Homework No. 04 (Fall 2025)

PHYS 203B-001: COLLEGE PHYSICS

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

Due date: Thursday, 2025 Sep 18, 11:59 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 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. (**10 points.**) Consider a region of uniform electric field $\vec{\mathbf{E}} = -E\,\hat{\mathbf{j}}$ of magnitude $E = 1.0 \times 10^3\,\mathrm{N/C}$ and direction vertically down. Distance between points '1' to '2' is $h = 5.0\,\mathrm{cm}$, and the distance between points '2' to '3' is $d = 15\,\mathrm{cm}$. Refer Fig. 1.

   (a) Determine the work done by the electric force when a point charge $q = +1.0\,\mu\mathrm{C}$ moves along the path connecting points '1' to '2'.

   (b) Determine the change in the electric potential energy when the point charge q moves along the path connecting points '1' to '2'.

   (c) If there are no other forces acting on the point charge q, calculate the change in kinetic energy of the point charge q.

   (d) Determine the change in electric potential energy when the point charge q moves along the closed loop $1 \to 2 \to 3 \to 1$.

   Solution

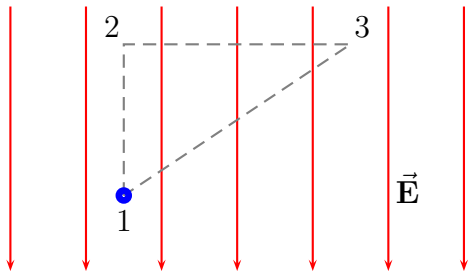

Figure 1: Problem 1

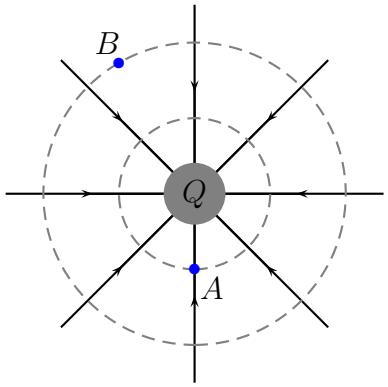

Figure 2: Problem 2

2. (**10 points.**) A sphere with uniform charge distribution $Q = -3.0\,\mu\text{C}$ is fixed at the origin. Point A is on a sphere of radius 5.0 cm and point B is on a sphere of radius 10.0 cm. Refer Figure 2.

   (a) What is the work done by the electric force acting on charge $q = +2.0\,\mu\text{C}$, when q is moved from point A to point B.

   (b) What is the change in the electric potential energy between Q and q when q is moved from point A to point B.

   (c) If there are no other forces acting on charge q, using the work-energy theorem calculate the change in kinetic energy of charge q.

   Solution

3. (**10 points.**) Determine the total energy required to assemble four identical positive charges Q at the corners of a square of length L. Assume that the charges are brought from infinity.

   Solution

4. (**10 points.**) Four charges $q_1 = q$, $q_2 = -2q$, $q_3 = -3q$, and $q_4 = 4q$, where $q = +1.0\,\mu\text{C}$,

are placed at the corners of a square of side $L = 10.0\,\text{cm}$, such that q_1 and q_4 are at diagonally opposite corners. Refer Figure 3.

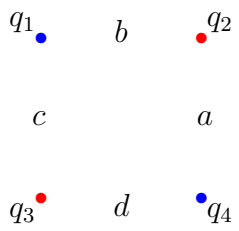

Figure 3: Problem 4

(a) What is the electric potential at the center of square?

(b) What is the electric potential at point a?

(c) What is the electric potential at point b?

(d) What is the electric potential difference between points a and c?

(e) How much electric potential energy is required to move another charge q from infinity to the center of the square?

(f) How much additional electric potential energy is required to move this charge from the center of the square to point a?

Solution

5. (**10 points.**) Two charges, $q_1 = +1.0\,\mu\text{C}$ and $q_2 = -4.0\,\mu\text{C}$, are separated by a distance of 10.0 cm. See Fig. 4. Find the spot on the line where the net electric potential is zero.

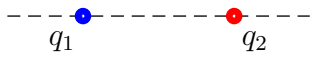

Figure 4: Problem 5.

Solution

6. (**10 points.**) Consider a perfectly conducting charged sphere of radius $R = 1.0\,\text{cm}$ carrying a charge $Q = +2.0\,\mu\text{C}$.

(a) What is the electric potential at the center of the conducting sphere?

(b) Calculate the electric potential at a point 0.25 cm away from the center of the conducting sphere.

(c) Calculate the electric potential on the surface of the conducting sphere.

(d) Calculate the electric potential at a point 5.0 cm away from the center of the conducting sphere.

Solution