Instructor: Dr. George R. Welch, 301D Doherty Bldg, 845-1571

Print your name **neatly**:

Last name: 

First name: 

*Sign your name: ________________________________*

Please fill in your Student ID number (UIN): ___ ___ ___ ___ ___ ___

**IMPORTANT**

Read these directions carefully:

- There are 7 problems totalling 100 points. Check your exam to make sure you have all the pages. Work each problem on the page the problem is on. You may use the back. If you need extra pages, I have plenty up front.

- **Indicate what you are doing!** We cannot give full credit for merely writing down the answer. **Neatness counts!** I will give generous partial credit if I can tell that you are on the right track. This means you must be *neat* and organized.

- Each problem with its associated figure is self explanatory. If you *must* ask a question, then come to the front, being as discrete as possible so as not to disturb others.

- Put your name on each page it is asked for. You will lose credit if you fail to print your name on each page it is asked for.
Problem 1. 15 points.

There is a uniform magnetic field $B$ (pointing into the page) through a large rectangular region of space. A wire carrying current $I$ goes a distance $a$ directly into the region of field, then bends and comes back out at an angle $\theta$ from its original direction.

Find the $x$ and $y$ components of the force on the wire. Express your answers in terms of $B$, $I$, $l$, $\theta$, and numerical factors.
Problem 2. 20 points.

Consider a long straight wire carrying a current $I$. Suppose that the wire has a circular cross-section of radius $R$, but that $R$ is very small compared to the length of the wire. Assume that the current flows through the wire uniformly distributed over the cross-sectional area of the wire.

(a) What is the magnetic field a distance $r$ from the center of the wire, where $r > R$?

(b) What is the magnetic field a distance $r$ from the center of the wire, where $r < R$?

NOTE: You must show your work and indicate what you are doing. I deliberately made this easy, so you MUST show the process, not just the answer.

If you work neatly I will find more partial credit for you!
Problem 3. 15 points.

Consider two long straight parallel wires, one directly above the other, separated by a distance $2d$. One wire carries a current $I$. The other wire carries an unknown current in the opposite direction. The magnetic field at the point S in the figure is zero. This point is a distance $d$ above the wire with the known current.

The figure shows a cross-section perpendicular to the wires.

(a) Calculate the $x$ and $y$ components of the magnetic field at the point P which is directly between the wires.

(b) Calculate the $x$ and $y$ components of the magnetic field at the point Q which is a distance $\sqrt{2}d$ to the right of the wire with the known current. Note: the $y$ component has very simple expression. Do not give me any complicated expression. Simplify it.

Make sure you are being neat. Working neatly will help you get it right.
Problem 4. (20 points)

A long straight wire carries a changing current $i(t)$. A rectangular loop of wire is placed near the long straight wire. The loop is made of a resistive material and the total resistance of the loop is $R$. The distance from the long straight wire to the near edge of the loop is $c$, and the width and height of the loop are $a$ and $b$ respectively. All these dimensions ($a$, $b$, and $c$) are much smaller than the length of the long straight wire. The situation is shown in the Figure.

Suppose that the current in the long straight wire varies according to

$$i(t) = \begin{cases} 
I_0 & 0 < t < \tau \\
0 & t > \tau 
\end{cases}$$

Calculate the magnitude and direction (clockwise or counter-clockwise) of the current induced in the loop, for $0 < t < \tau$.

Work neatly! If you are neat, I can read what you did and maybe find more points for you.
Problem 5. (10 points)

For each of the following 5 cases (a)–(e) there is a loop of wire denoted $A$ near another wire that is conducting some current. In each case, current is induced in loop $A$. Indicate whether the induced current is clockwise or counter-clockwise.

Please only write either “clockwise” or “counter-clockwise” as the answer for each case.

Points: 5 correct = 10 points, 4 correct = 7 points, 3 correct = 3 points.

(a) \[ \text{I increasing} \quad \text{Answer: } \]

(b) \[ \text{I decreasing} \quad \text{Answer: } \]

(c) \[ \text{I increasing} \quad \text{Answer: } \]

(d) \[ \text{I increasing} \quad \text{Answer: } \]

(e) \[ \text{I constant} \quad \text{Loop moving to right} \quad \text{Answer: } \]

Print your name: ________________________________

Physics 208: Electricity and Magnetism, Exam 2
Problem 6. (5 points)

The following laws were found empirically and formed the basis for understanding the interaction of charges and currents.

Gauss:

\[ \oint \vec{E} \cdot d\vec{A} = \frac{Q_{\text{inside}}}{\varepsilon_0} \]

\[ \oint \vec{B} \cdot d\vec{A} = 0 \]

Ampère:

\[ \oint \vec{B} \cdot d\vec{l} = \mu_0 I_{\text{enclosed}} \]

Faraday:

\[ \oint \vec{E} \cdot d\vec{l} = -\frac{d}{dt} \Phi_B \]

Indicate which one of these laws Maxwell changed in advance of his prediction of electromagnetic waves, and write down the corrected version of that law.

You should be neat. You are more likely to get it right if you work neatly.
Problem 7. (15 points)

Consider the circuit shown below. Initially, both switches are open.

(a) Suppose the switch $S_1$ is closed. What is the current through $R_2$ immediately after this happens?

(b) Now suppose we wait a long time after closing switch $S_1$. What is the current through $R_2$ then?

(c) Now, after waiting a long time as above, suppose we close switch $S_2$. What is the current through $R_2$ immediately after that?

(d) Now, write an equation for the current through $R_2$ as a function of time, taking $t = 0$ to be the moment $S_2$ is closed (in part c).

Working *neatly* will help you think about what you are doing.