Final Exam (2015 Fall)

PHYS 205B: University Physics

Date: 2015 Dec 17

(Name) (Signature)

Instructions

1. Seating direction: Please be seated on odd-numbered seats.
2. Total time = 2 hours.
3. There are 12 questions in this exam.
4. Equation sheet is provided separately.
5. To be considered for partial credit you need to show your work in detail and organize it clearly.
6. A simple calculator (with trigonometric functions) is allowed.
7. Use of mobile phones is strictly prohibited. It should stay out of reach during the exam.

1. (**10 points.**) Two equal and opposite point charges of magnitude 1.0 nC are separated by a distance 2.00 cm. Determine the magnitude and direction of the electric field along the bisector, a distance $y = 2.50$ cm above the charges.

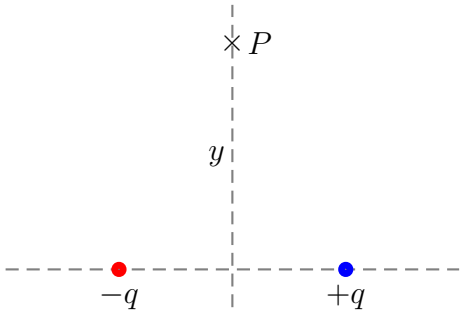

Figure 1: Problem 1.

2. (**10 points.**) A positively charged plastic ball, $q = +10.0\,\mu\text{C}$ and $m = 1.00\,\text{g}$, is suspended using a 20.0 cm long string in a uniform electric field $E = 1.0 \times 10^3\,\text{N/C}$ as shown in the figure below. Determine the angle θ the string makes with the vertical when the ball is in equilibrium. (Use $g = 10.0\,\text{m/s}^2$.)

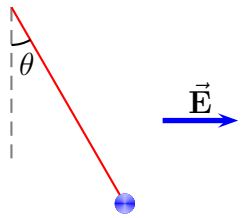

Figure 2: Problem 2.

3. (**10 points.**) The potential in a region between $x = 0$ and $x = 5.00\,\text{cm}$ is given by

$$V = a + bx, \tag{1}$$

where $a = 0\,\text{V}$ and $b = -450\,\text{V/cm}$. Determine the magnitude and direction of the electric field at $x = 2.00\,\text{cm}$.

4. (**10 points.**) A potential difference $V = 10\,\mathrm{V}$ is applied across a capacitor arrangement with two capacitances connected in series, $C_1 = 10.0\,\mu\mathrm{F}$ and $C_2 = 20.0\,\mu\mathrm{F}$.

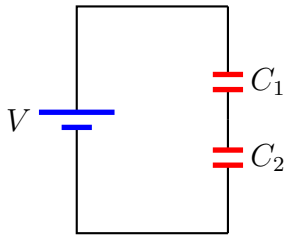

Figure 3: Problem 4

(a) Find the equivalent capacitance.

(b) Find the charges Q_1 and Q_2 on each of the capacitors.

(c) Find the voltages V_1 and V_2 across each of the capacitors.

(d) Find the potential energies U_1 and U_2 stored inside each of the capacitors.

5. (**10 points.**) Uniform electric field of magnitude $3.00 \times 10^3\,\mathrm{N/C}$ and uniform magnetic field of magnitude $2.00\,\mathrm{mT}$ are both pointing the $\hat{\mathbf{x}}$ direction. Determine the magnitude and direction of the total force on a positive charge $q = 1.0\,\mu\mathrm{C}$ that is moving with speed $2.0 \times 10^6\,\mathrm{m/s}$ in the $\hat{\mathbf{z}}$ direction.

6. (**10 points.**) A loop in the shape of a semi circle of radius $R = 5.0\,\text{cm}$, carrying a current $I = 1.0\,\text{A}$, is placed in a magnetic field $B = 0.10\,\text{T}$.

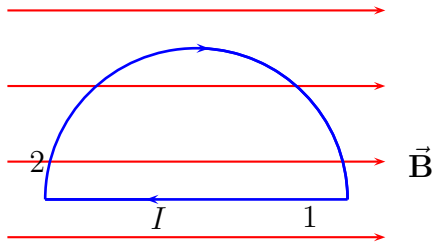

Figure 4: Problem 6.

(a) Determine the magnitude and direction of the force on side 1 of the loop.

(b) Determine the magnitude and direction of the force on side 2 of the loop.

(c) Determine the magnitude and direction of the total force on the loop.

7. (**10 points.**) Figure 5 shows two, infinitely long, current carrying wires, passing through a plane. The directions of the currents, either going into the page or coming out of the page, are shown in the figure. Determine the magnitude and direction of the magnetic field at the point $\times$, the origin. Let $I_1 = 1.0\,\mathrm{A}$, $I_2 = 2.0\,\mathrm{A}$, $x = 4.0\,\mathrm{cm}$, and $y = 3.0\,\mathrm{cm}$. Find the magnitude and direction of the total magnetic field at the origin.

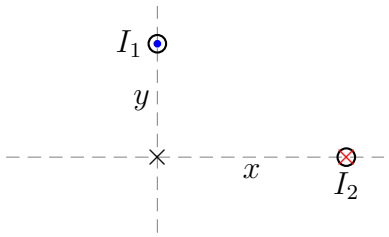

Figure 5: Problem 7.

8. (**10 points.**) Consider the diagram shown in Figure 6 in which the free conducting rod is pulled with velocity v. Let $R_1 = 100.0\,\Omega$, $R_2 = 200.0\,\Omega$, $B = 0.20\,\mathrm{T}$, $l = 10.0\,\mathrm{cm}$, and $v = 10.0\,\mathrm{m/s}$. Determine the currents in the two resistances.

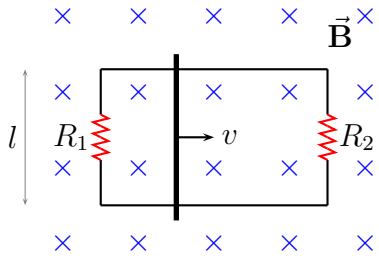

Figure 6: Problem 8.

9. (**10 points.**) A series RL circuit with $L = 3.00\,\mathrm{H}$ and a series RC circuit with $C = 2.00\,\mu\mathrm{F}$ have equal time constants. The two circuits contain the same resistance R.

   (a) What is the value of R?

   (b) What is the time constant?

10. (**10 points.**) A glass optical fiber ($n_g = 1.50$) is submerged in water ($n_w = 1.33$). What is the critical angle of incidence for light to stay inside the fiber?

11. (**10 points.**) A 1.0 cm object is placed upright at a distance 15.0 cm away from a concave mirror. The mirror's focal length is 10.0 cm.

    (a) What is the mirror's radius of curvature?

    (b) Calculate the image distance.

    (c) What is the magnification?

    (d) Is the image real or virtual?

    (e) Is the image inverted or upright?

    (f) Determine the height of the image.

    (g) Confirm your results by drawing a ray diagram for the above case. Choose the scale for the two relevant directions appropriately so that the relevant features are illustrated well. Points will be awarded for clarity.

12. (**10 points.**) A 1.0 cm object is placed upright at a distance 10.0 cm away from a convex lens. The lens' focal length is 10.0 cm.

    (a) Calculate the image distance.

    (b) What is the magnification?

    (c) Is the image real or virtual?

    (d) Is the image inverted or upright?

    (e) Confirm your results by drawing a ray diagram for the above case. Choose the scale for the two relevant directions appropriately so that the relevant features are illustrated well. Points will be awarded for clarity.