Midterm Exam No. 01 (2024 Spring)

PHYS 205B: UNIVERSITY PHYSICS

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

Date: 2024 Feb 15

(Name) (Signature)

Instructions

1. Seating direction: Please be seated on seats with seat-numbers divisible by 4.
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. Restroom breaks are allowed. Under questionable circumstances this might lead up to a Makeup Exam.
9. Academic misconduct will lead to a failing grade in the course.

1. (**5 points.**) Two identical conducting spheres A and B carry charges $Q_A = -2.0\,\mu\text{C}$ and $Q_B = +7.0\,\mu\text{C}$. 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 charge on B.

2. (**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?

3. (**5 points.**) A spherical thin conducting shell of radius a has a negative charge $-2.0\,Q$ on it. Another concentric spherical thin conducting shell of radius $b > a$ has a positive charge $+3.0\,Q$ on it. Draw the resultant electric field lines in the three regions.

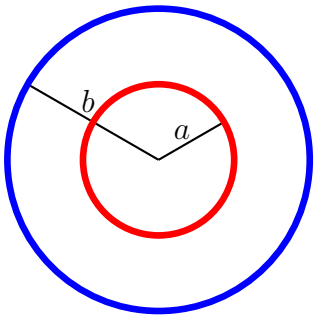

Figure 1: Problem 3

4. (**5 points.**) Figure 2 illustrates the electric field lines for a configuration consisting of two charges, $q_1 = -1.0\,\mu$C and $q_2 = +3.0\,\mu$C, separated by distance d. Draw the equipotential surface associated with zero voltage.
Hint: Regions very close to positive charges are higher in electric potential relative to regions very close to negative charges.

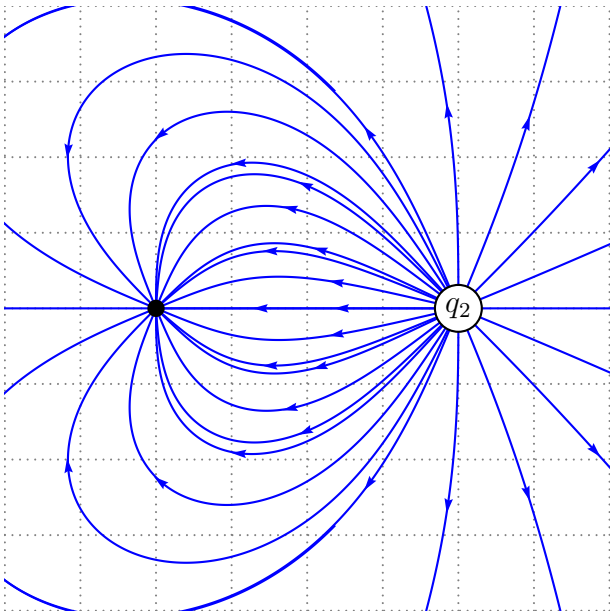

Figure 2: Electric field lines due to two charges, a negative charge q_1 and a positive charge q_2 such that $|q_2| > |q_1|$.

5. (**10 points.**) Four charges $q_1 = +q$, $q_2 = +2.0\,q$, $q_3 = -q$, and $q_4 = -2.0\,q$, 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 3. Calculate the magnitude and direction of the total electric field at the center of the square.

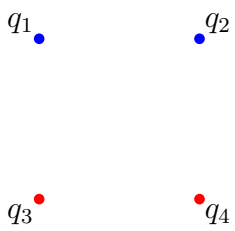

Figure 3: Problem 5

6. (**10 points.**) An electron and a proton are released from rest in a uniform electric field. The particles attain speeds v_e and v_p in a time Δt. Determine the ratio of velocities v_e/v_p. Then, determine the ratio of their linear momentums. Then, determine the ratio of their kinetic energies.

7. (**10 points.**) Consider a configuration consisting of one negative charge $q_1 = -2.0\,Q$ and two positive charges $q_2 = +Q$, $q_3 = +Q$, at the corners of an equilateral triangle of sidelength L. How much energy is needed to move a positive charge q_4 from infinity to the center of the triangle.

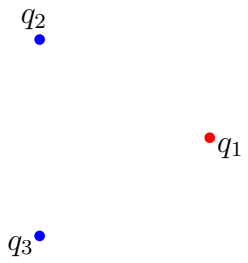

Figure 4: Problem 7