_b = -5.4\,\text{nC}$. See Figure 1. Determine the total electric flux passing through a closed surface of concentric sphere of radius $c = 1.5\,a$ enclosing the charges.

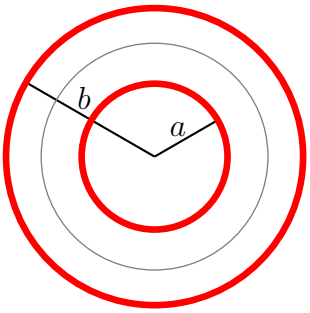

Figure 1: Problem 4

5. (**10 points.**) Three charges $q_1 = +q$, $q_2 = -q$, and $q_3 = -q/2$, with $q = 1.0\,\text{nC}$, are placed at the corners of an equilateral triangle of side $L = 3.0\,\text{cm}$. Refer Figure 2. Calculate the magnitude and direction of the total electric force on charge q_2.

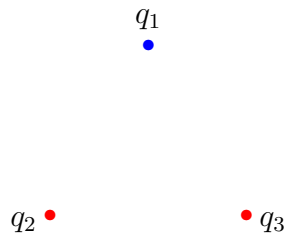

Figure 2: Problem 5

6. (**10 points.**) The deflection plates of a cathode ray tube has an electric field of $9.1 \times 10^3\,\mathrm{N/C}$. Let the electron beam be aligned parallel to the plates. The electrons enter the plates with a speed of $4.0 \times 10^6\,\mathrm{m/s}$. The horizontal distance of the plates is $x = 2.0\,\mathrm{cm}$ and the beam gets deflected vertically by a distance y. Refer Figure 3. Calculate the deflection y in centimeters.

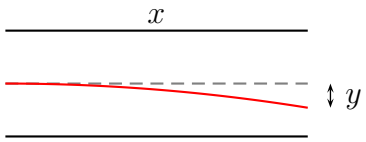

Figure 3: Deflection of an electron beam in a cathode ray tube.

7. (**10 points.**) Four charges $q_1 = +q$, $q_2 = -3q$, $q_3 = -3q$, and $q_4 = +q$, with $q > 0$, 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.

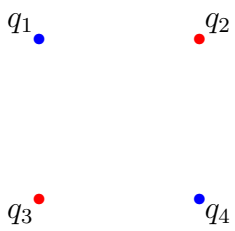

Figure 4: Problem 7