Physics 152 Roster No.:________________________

Score:__________**17 points possible**_____

FALL 2004 Midterm Exam #2, Part A

Exam time limit: 50 minutes. You may use a calculator and both sides of ONE sheet of notes, *handwritten only*. Closed book; no collaboration. For multiple choice questions, circle the letter of the one best answer (unless more than one answer is asked for). Ignore gravity and relativistic effects in all problems, unless told otherwise.

$k_e = 8.988 \times 10^9$ N·m^2/C^2 $e = 1.602 \times 10^{-19}$ C $m_e = 9.109 \times 10^{-31}$ kg

$\varepsilon_0 = 1/(4\pi k_e) = 8.854 \times 10^{-12}$ C^2/(N·m^2) $c = 2.998 \times 10^8$ m/s $m_p = 1.673 \times 10^{-27}$ kg

$\mu_0 = 4\pi \times 10^{-7}$ T·m/A

1. (2 pts.) Which one of the following statements is **TRUE**?

A. The Earth's magnetic field has always been constant in both strength and direction since the Earth was formed.
B. The Earth's magnetic field is thought to be generated by currents flowing in the Earth's molten metal core.
C. The strength of the Earth's magnetic field is constant at all distances above the Earth's surface.
D. The Earth's magnetic field can be modeled as a giant North magnetic monopole near the center of the Earth.

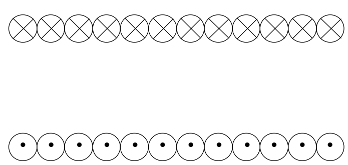
2. (2 pts.) Which THREE of the following *primarily* utilize or depend upon **magnetic fields**? ***Circle three:***

A. formation of the auroras
B. saving data on a computer hard drive
C. using a portable flashlight
D. riding a bicycle
E. bolts of lightning during a storm
F. "swiping" a credit card in a credit-card reader

3. (2 pts.) **Magnetic field lines…**

A. never cross each other at any point in space.
B. are spaced farther apart where magnetic field strength increases.
C. point in the direction that a small positive electric charge would feel a magnetic force.
D. always point toward magnetic North poles.

4. On the lengthwise cross-section of an ideal solenoid below, the "into page" and "out of page" symbols represent the direction of the current I flowing through its coils. (The long axis of the solenoid lies in the plane of the page, its loops of wire extending above and below the page.)



a. (2 pts.) **Sketch the B-field lines inside the solenoid** and a little ways beyond its ends. (The number of field lines does not matter, but the *shape and spacing* do.) Be sure to include directional **arrowheads**.

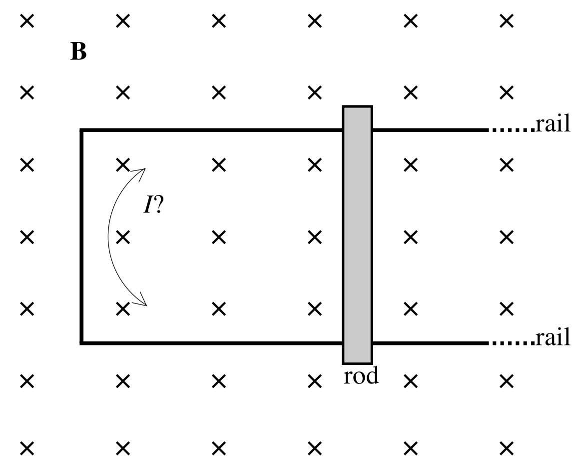
b. (1 pt.) You have a permanent bar magnet handy. The *North pole* of your bar magnet will be *attracted* to **which end** of the solenoid?

A. left end B. right end C. neither end

c. (1 pt.) Suppose the current is turned off and eventually drops to zero. In order to *induce* a new current in the coils in the *same* direction as the current shown in the picture, you could quickly insert the N pole of your permanent bar magnet into **which end** of the solenoid?

A. left end B. right end C. neither end

5. Consider the "sliding-rod generator" shown at right, in which the conducting rod can slide frictionlessly along the metal rails. The apparatus is located in the plane of the page, inside a uniform **B**-field directed into the page.



a. (1 pt.) If the rod is held still, but the **B**-field is quickly doubled in strength, in which direction is a current I induced in the rails?

A. clockwise
B. counter-clockwise
C. no current is induced

b. (1 pt.) If **B** is held constant, but the **rod is pulled to the right**, in which direction is a current I induced in the rails?

A. clockwise
B. counter-clockwise

c. (2 pts.) All of the following are true **EXCEPT**:

A. An external force needs to be applied to the rod to keep it moving at constant speed.
B. The strength of the induced current does NOT depend on the speed of the rod.
C. The strength of the induced current DOES depend on the resistance of the rails and rod.
D. Pulling the rod to the left induces a current in the opposite direction than pulling the rod to the right does.

6. A radio "tuner" circuit contains a fixed-value inductor in series with a variable capacitor.

a. (2 pts.) When the capacitor is adjusted to a value of 1.96 pF, the circuit is tuned to a resonant (natural) frequency of 88.0 MHz. What must be the **inductance** of the inductor in the circuit?

A. 1.67 μH   D. 385 μH
B. 22.0 μH   E. 4.55 mH
C. 83.3 μH   F. 17.1 mH

b. (1 pt.) Suppose that as you turn the radio's "tuner" dial from one end to the other, you increase the resonant frequency from 88.0 MHz to 108 MHz (the full range of FM radio stations). As you do that, how are you **changing** the value of the variable **capacitor**?

A. increasing C B. decreasing C

Physics 152 Roster No.:__________________________

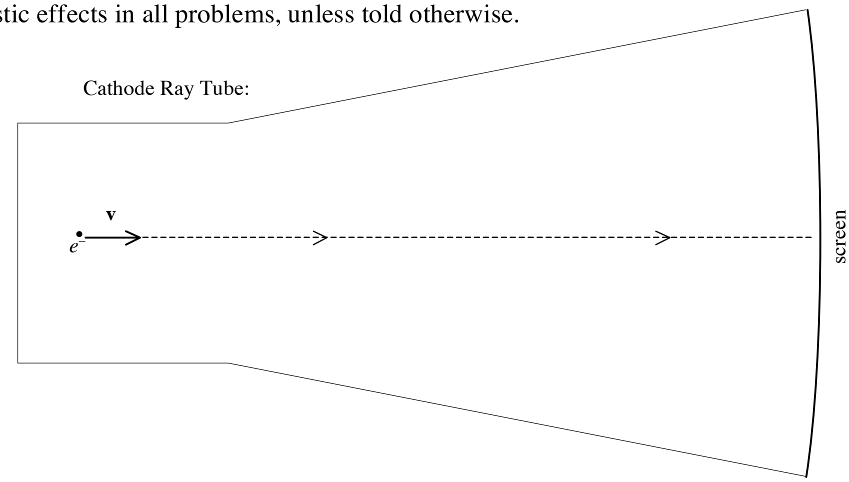
Score:_________33 points possible_____

FALL 2004 Midterm Exam #2, Part B

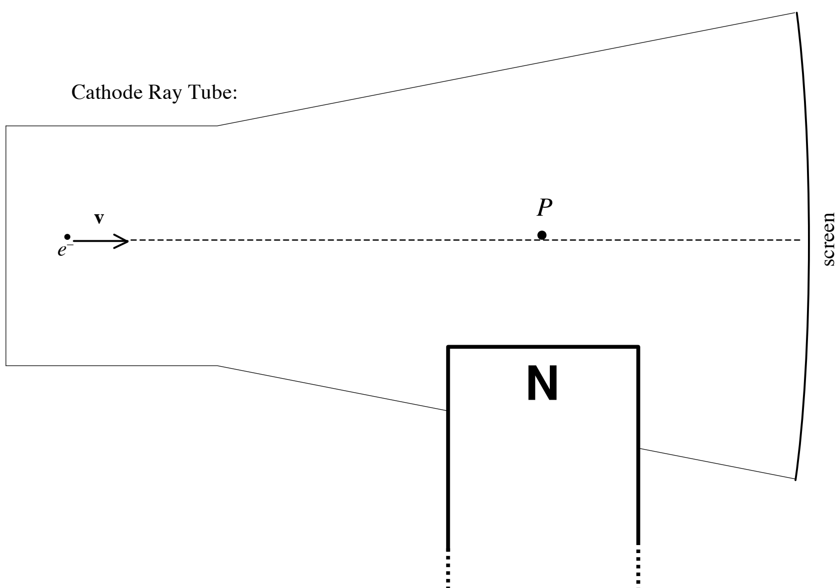
Show your work on all free-response questions. Be sure to use **proper units** and **significant figures** in your final answers. Ignore gravity and relativistic effects in all problems, unless told otherwise.

1. Suppose you have a cathode ray tube (CRT) similar to the one used in a demonstration in class. Inside the CRT, electrons travel at constant **v** from the "gun" at the rear of the CRT toward the screen, where they create a glowing spot at the point where they strike.

The dashed line on the diagram at right shows the undeflected "straight-line" path of the electrons in the absence of any external fields. Assume that this path lies in the plane of the page.



a. (2 pts.) Suppose that you introduce the North pole of a simple bar magnet directly below the CRT, pointing toward the top of the page, as shown below. (The bar magnet lies in the plane of the page. The South end of the bar magnet is located somewhere below the diagram, but is not shown.) **Sketch** 6 to 10 **magnetic field lines** in the space surrounding the North pole of the bar magnet. Include directional **arrowheads** on the field lines.



b. (1 pt.) In which **direction** will the electrons now be **deflected** from their original straight-line path? (You do NOT need to draw the new path on the diagram at left.)

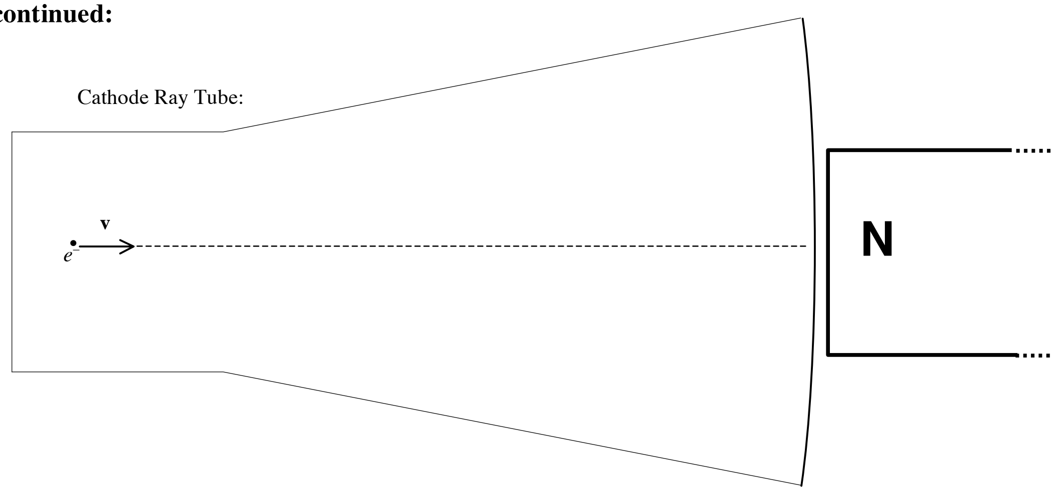
A. toward top of the page
B. toward bottom of the page
C. into the page
D. out of the page
E. undeflected

c. (1 pt.) Suppose that you had used a *South pole* instead of a North pole in the diagram at left. How would **your answer to part (b) change**, if at all?

A. no change
B. change by 90°
C. change by 180°

d. (4 pts.) Suppose that the electron momentarily passes through point P, where $B = 0.0032$ T, the electron's velocity is 8.8×10^6 m/s, and the angle between **v** and **B** is exactly 90°. Calculate the **radius of curvature** of the electron's path at that instant.

1. continued:



e. (1 pt.) Suppose, in a similar but separate experiment, that you introduce the bar magnet's North pole on the right side of the CRT, facing left, as shown in the diagram above. Now, in which **direction** will the electrons be **deflected** from their original straight-line path? (You do NOT need to draw their new path on the diagram above.)

A. toward top of the page
B. toward bottom of the page
C. into the page
D. out of the page
E. undeflected from straight-line path

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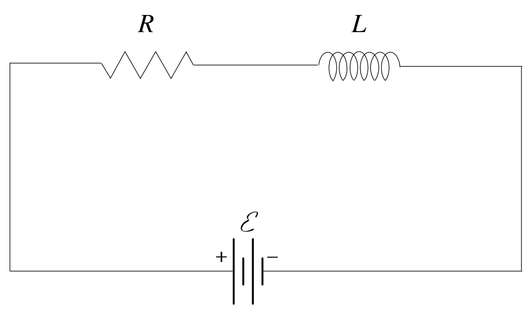
2. Circuit #1 is shown at right:

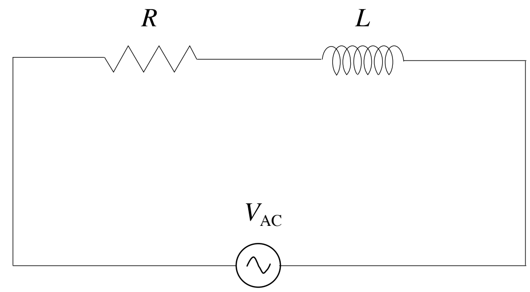


a. (3 pts.) The 450-mH inductor and 18-Ω resistor in circuit #1 are connected in series to a 120.-V *DC battery* at time $t = 0$. *After a very long period of time has passed*, what is the **current** in circuit #1? Show your work.

b. (2 pts.) Qualitatively **graph** the **current** in circuit #1 as a function of **time**. You do not need to label the horizontal axis, but pay attention to $I_{(a)}$ [the value of I calculated in part (a)] on the vertical axis. Start at time $t = 0$, and use the axes at right:

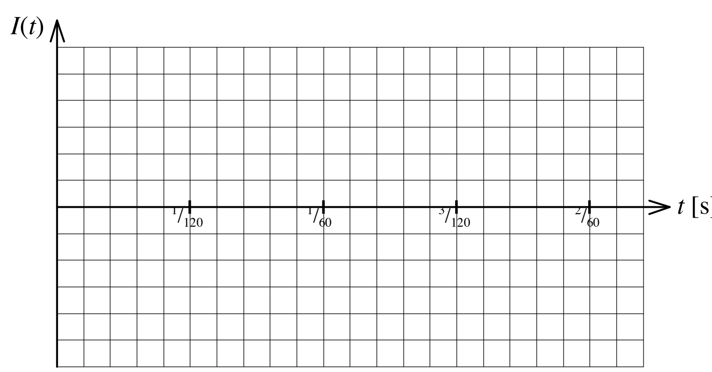
2. continued:

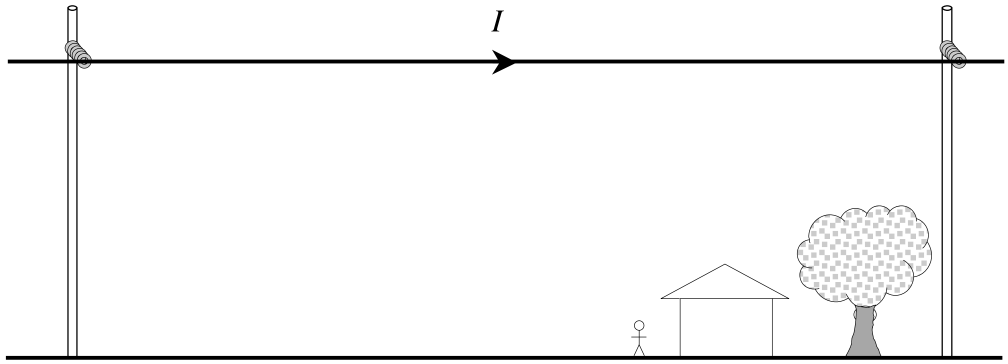
Circuit #2 is shown at right:



c. (6 pts.) In circuit #2, the same 450-mH inductor and 18-Ω resistor are connected in series to a 120-V-rms, 60.0-Hz *AC voltage source*. After a long period of time has passed, what is the **rms current** in circuit #2? Show your work. (*Hint:* You will first need to calculate the **total impedance** of the circuit.)

d. (2 pts.) Qualitatively **graph** the **current** in circuit #2 as a function of **time**. You do not need to label the vertical axis, but pay attention to the values on the *time* axis. Let $t = 0$ occur long after the circuit was first connected. Use the axes at right:





3. Suppose a high-voltage power line passes directly over a house, as shown in the diagram above. At the moment pictured, the wire is carrying a current *to the right*. Both the house and the power line lie in the plane of the page.

a. (1 pt.) At the instant shown above, the current-carrying wire is creating a **B-field** through the house in which **direction**?

A. toward top of the page
B. toward bottom of the page
C. into the page
D. out of the page
E. to the right
F. to the left

b. (4 pts.) HECO's power lines are mounted on poles varying from 24 m to 42 m high. Suppose the power line shown is a low-hanging one, only 24 m above the house, and that the current is 980 A at the moment depicted above. What is the **magnitude of the B-field** through the house at that instant?

c. (1 pt.) What is a typical value for the **strength of the Earth's magnetic field** near the surface of the Earth?

A. 5.0×10^{-5} G
B. 5.0×10^{-3} G
C. 0.5 G
D. 5.0×10^{-3} T
E. 0.5 T
F. 50. T

(*Hint:* This answer is approx. 6 times stronger than your answer to part (b). So, fears about exposure to magnetic fields from overhead power lines are probably unfounded… the Earth's natural magnetic field is far stronger.)

d. (4 pts.) Suppose the 980-A current in part (b) is being carried along the high-voltage power line at 138 kV, and is enough to supply 150,000 homes (roughly half of O‘ahu). The voltage is changed to 120 V for use in our homes by a series of transformers. (Assume the transformers are 100% efficient.) What is the **current** being drawn at **120 V by each individual home**, on average?

e. (1 pt.) Collectively, the transformers in part (d) are: A. **step-up** B. **step-down**