Homework No. 04 (Spring 2022)

PHYS 203B-001: COLLEGE PHYSICS

Department of Physics, Southern Illinois University–Carbondale

Due date: Wednesday, 2022 Feb 16, 10:00am, on D2L

Instructions

- To the extent to which you depend on resources to complete this homework is a measure of how much extra work you need to put in to master the related concepts.
- Describe your thought process in detail and organize it clearly. Make sure your answer has the correct units and the right number of significant digits.
- After completion, scan the pages as a single PDF file, and submit the file on D2L (Assessments → Assignments).

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.

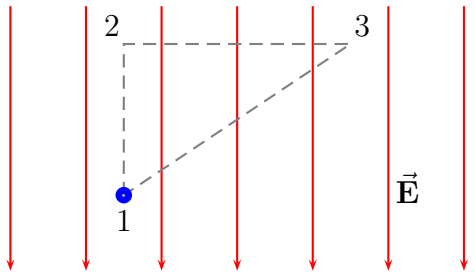

Figure 1: Problem 1

   (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

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.

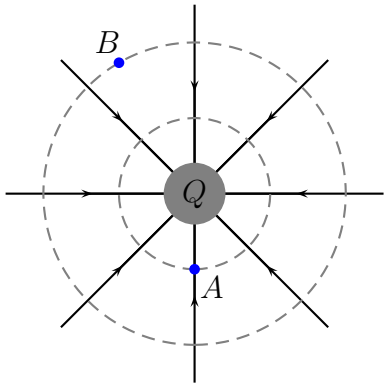

Figure 2: Problem 2

(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.

(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?

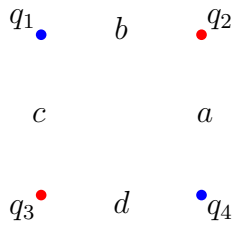

Figure 3: Problem 4

(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.

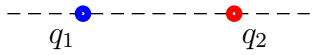

Figure 4: Problem 5.

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

7. (**10 points.**) An electric potential difference of 12 V exists between the plates of a capacitor. Equal and opposite amount of charge of 3.6 μC is placed on the plates. Determine the capacitance of the capacitor.

Solution