Phys 0175 **Practice Midterm Exam II** Feb 25, 2009

Note: THIS IS A REPRESENTATION OF THE ACTUAL TEST. *It is a sample and does not include questions on* every topic covered since the start of the semester.

Also be sure to review

homework assignments on WebAssign

White board problems worked in the class

Exercises, Examples, and Review Questions (at the end of each chapter) in your textbook

On the actual test, do not use other paper. If you need more space, write on the blank page included at the beginning of the test, and indicate that you did this.

- **Read all problems carefully before attempting to solve them.**
- **Your work must be legible, and the organization must be clear.**
- **You must show all your work, including correct vector notation.**
- **Correct answers without adequate explanation will be counted wrong.**
- **Incorrect work or explanations mixed in with correct work will be counted wrong.** *Cross out anything you don't want us to read!*
- **Make explanations complete but brief. Do not write a lot of prose.**
- **Include diagrams!**
- **Show what goes into a calculation, not just the final number:**

$$\frac{a \cdot b}{c \cdot d} = \frac{(8 \times 10^{-3})(5 \times 10^{6})}{(2 \times 10^{-5}))(4 \times 10^{4})} = 5 \times 10^{4}$$

- **Give standard SI units with your results.**

Unless specifically asked to derive a result, you may start from the formulas given on the formula sheet, including equations corresponding to the fundamental concepts. If a formula you need is not given, you must derive it.

If you cannot do some portion of a problem, invent a symbol for the quantity you can't calculate(explain that you are doing this), and use it to do the rest of the problem.

NAME: ____

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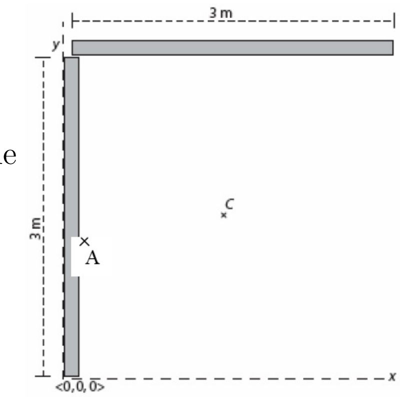
INSTRUCTIONS: Please print your name above in the space provided.

The exam consists of N questions worth differing number of points. WRITE NEATLY. Clearly mark your answers with a bounding box at the bottom of your work area. It is important to show your work to get credit. You may use calculators.

Question Number	Possible Points	Score
1	?	
2	?	
⋮	⋮	
N	?	
Total	100	

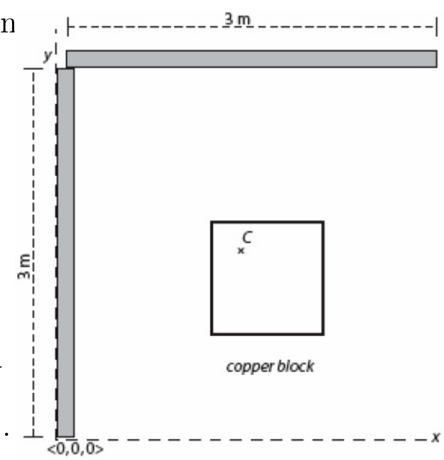
1. Two thin glass rods, each 3 meters long, are rubbed all over with silk. Each rod acquires a charge of $+3\times10^{-7}$ C. The rods are arranged at right angles to each other, as shown in the diagram. The rods lie in the xy plane; the origin is at the base of the vertical rod, as shown.



   (a) What is the net electric field at location C, at $\langle 1.5, 1.5, 0\rangle$ m, marked by the "x"? Express your answer as a vector. Clearly show all steps in your work.

In the following questions, if a quantity is zero, state this explicitly.

   (b) A neutral copper block is now placed so location C is inside the block. Draw the approximate distribution of charge in and/or on the copper block, following the conventions for diagrams used in the textbook and in class.



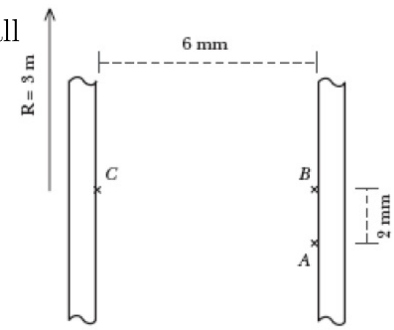
   (c) Draw an arrow representing the electric field at location C, inside the copper block, due only to the two charged rods. Label this arrow $\vec{E}_{rods}$.

   (d) Draw an arrow representing the electric field at location C, due only to the charges in and/or on the copper block. Label this arrow $\vec{E}_{copper}$.

   (e) Draw an arrow representing the net electric field at location C.

2. A capacitor consists of plates 3 m in radius, separated by a distance of 6 mm. The left plate of the capacitor has a charge of -7 × 10^{-7} C.

   (a) What is the potential difference $V_C - V_B$? Show all steps in your work.



   (b) What is the potential difference $V_B - V_A$? Show all steps in your work.

   (c) What is the potential difference $V_C - V_A$? Show all steps in your work.

   (d) A moving electron enters the capacitor through a tiny hole in the right plate. Its initial velocity is such that it passes through location A, and a short time later it reaches location C. What is the change in kinetic energy of the electron between the location A and location C. (Remember that the gravitational force on the electron is negligible compared to electric forces.) Show all steps in your work.

3. The arrangement of charged particles shown in the diagram is called an electric quadrupole. At locations on the x-axis far from the quadrupole, the electric field due to the quadupole has the form

$$\vec{E} = \langle \frac{1}{4\pi\epsilon_0}\frac{h}{x^4}, 0, 0\rangle$$

(h is a constant with units $\mathrm{C} \cdot \mathrm{m}^2$, combining the magnitude of the charges and their separations).

The diagram below is not drawn to scale; both locations A and B are far from the quadrupole. The origin is at the center of the quadrupole.

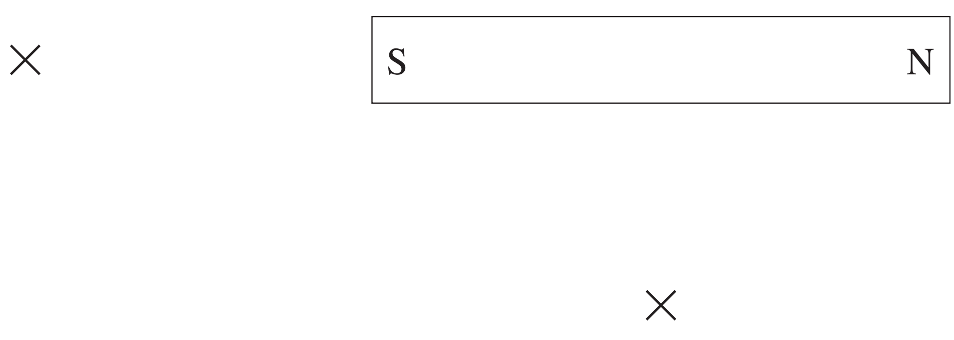
(a) At the two locations A and B, draw arrows showing the electric field at that location. The relative magnitudes of the arrows should be correct (longer arrows mean larger magnitude).

(b) is $V_B - V_A$ positive, negative, or zero? Briefly but clearly explain your reasoning.

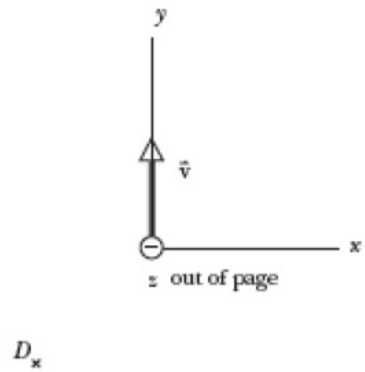
(c) What is $V_B - V_A$? Your answer should be a symbolic (algebraic) expression, which may include the constants h, a, b, and $1/(4\pi\epsilon_0)$. Show all steps in your work.

4. In a circuit in the steady state, 3.5×10^{17} electrons enter a particular wire each second flowing in the -x direction. What is the magnitude and direction of the conventional current in this wire? Show your work.

5. At each of the location marked by an "X" draw an arrow representing the magnetic field at that location due to the bar magnet.



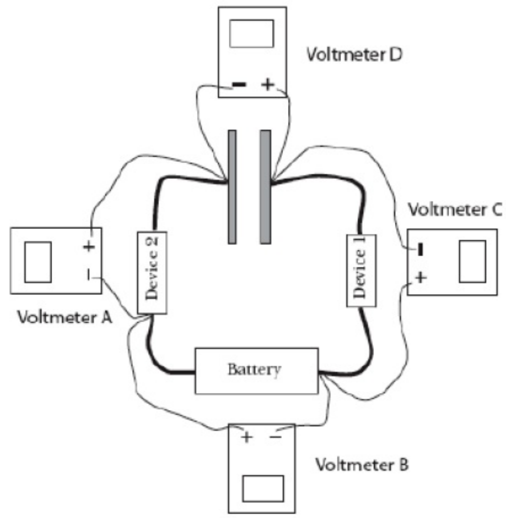
6. An electron moves in the +y direction with a speed of 3×10^6 m/s, as shown in the diagram. At a particular instant the electron is at $\langle 2 \times 10^{-8}, 1.5 \times 10^{-8}, 0 \rangle$ m. The location D is at $\langle -1.0 \times 10^{-8}, -1.5 \times 10^{-8}, 0 \rangle$ m.



(a) Find the direction and magnitude of the electric field at location D due to the electron. Your answer should be expressed as a vector. Show all of your work.

(b) Find the direction and magnitude of the magnetic field at location D due to the electron. Your answer should be expressed as a vector. Show all of your work.

7. Four voltmeters are connected to a circuit as shown. As on the voltmeter you used in lab, if the negative lead (black, COM) is attached to a location of lower potential than the positive (red) lead, the voltmeter reading is positive. The circuit contains two devices whose identity is unknown, and a capacitor. The separation between the plates of the capacitor is 3 mm. At a particular moment, the readings observed on the voltmeters are:



Voltmeter A: -2.5 V

Voltmeter B: +9.0 V

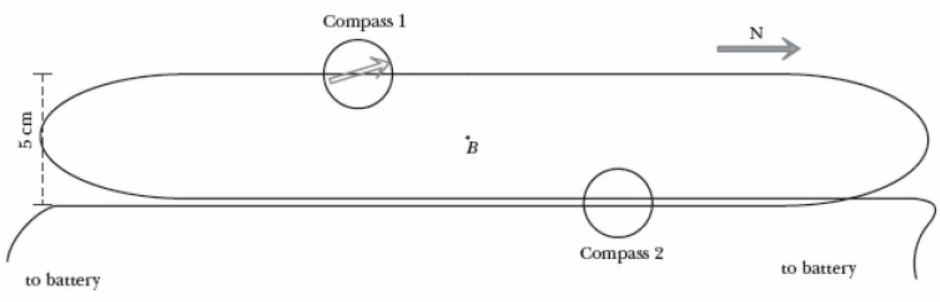
Voltmeter C: -3.0 V

(a) At this moment, what is the reading on voltmeter D, both is magnitude and sign. Briefly explain your reasoning.

(b) On the diagram draw an arrow indicating the direction of the electric field at a location inside the capacitor. Label the arrow $\vec{E}$.

(c) What is the magnitude of the electric field inside the capacitor? Show your work.

8. A long wire is connected to a battery, and a steady-state current runs through the wire. The wire passes once over Compass #1 and twice over Compass #2, as shown in the diagram. While the current runs in the wire, Compass #1 deflects 11° to the West as shown. When the wire lies on top of the compass, it is about 5 mm above the compass needle.



(a) Draw an arrow on the diagram showing the direction of electron current in the segment of wire that passes over Compass #1. Label the arrow "electron current".

(b) Draw an arrow on the diagram showing the direction in which the needle of Compass #2 will point.

(c) What is the magnitude of the deflection of the needle of Compass #2? Briefly explain your reasoning.

(d) What is the direction of the magnetic field at location B, due only to the current in the wire?

(e) What is the magnitude of the magnetic field at location B, due only to the current in the wire? Clearly show all steps in your work.

Things you must know

Relationship between electric field and electric force

Electric field of a point charge

Magnetic field of a moving point charge

Conservation of charge

The Superposition Principle

Other Fundamental Concepts

$\Delta U_{el} = q\Delta V$

$\Delta V = -\int_i^f \vec{E} \cdot d\vec{l} \approx -\Sigma(E_x \Delta x + E_y \Delta y + E_z \Delta z)$

Specific Results

$\vec{E}$ due to uniformly charged spherical shell: *outside* like point charge; *inside* zero

$|\vec{E}_{dipole,\ axis}| \approx \frac{1}{4\pi\epsilon_0}\frac{2qs}{r^3}$ (on axis, $r \gg s$)

$|\vec{E}_{dipole,\ \perp}| \approx \frac{1}{4\pi\epsilon_0}\frac{qs}{r^3}$ (on $\perp$ axis, $r \gg s$)

$|\vec{E}_{rod}| = \frac{1}{4\pi\epsilon_0}\frac{Q}{r\sqrt{r^2 + (L/2)^2}}$ (r $\perp$ from center)

$|\vec{E}_{rod}| \approx \frac{1}{4\pi\epsilon_0}\frac{2Q/L}{r}$ (if $r \ll L$)

$|\vec{E}_{ring}| = \frac{1}{4\pi\epsilon_0}\frac{qz}{(z^2 + R^2)^{3/2}}$ (z alongaxis)

$|\vec{E}_{disk}| = \frac{Q/A}{2\epsilon_0}\left[1 - \frac{z}{\sqrt{z^2 + R^2}}\right]$ (z alongaxis)

$|\vec{E}_{disk}| \approx \frac{Q/A}{2\epsilon_0}\left[1 - \frac{z}{R}\right] \approx \frac{Q/A}{2\epsilon_0}$ (if $z \ll R$)

$|\vec{E}_{capacitor}| \approx \frac{Q/A}{\epsilon_0}$ ($+Q$ and $-Q$ disks)

$|\vec{E}_{fringe}| \approx \frac{Q/A}{\epsilon_0}\left(\frac{s}{2R}\right)$ (just outside capacitor)

$\Delta\vec{B} = \frac{\mu_0}{4\pi}\frac{I\Delta\vec{l} \times \vec{r}}{r^2}$ (shortwire)

$|\vec{B}_{wire}| = \frac{\mu_0}{4\pi}\frac{LI}{r\sqrt{r^2 + (L/2)^2}} \approx \frac{\mu_0}{4\pi}\frac{2I}{r}$ ($r \ll L$)

$|\vec{B}_{loop}| = \frac{\mu_0}{4\pi}\frac{2I\pi R^2}{(z^2 + R^2)^{3/2}} \approx \frac{\mu_0}{4\pi}\frac{2I\pi R^2}{z^3}$ (on axis, $z \gg R$)

$\mu = IA = I\pi R^2$

$|\vec{B}_{dipole,\ axis}| \approx \frac{\mu_0}{4\pi}\frac{2\mu}{r^3}$ (on axis, $r \gg s$)

$|\vec{B}_{dipole,\ \perp}| \approx \frac{\mu_0}{4\pi}\frac{\mu}{r^3}$ (on $\perp$ axis, $r \gg s$)

$i = nA\bar{v}$

$I = |q|nA\bar{v}$

$\Delta V = \frac{q}{4\pi\epsilon_0}\left[\frac{1}{r_f} - \frac{1}{r_i}\right]$ (due to a point charge)

$E_{dielectric} = \frac{E_{applied}}{K}$

$K \approx \frac{1}{2}mv^2$ if $v \ll c$

circular motion : $\left|\frac{d\vec{p}_\perp}{d_t}\right| = \frac{|\vec{v}|}{R}|\vec{p}| \approx \frac{mv^2}{R}$

Constant	Symbol	Approximate Value
Speed of light	c	3×10^8 m/s
Gravitational constant	G	6.7×10^{-11} N $\cdot$ m^2/kg^2
Approx. grav field near Earth's surface	g	9.8 N/kg
Electron mass	m_e	9×10^{-31} kg
Proton mass	m_p	1.7×10^{-27} kg
Neutron mass	m_n	1.7×10^{-27} kg
Electric constant	$\frac{1}{4\pi\epsilon_0}$	9×10^9 N $\cdot$ m^2/C^2
Epsilon-zero	ϵ_0	8.85×10^{-12} C^2/(N $\cdot$ m^2)
Magnetic Constant	$\frac{\mu_0}{4\pi}$	1×10^{-7} T $\cdot$ m/A
Mu-zero	μ_0	$4\pi \times 10^{-7}$ T $\cdot$ m/A
Proton charge	e	1.6×10^{-19} C
Electron volt	1 eV	1.6×10^{-19} J
Avogadro's number	N_A	6.02×10^{23} molecules/mole
Atomic radius	R_a	$\approx 1 \times 10^{-10}$ m
Proton radius	R_p	$\approx 1 \times 10^{-15}$ m
E to ionize air	E_{ionize}	$\approx 3 \times 10^6$ V/m
B_{Earth} (horizontal component)	B_{Earth}	$\approx 2 \times 10^{-5}$ T