Phys212 Test 3, Spring 2004

Work the following 6 problems/questions.
Show your work and/or explain your answers.
You should draw a meaningful figure for ALL problems.
For maximum credit you should show:

Figure
Basic equation(s) you will use (as it appears in the book, equation sheet, etc.)
Equation(s) with numbers plugged in (if numerical)
Solution to equation (you may need to show at least some of the algebra depending on the problem.)
If you use your calculator to get results, be sure to show explicitly what your entered into the calculator, and
the results it gave you.
Make sure you answer the question and use appropriate units if needed!!!

1. How can a particular element have a permanent magnetic field?

An atom has electrons which orbit around the nucleus. In some elements, these electrons create a magnetic moment. In some atoms, there is a predominance of the electron orbital magnetic moment in a certain direction which makes the atom into a tiny magnet.

2. In the circuit below, A and B are both identical lightbulbs (resistors) and S is a switch. If the inductor starts out with no current in it, describe the brightness of Bulb B when the switch is closed. Be sure to account for the brightness when the switch is first closed, after a long time, and in-between.

1st no current flows through L, so all current is forced into B.

then Current exponentially rises in the inductor, and so the current in B will decrease.

last Inductor acts like a wire so all current goes through L and none in B.

So B starts off bright, then it dims until it is finally out.
3. Two unequal currents are directed in the same direction in parallel wires. What is the direction of the magnetic field at a point midway between the two wires?

A: 
B: 
C: 
D: 
E: 
F: 
G: 
H: 
I: zero (no direction)

4. Consider an inductor which is placed in a branch of an arbitrary circuit. After the circuit has been turned on for a long time, the inductor will behave like what?

A: broken circuit (or open switch)
B: capacitor
C: forward emf battery
D: light bulb
E: resistor
F: reverse emf battery
G: wire

5. When the switch is closed in the circuit below, what will be the direction of induced magnetic flux in the upper loop and the current through the resistor of the upper loop?

Note that clockwise and ccw (counter clockwise) are when the flux is viewed from above.

\[
\begin{array}{c|c|c}
\text{flux} & \text{current} & \\
\text{A:} & \text{right} & \text{right} \\
\text{B:} & \text{left} & \text{left} \\
\text{C:} & \text{up} & \text{right} \\
\text{D:} & \text{up} & \text{left} \\
\text{E:} & \text{down} & \text{right} \\
\text{F:} & \text{down} & \text{left} \\
\text{G:} & \text{clockwise} & \text{right} \\
\text{H:} & \text{ccw} & \text{left} \\
\end{array}
\]
6. The current in the straight wire varies according to the graph. Consider the induced current in the loop. Rank the MAGNITUDE of the induced current for each of the 5 segments. Be sure to indicate if two or more segments result in the same induced current.

\[ I_{\text{wire}} \]

\[ \text{time} \]

\[ \text{wire} \]

\[ \text{loop} \]

\[ \text{Induced} \propto E_{\text{induced}} \]

\[ E_{\text{induced}} \propto \frac{\text{d}I_{\text{wire}}}{\text{d}t} \]

\[ \text{slope} \]

\[ \text{A} \quad \text{D} \quad \text{B} \quad \text{E} \quad \text{C} \]

\[ \text{(least)} \quad \text{A} \quad \text{D} \quad \text{B} \quad \text{E} \quad \text{C} \]

\[ \text{(greatest)} \]

7. In each of the figures below, there is a magnetic field directed out of the page and a thin conducting bar moving through the field in the direction indicated. For which case will the motional emf be the greatest from one tip of the bar to the other. Each bar has the same length and moves at the same speed. **(If two or more cases are equally great, then circle each.)**

\[ \text{we want} \]

\[ \text{B} \quad \text{L} \quad \text{E} \quad \text{V} \]

\[ \text{as much as possible} \]

\[ \text{v} \]

\[ \text{v} \]

\[ \text{v} \]

\[ \text{v} \]

\[ \text{v} \]

\[ \text{v} \]

\[ \text{v} \]

\[ \text{v} \]

\[ \text{v} \]

\[ \text{v} \]
(11 pts)

8. The switch is closed in the circuit below for just long enough for the current in the 200 mH inductor to reach 1.5 A and the charge on the 800 μF capacitor to reach 6 mC. The switch is then opened at this instant when there is BOTH current in the inductor AND charge on the capacitor. Assume that there is no resistance at all anywhere in the circuit.

Find the maximum amount of charge that will ever be on the capacitor.
Find the maximum current which will ever pass through the inductor.
How much time elapses between the maximum charge and the maximum current occurs. (Hint: For this last question, in addition to Phys 212 you will have to use some things from Phys 211.)

\[ E_{\text{total}} = \frac{1}{2} L I_0^2 + \frac{1}{2} \frac{Q_0^2}{C} \]

\[ = \frac{1}{2} (0.24 H)(1.5 A)^2 + \frac{1}{2} \frac{(0.006 C)^2}{0.000 8 F} \]

\[ = 0.225 J + 0.0225 J \]

\[ E_{\text{tot}} = 0.2475 J \]

\[ E_{\text{tot}} = \frac{1}{2} L I_{\text{max}}^2 \]

\[ I_{\text{max}} = 1.57 A \]

\[ Q_{\text{max}} = 0.0199 C \]

\[ t = \frac{1}{4} \phantom{0} \text{period} \]

\[ = \frac{1}{4} \left( \frac{2 \pi}{\omega} \right) \]

\[ = \frac{1}{4} \frac{2 \pi}{\sqrt{LC}} = \frac{\pi}{2 \sqrt{LC}} \]

\[ t = 0.0199 s \]
9. A 40 g, 30 cm long conducting bar slides down on two rails as shown. There is a magnetic field of 2.8 T also shown in figure. The terminal velocity (the velocity when the acceleration is zero) for the falling bar is 170 m/s. What is the resistance in the resistor? In what direction will the current be going through the resistor?

\[ \sum F = ma \]
\[ F_g - mg = 0 \]
\[ F_b = mg \]

I \cdot LB = mg

I = \frac{\Delta V}{R} = \frac{E_{induced}}{R}

E_{induced} = BLV

\frac{E_{induced}}{R} \cdot LB = mg

R = \frac{B^2L^2V}{mg}

= \frac{(2.8T)^2(0.3m)^2(170 \text{ m/s})}{(0.04 \text{ kg})(9.8 \text{ m/s}^2)}

R = 306 \Omega

\text{so current, Emf is clockwise.} \\
\text{Induced is to the left in R.}
10. Using the equations on the equation sheet, determine the magnitude and direction of the magnetic field at point P in the figure below. The current in the wire is 3 A, and note that the wire makes a sharp 90° bend, not a smooth arc.

\[
B_{\text{long wire}} = \frac{\mu_0 I}{2\pi a}
\]

\[
B_{\text{half long wire}} = \frac{1}{2} B_{\text{long wire}}
\]

\[
B_{\text{wire segment}} = \frac{\mu_0 I L}{2\pi a \sqrt{L^2 + 4a^2}}
\]

\[
B_{2/3} = \frac{1}{2} \left( \frac{\mu_0 I L}{2\pi a \sqrt{L^2 + 4a^2}} \right)
\]

\[
B_{1/3} = \frac{\mu_0 I}{4\pi a \sqrt{L^2 + 4a^2}}
\]

But note that \( L = 16 \text{ cm} \)

so if \( a = 8 \text{ cm} \)

\( L = 2a \)

\[
B_{2/3} = \frac{\mu_0 I 2a}{2\pi a \sqrt{4a^2 + 4a^2}}
\]

\[
B_{1/3} = \frac{\mu_0 I}{4\pi \sqrt{a^2 + a^2}} = \frac{\mu_0 I}{4\pi \sqrt{2a^2}}
\]

\[
B = 12.8 \text{ \mu T (into page)}
\]