Homework No. 01 (Spring 2023)

PHYS 205B: UNIVERSITY PHYSICS

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

Due date: Thursday, 2023 Jan 26, 9:30 AM, 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 homework is usually a measure of how much extra work you need to put in to master the associated concepts. Solutions should be the last resource.
- Describe your thought process in detail and organize it clearly. Make sure your answer has units and the right number of significant digits.
- After completion, scan the pages as a single PDF file, and submit the file on D2L (under Assessments → Assignments).

Problems

1. (**10 points.**) Determine the number of protons in one nano-gram of protons. Then, calculate the total charge of one nano-gram of protons.

   Solution (Errata: At time 3:35 minutes it should read 9.58×10^{-5} C. The answer, in the line following this error, is correct.)

2. (**10 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.

   (a) As a result, what is the charge on A, if it was originally Q.

   (b) As a result, what is the charge on B, if it was originally Q.

   (c) As a result, what is the electrostatic force between A and B, if it was originally F.

   Solution

3. (**10 points.**) Three identical charges of equal magnitude q are placed at the corners of an equilateral triangle of length L. Determine the magnitude of the Coulomb force on one of the charges.

   Solution

4. (**10 points.**) Draw the electric field lines for a configuration consisting of two positive charges with unequal charge on them.

   (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

5. (**10 points.**) Two charges, $q_1 = +1.00\,\mu\text{C}$ and $q_2 = -8.00\,\mu\text{C}$ are a distance D apart. Refer Figure 1. As a multiple of distance D, at what coordinate x on the line connecting the two charges is the total electric field zero?

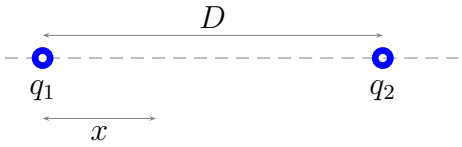

Figure 1: Problem 5

Solution

6. (**10 points.**) Watch the following YouTube video by Bruce Yeany

   https://youtu.be/-csQiBHoucI

   to gain insight on how easy it is to charge styrofoam balls.

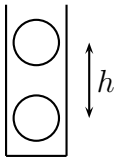

Figure 2: Two charged styrofoam balls trapped in a cylinder.

Two identical styrofoam balls have a charge Q on each one of them. They are trapped inside a cylinder so that the electrostatic repulsion on the top ball from the bottom balances the gravitational force acting on it. Refer Figure 2. Assume that the walls of the cylinder does not exert any net vertical force on the top ball. Given that the balls weigh 0.040 grams each and the height $h = 1.0\,\text{cm}$, determine the charge Q on each ball.

Solution

7. (**10 points.**) Watch the following YouTube video by Science Marshall

   https://youtu.be/ysaUfsJyer0

   on how a Cathode Ray Tube works.

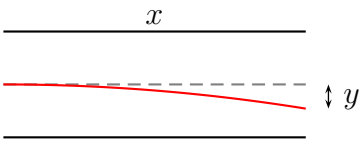

Figure 3: Deflection of an electron beam in a cathode ray tube.

The deflection plates of a cathode ray tube has an electric field of $1.0 \times 10^3\,\mathrm{N/C}$. 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 $x = 5.0\,\mathrm{cm}$ and the beam gets deflected vertically by a distance y. Refer Figure 3.

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

(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 after being released simultaneously. Determine the ratio v_e/v_p. Which of them gains higher speed? Which of them has a higher kinetic energy?

Solution