Physics 211L

Final Exam   January 2006

Name:________________________________ID__________________

Section: M-1   M-3   T-1   T-3   W-1   W-3   Th-1   Th-3   F-1   F-3

1. The magnetic field due to a long straight current -carrying wire is measured by means of a Tesla meter, which has not been properly zeroed (**Ignore the magnetic field of the Earth**). The magnetic field ***H*** and the probe-head distance from the wire ***d*** are recorded, with the following results:

H (mT)	***d***(mm)					
3.42	2.0					
2.26	3.1					
1.80	3.9					
1.55	5.1					
1.32	6.2					

The current is kept constant at 30.1 A; the ammeter tolerance is 2%.
Write the relation between ***H*** and ***d***. Choose the proper variables and use linear regression to find the permeability of free space ($_0$) and the meter reading when it is very far from the wire. Compare $_0$ to the literature value x 10^{-7} SI. **(60%)**

2. How did you measure currents in the PHYS211L DMM experiment? (10%)

3. Why is the electron track visible in your PHYS211L e/m experiment? The electrons circulate counterclockwise, looking from above; what is the direction of the magnetic field? (10%)

4. In your best PHYS211L transformer configuration the primary coil has 400 turns while the secondary has 1600 turns. The input voltage is 1 $V_{p\text{-}p}$ and the input current is 20 mA at 70Hz. What are the expected values of the open circuit voltage and short circuit current in the secondary coil? Do you expect the measured values to be more or less than expected? Why? (12%)

5. Why can you <u>not</u> use the PHYS 211L Wheatstone Bridge to measure the resistances of your metal rods? (8 %)

LINEAR REGRESSION

Many experiments yield a series of pairs of data values. Usually the x_i values are selected and the y_i values are measured.
The *method of least squares* is used to fit a curve (find a theoretical equation) to a set of experimental data. First assume that a linear relation exists between y and x

$$y = Ax + B \qquad (1)$$

Substitution of $x = x_i$ will in general not give the value of y_i

$$e_i = y \quad y_i = Ax_i + B \quad y_i \qquad (2)$$

To determine the best straight line that fits the N, sets of data, A and B have to be chosen

simultaneous equations, obtained by equating the partial derivatives of $(y \quad y_i)^2$ with respect to A and B to zero, should be solved. This condition leads then to the following results

$$A = \frac{N\sum(x_i y_i) - \sum x_i \sum y_i}{\Delta} \qquad (3)$$

and

$$B = \frac{\sum x_i^2 \sum y_i - \sum x_i \sum (x_i y_i)}{\Delta} \qquad (4)$$

where

$$\Delta = N\sum x_i^2 - (\sum x_i)^2 \qquad (5)$$

The *correlation coefficient r* provides an indicator of how good a fit the best straight line is. This coefficient is defined as

$$r = \frac{\sum(x_i - \bar{x})(y_i - \bar{y})}{\sqrt{\sum(x_i - \bar{x})^2 \sum(y_i - \bar{y})^2}} \qquad (6)$$

For $r = 0$, the values of x and y are independent of one another and there is no linear correlation. The closer r is to +1 or to 1, the better the linear correlation is.
Finally, the errors in A and B are given by:

$$s_A^2 = \frac{N}{N-2}\frac{\sum e_i^2}{\Delta} \qquad s_B^2 = \frac{s_A^2 \Sigma x_i^2}{N}$$

(7)