Midterm Exam No. 01 (2014 Fall)

PHYS 205B: University Physics

Date: 2014 Sep 11

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(Name)   (Signature)

Instructions

1. Total time = 75 minutes.

2. There are 10 questions in this exam.

3. Equation sheet is provided separately.

4. To obtain partial credit for your work you need to show your work in detail and organize it clearly.

1. (**10 points.**) A hydrogen atom consists of a proton and an electron. Find the ratio of the electrostatic force to that of the gravitational force between the proton and electron in the hydrogen atom. (You do not need the knowledge of the radius of the hydrogen atom for this calculation.)

2. (**10 points.**) Two positive charges and two negative charges of magnitude Q are placed at the corners of a square of length L such that the like charges are at diagonally opposite corners. Determine the magnitude and direction of the force on one of the positive charges due to the other three charges.

3. (**10 points.**) See Figure 1. Particle 1 of charge $q_1 = +2.00q$ and particle 2 of charge $q_2 = -8.00q$ are fixed to an x axis. As a multiple of distance L, at what coordinate on the axis is the net electric field of the particles zero?
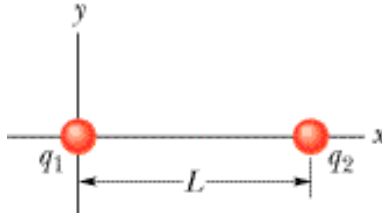

Figure 1: Problem 3.

4. (**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?

5. (**10 points.**) Consider an infinite number of identical particles, each with charge q, placed along the x axis at distances a, $2a$, $3a$, $4a$, ...from the origin. What is the electric field at the origin due to this distribution? Suggestion: Use

$$1 + \frac{1}{2^2} + \frac{1}{3^2} + \frac{1}{4^2} + \ldots = \frac{\pi^2}{6}. \tag{1}$$

6. (**10 points.**) What is the magnitude of the flux of the electric field,

$$\vec{\mathbf{E}} = \left[14\,\hat{\mathbf{i}} + 20\,\hat{\mathbf{j}} + 16\,\hat{\mathbf{k}}\right]\frac{\mathrm{N}}{\mathrm{C}}, \tag{2}$$

through a $2.0\,\mathrm{m}^2$ portion of the x-y plane?

7. (**10 points.**)

    (a) Plot the electric field of a charged conducting solid sphere of radius R as a function of the radial distance r, $0 < r < \infty$, from the center.

    (b) Plot the electric field of a uniformly charged nonconducting solid sphere of radius R as a function of the radial distance r, $0 < r < \infty$, from the center.

8. (**10 points.**) An infinitely large, flat, horizontal sheet of charge has a charge per unit area of $8.00\,\mu\text{C}/\text{m}^2$. Find the magnitude of the electric field just above the sheet, assuming it to be nonconducting. Sketch the electric field lines near the sheet.

9. (**10 points.**) Positive charge Q is distributed uniformly throughout an insulating sphere of radius R, centered at the origin. A particle with positive charge Q is placed at $x = 2R$ on the x axis. What is the magnitude of the electric field at $x = 3R/2$ on the x axis?

10. (**10 points.**) An electron with speed $v = 2.99 \times 10^5$ m/s orbits just outside a charged sphere of radius $r = 0.95$ cm. What is the charge on the sphere?