STAPLE

Physics 201 Name _____

Exam 2 – Voltage and Moving Charges

March 7, 2013

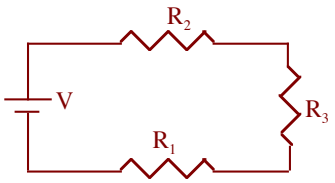
This is a closed book examination but during the exam you may refer to a 3"x5" note card with words of wisdom you have written on it. There is extra scratch paper available. Your explanation is worth ¾ of the points. Explain your answers!

A general reminder about problem solving:

- Show all your work.
- Really; Show All Work!
- Focus
  - Draw a picture of the problem
  - What is the question? What do you want to know?
  - List known and unknown quantities
  - List assumptions
- Physics
  - Determine approach – What physics principles will you use?
  - Pick a coordinate system
  - Simplify picture to a schematic (if needed)
- Plan
  - Divide problem into sub-problems
  - Modify schematic and coordinate system (if needed)
  - Write general equations
- Execute
  - Write equations with variables
  - Do you have sufficient equations to determine your unknowns?
  - Simplify and solve
- Evaluate
  - Check units
  - Why is answer reasonable?
  - Check limiting cases!

1. [4 PTS] An object with negative charge, q = - 7 uC, is moving with a constant speed along the x-axis, $\vec{v} =< 8\times10^4, 0, 0 > m/s$. When the object is at $\vec{x} =< 5, 0, 0 > m$, where is the magnetic field produced by this moving charge zero?
   a) The magnetic field is zero everywhere.
   b) $\vec{x} =< 5, 5, 0 > m$
   c) $\vec{x} =< 5, 0, 5 > m$
   d) $\vec{x} =< 10, 0, 0 > m$
   e) The magnetic field is not zero anywhere.

2. [4 PTS] You connect three light bulbs (resistors) to a battery as shown in the diagram to the right. If the light bulb labeled R_2 is dimmest (i.e. uses least power), what must be true?
   a) R_2 has the largest resistance.
   b) R_2 has the same resistance as the other light bulbs, it just has the current (which is really electrons traveling the opposite direction) pass through it last.
   c) R_2 has the smallest current.
   d) R_2 has the smallest resistance.
   e) R_2 has the largest voltage drop.



The next two problems concern a long wire positioned along the x-axis that has a current of $\vec{I} =< 1.2, 0, 0 > A$ flowing through it. The wire's center is at the origin, $\vec{x} =< 0, 0, 0 > m$.

3. [4 PTS] What is the direction of the magnetic field directly above the wire at $\vec{x} =< 0, 2, 0 > mm$?
   a) $\vec{B} \propto < 0, 1, 0 > T$
   b) $\vec{B} \propto < 0, -1, 0 > T$
   c) $\vec{B} \propto < 1, 0, 0 > T$
   d) $\vec{B} \propto < -1, 0, 0 > T$
   e) $\vec{B} \propto < 0, 0, 1 > T$
   f) $\vec{B} \propto < 0, 0, -1 > T$

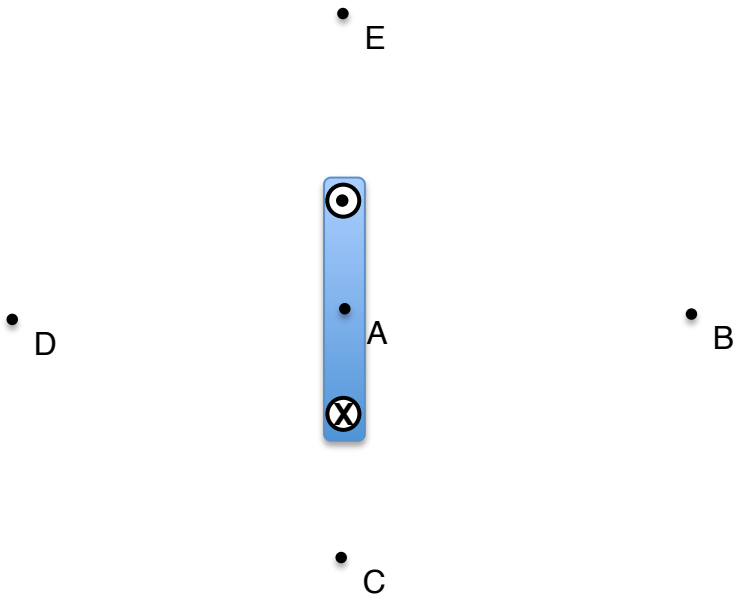
4. [4 PTS] The current in the wire is doubled and you move twice as far away. What happens to the magnitude of the magnetic field your new observation point?
   a) Increases by a factor of 4
   b) Increases by a factor of 2
   c) Does not change
   d) Decreases by a factor of 2
   e) Decreases by a factor of 4

5. [4 PTS] A neutral hollow metal sphere is placed between two large charged plates. The plates are 15 cm apart. The voltage difference between the plates is kept at a high voltage of 150kV. What is the voltage inside the hollow metal sphere?
   a) The voltage is zero.
   b) The voltage increases toward the center.
   c) The voltage is constant inside the sphere.
   d) The voltage decreases toward the center.
   e) There is no voltage inside the sphere.

6. [4 PTS] You connect three light bulbs in parallel to a 9 V battery. One of the light bulbs is noticeably brighter (uses more power) than the other two light bulbs. What happens when you disconnect this bright bulb? Assume the battery is ideal – it can supply any amount of current.
   a) The other two light bulbs increase in brightness.
   b) The bulb closest to the battery increases in brightness.
   c) Nothing happens to the brightness of the other two bulbs.
   d) The bulb furthest from the battery decreases in brightness.
   e) The other two light bulbs decrease in brightness.

7. [4 PTS] A resistor is placed in series with a 1.5 volt battery. What is the resistance if you measure a current of 0.25 A in this circuit?
   a) 0.167 Ω
   b) 0.375 Ω
   c) 2.67 Ω
   d) 6.00 Ω
   e) 24.0 Ω

8. [4 PTS] The diagram to the right is the side of a wire loop with a current flowing in it. The current flows into the bottom of the loop and out of the top of the loop. Indicate the direction of the magnetic field at the 5 locations indicated.



9. [4 PTS] A negative point charge is located at the origin. You measure the voltage 2 cm from the charge. What is the voltage 4 cm from the charge?
   a) The voltage increases by a factor of 4
   b) The voltage increases by a factor of 2
   c) The voltage does not change
   d) The voltage decreases by a factor of 2
   e) The voltage decreases by a factor of 4

10. [4 PTS] Two charges form a dipole centered at the origin. Both charges have the same magnitude $|q| = 3.21\times10^{-19}C$ and have a center-to-center separation of 8.75 nm. What is the electric potential at the origin (midway between the charges)?
   a) 0.66 V
   b) 0.33 V
   c) 0 V
   d) - 0.33 V
   e) - 0.66 V

The next two problems can be done using problem solving sheets or on additional paper.

11. [12 PTS] An electron is released from a heated filament (basically a light bulb). The filament is at a voltage of 120 V. There is a large plate 2 cm from the filament. You would like the velocity of the electron to be $3\text{x}10^6$ m/s (1% the speed of light!) when it reaches the plate. Determine the necessary voltage on the plate.
    BONUS [10%]: If you apply relativistic methods to this problem.

12. [12 PT] You are given a 15W light bulb and a 150W light bulb. The power ratings for these light bulbs refer to a standard configuration where the bulbs are hooked in parallel to a 120 V power supply. For some reason you decide to connect these light bulbs in series to the 120 V power supply. Determine the power ratings for the bulbs in this new configuration.

$\frac{\mu_0}{4\pi} = 10^{-7}\frac{N}{A^2}$ $\frac{1}{4\pi\epsilon_0} = k = 9\times10^9\frac{Nm^2}{C^2}$ $V_{sphere} = \frac{4\pi r^3}{3}$ and $A_{sphere} = 4\pi r^2$
mass of electron $m_e = 9.109\times10^{-31}kg$ mass of proton $m_p = 1.673\times10^{-27}kg$
charge of electron $q_e = 1.602\times10^{-19}C$