Physics 208 **EXAM 2** **October 24, 2003**

NAME: SOLUTIONS.

SECTION #: ______

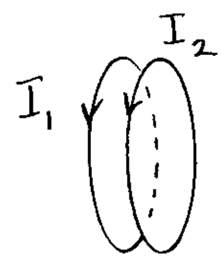
TA: ______

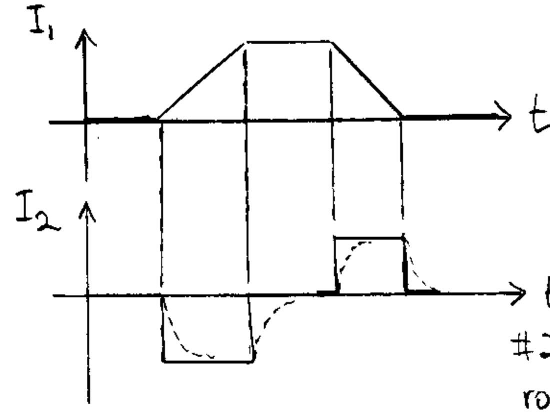
Problem	Points	Score
1	25	
2	20	
3	15	
4	25	
5	15	
Total	100	

- No books or notes are permitted. Use only the formula sheet provided with the exam.
- Write your final answer in the box provided.
- All answers should include units.
- To get credit for a problem you need to show your work in the space provided. If no work is shown you will get no credit, even if the answer in the box is correct. You are expected to work all problems using the basic laws of physics and the equations provided on the formula sheet. If you happen to remember the answer to a particular problem or know a shortcut formula you must still work the problem to get full credit.
- If you need more space, use the back of one of the sheets, and make a note that the work is continued on the back.
- Turn your exam in to your TA when you are finished.

1) Short questions:

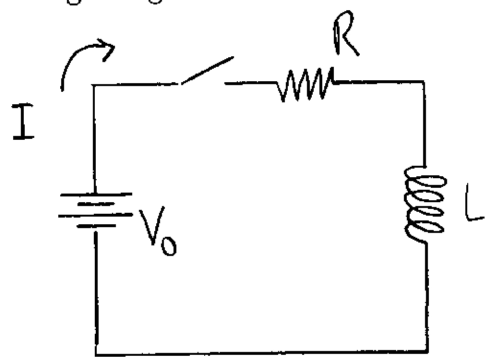
(a) Two coils are located side-by-side as shown in the drawing. The arrows in the drawing define the direction of positive current. Make a sketch showing the general behavior of the induced current, $I_2(t)$, in the right-hand coil, if we pass a current $I_1(t)$ through the left-hand coil.





The current I_1 produces a field $\propto I_1$. If B is changing there is an induced current in coil #2. (If we include the self-inductance of #2 the curves are rounded a bit - dashed lines).

(b) In the circuit shown below the switch is initially open and the current is zero. Make a sketch showing the general behavior of the current as a function of time after the switch is closed.

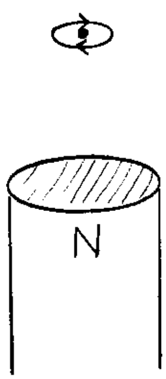


The current exponentially approaches the steady-state value of V_0/R

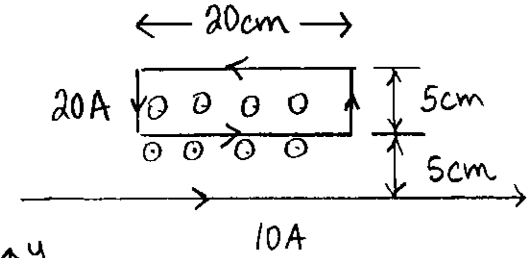
(c) An atom consisting of a single electron orbiting a nucleus is located near the north pole of a magnet as shown. The electron's orbit is clockwise as seen from above. Determine whether the atom is attracted to the magnet or repelled by it. Remember that the electron's charge is **negative**.

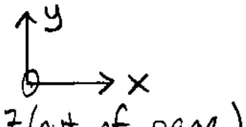
The electron's angular momentum is downward, so the magnetic moment of the atom is upward.

The loop is like a tiny bar magnet with north pole upward. Opposite poles attract, so the atom is attracted to the magnet



2) A square conducting loop is located next to an infinitely long wire as shown in the drawing. The current in the long wire is 10 A and the current in the loop is 20 A Find the magnitude and direction of the force acting on the loop. Use the coordinates shown to specify the direction of $\vec{F}$.





NOTE: Forces on ends of loop are equal + opposite

The long wire produces a field $B = \frac{\mu_0 I_1}{2\pi R}$ out of the page. The resulting force on a length of wire l parallel to the long wire is

$$F = I_2 l B = \left(\frac{\mu_0}{2\pi}\right) I_1 I_2 l / R$$

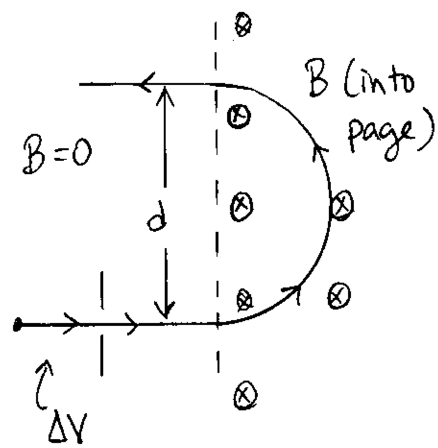
NEAR EDGE $F = (2\times10^{-7})(10A)(20A)(0.2m)/0.05m = 1.6\times10^{-4}N$ downward

FAR " $F =$ " " " " $/(0.10m)$ $= 0.8\times10^{-4}N$ upward

Magnitude: $0.8\times10^{-4}N$

Direction: $-y$

3) A particle of mass m and charge q, starting from rest, accelerates through a potential difference ΔV and then enters a magnetic field, B, as shown in the drawing. Using basic principles of physics together with equations from the formula sheet, obtain a formula for the ratio, q/m, in terms of B, ΔV, and the displacement d shown in the picture.



R = radius of curvature $= \frac{d}{2} = \frac{mv}{qB}$

The velocity comes from acceleration of the charge through the potential difference giving

$$q\Delta V = \frac{1}{2}mv^2$$

From above

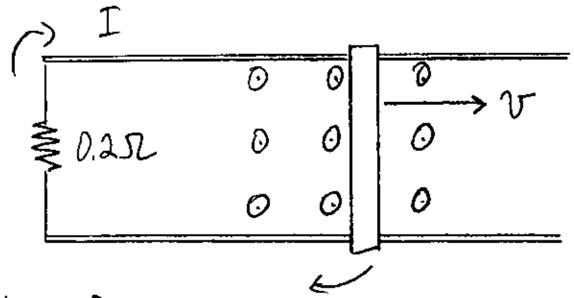
$$v = \left(\frac{d}{2}\right)\left(\frac{qB}{m}\right) \Rightarrow q\Delta V = \frac{1}{2}m\left(\frac{d}{2}\right)^2\left(\frac{qB}{m}\right)^2$$

$$\Delta V = \frac{1}{8}\frac{d^2 q B^2}{m}$$

$$\frac{q}{m} = 8\Delta V / d^2 B^2$$

$8\Delta V / d^2 B^2$

4) A conducting bar 20 cm long slides along a pair of rails, making electrical contact with the rails. The bar moves through a magnetic field of 0.5 T, directed out of the paper. The completed loop circuit has a net resistance of 0.2 Ω. Find the magnitude and direction of the force required to keep the bar moving to the right at a constant speed of 60 cm/s.



There is a motional EMF

$$\mathcal{E} = vBl$$

producing a current

$$I = vBl/R = (0.6\,\text{m/s})(0.5\,\text{T})(0.2\,\text{m})/(0.2\,\Omega) = 0.3\,\text{A}$$

The resulting magnetic force is

$$F = I \cdot l \cdot B = \frac{vBl}{R} \cdot l \cdot B$$

$$= (0.3\,\text{A})(0.2\,\text{m})(0.5\,\text{T}) = 0.03\,\text{N}$$

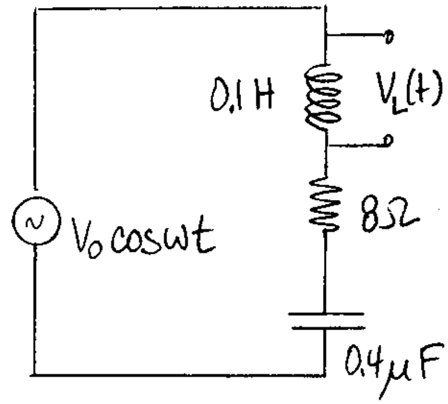
$\vec{F} = I\vec{l} \times \vec{B}$ is to the left.

To keep the bar moving we need to apply an equal force to the right.

Magnitude: 0.03 N

Direction: Right

5) (a) What angular frequency, ω, gives the largest current in the circuit shown?



$I_0 = V_0 / Z \qquad Z = \left[R^2 + (X_L - X_C)^2\right]^{\frac{1}{2}}$

I is maximum when $X_L = X_C$

$\omega L = \frac{1}{\omega C}$

$\omega = \frac{1}{\sqrt{LC}} = 5000/s$

5000 /s

(b) Find the ratio $V_{L,0}/V_0$ at this frequency. Here V_0 stands for the peak voltage from the AC source and $V_{L,0}$ is the peak voltage across the inductor.

$V_{L0} = I_0 \cdot X_L$

$V_0 = I_0 \cdot Z \quad \Rightarrow \quad \frac{V_{L0}}{V_0} = \frac{X_L}{Z} = \frac{X_L}{R}$

$= \frac{\omega L}{R} = \frac{(5000)(0.1)}{8} = 62.5$

62.5