Final Exam (2015 Summer)

PHYS 203B: College Physics

Date: 2015 Aug 7

(Name) (Signature)

Instructions

1. Total time = 110 minutes.
2. There are 12 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.
5. A simple calculator (with trigonometric functions) is allowed.
6. Use of mobile phones is strictly prohibited.

1. (**10 points.**) Figure 1 shows three point charges that lie in the x-y plane. Given $q_1 = -4.0\,\mu\text{C}$, $q_2 = +6.0\,\mu\text{C}$, $q_3 = +5.0\,\mu\text{C}$, charges q_1 and q_2 are separated by a distance of 4.0 cm, and charges q_1 and q_3 are separated by a distance of 6.0 cm. Find the magnitude and direction of the net electrostatic force on charge q_1.

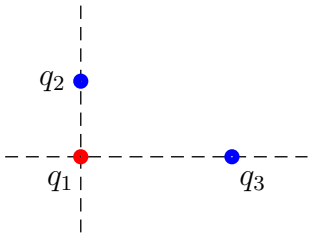

Figure 1: Problem 1

2. (**10 points.**) Two electrons and two protons are placed at the corners of a square of side 5.00 cm, such that the electrons are at diagonally opposite corners.

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

   (b) What is the electric potential at the midpoint of either one of the sides of the square?

   (c) How much potential energy is required to move another proton from infinity to the center of the square?

   (d) How much additional potential energy is required to move the proton from the center of the square to one of the midpoint of either one of the sides of the square?

3. (**10 points.**) A potential difference $V = 10.0\,\mathrm{V}$ is applied across a resistor arrangement with two resistances connected in series, $R_1 = 10.0\,\Omega$ and $R_2 = 20.0\,\Omega$.

   (a) Find the equivalent resistance.

   (b) Find the currents I_1 and I_2 through each of the resistors.

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

   (d) Determine the power consumed by each resistor.

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

   (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.**) In a region, a uniform magnetic field of $1.50 \times 10^{-3}\,\mathrm{T}$ points along the positive z-axis and a uniform electric field of $4.50 \times 10^{3}\,\mathrm{N/C}$ points along the positive x-axis. A positive $1.80\,\mu\mathrm{C}$ charge moves at a speed of $3.00 \times 10^{6}\,\mathrm{m/s}$ along the positive x-axis in the region. Determine the magnitude of the net force that acts on the charge.

6. (**10 points.**) Figure 2 shows a conducting rod being pulled along horizontal, frictionless, conducting rails at a constant speed v. A uniform magnetic field $\mathbf{B}$ fills the region in which the rod moves. Assume $L = 5.00\,\text{cm}$, $v = 4.00\,\text{m/s}$, $B = 1.20\,\text{T}$, and $R = 400.0\,\Omega$.

   (a) Is the magnetic flux in the loop increasing or decreasing?

   (b) What is the direction of the induced current in the loop?

   (c) Determine the magnitude of the induced current in the loop.

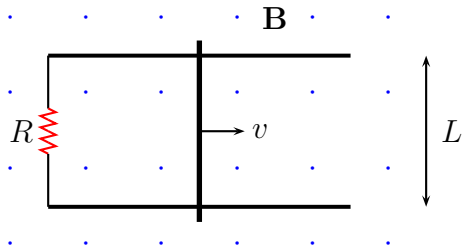

Figure 2: Problem 6

7. (**10 points.**) How far (in meters) is a light-year?
   Hint: A light-year is the distance travelled by light in one year.

8. (**10 points.**) A distant galaxy emits light that has a wavelength of 540.0 nm. On Earth, the wavelength of this light is measured to be 510.0 nm.

   (a) Find the speed of the galaxy relative to the Earth.

   (b) Decide whether this galaxy is approaching or receding from the Earth.

9. (**10 points.**) A 2.00 cm object is placed upright at a distance 12.0 cm from a convex mirror. The mirror's radius of curvature 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) What is height of the image?

   (f) Confirm your above results by drawing a ray diagram for the above case. Points will be awarded for precision.

10. (**10 points.**) A 2.00 cm object is placed upright at a distance 4.00 cm from the center of a concave lens (diverging lens). The lens' focal length is 6.00 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) What is height of the image?

    (f) Confirm your above results by drawing a ray diagram for the above case. Points will be awarded for precision.

11. (**10 points.**) Two slits in the Young's double slit experiment have a separation of 0.300 mm. The fifth-order maximum occurs at an angle of 0.500° from the central maximum. Determine the wavelength of light (in nm).

12. (**10 points.**) Light of wavelength 665 nm is incident perpendicularly on a soap film ($n = 1.33$) suspended in air ($n = 1.00$). What is the smallest nonzero thickness (in nm) of the film for which the transmitted light from the film undergoes fully constructive interference? (Caution: The observer is viewing transmitted light.)