Physics 210L Final exam

January 12, 2008

Name:_____

Section number:_____

Instructor's Name:_____

ID number:_____

DO NOT START THE EXAM BEFORE YOU ARE TOLD TO BEGIN

Grading

I	
II-1	
II-2	
II-3	
TOTAL	

The duration of this exam is 60 minutes.

No notes or books allowed.

Scientific calculators are allowed

All results should be given with the exact number of significant figures.

I. (50%)

In the "Standing Waves on a Stretched String" experiment, the string length is changed and the corresponding resonant frequencies are measured. The hanging mass is $M=12Kg \pm 6\%$

The following results were obtained for the **2nd Harmonic** standing waves**.**

L(cm)	f(KHz)				
50	1.297				
60	0.901				
70	0.662				
80	0.507				
90	0.400				

You may find the formulae on page 4 useful.

a- Write down the necessary equation. **(10%)**

b- Choose your variables such that you obtain a linear relationship between them. **(10%)**

c- Use linear regression to find the slope of your line along with its error. **(15%)**

d- Determine from the slope the linear density of the string along with its error. **(15%)**

Linear Regression

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

$$y = Ax + B \tag{1}$$

Substitution of $x = x_i$ will in general not give the value of y_i. The "errors" will be

$$e_i = y - y_i = Ax_i + B - y_i \tag{2}$$

To determine the best straight line that fits the N, sets of data, A and B have to be chosen so that the sum of the squares of the "errors" is minimized. This means that the simultaneous equations, obtained by equating the partial derivatives of $(y - y_i)^2$ with respect to A and B to zero, should be solved. This condition leads then to the following results

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

and

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

where

$$\Delta = N\sum x_i^2 - (\sum x_i)^2 \tag{5}$$

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

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

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 error in A is given by:

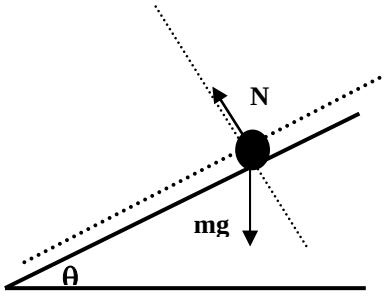
$$\sigma_A^2 = \frac{N}{N-2}\frac{\sum e_i^2}{\Delta}$$

II. Questions

1. **(15%)** In the "Michelson Interferometer" experiment,
   a- Explain why the interference fringes shown on the screen appear to move when we change the inclination of the glass plate placed between the beam splitter and the mirror. **(8%)**

   b- In this part of the experiment what variables were measured in order to determine the index of refraction of the glass plate? **(7%)**

2. (20%) In an attempt to determine the gravitational acceleration experimentally, the motion of an object down an inclined frictionless surface was studied. The time needed to cover a certain distance d was measured. The inclination angle is $\theta = 17^o \pm 0.1\%$ .The following results were obtained:



t(seconds)	d(cm)	a( )
0.198	6	
0.262	10	
0.286	12	
0.321	14	

a- Determine the average value of the acceleration down the incline along with its error**. (10%)**

b- Derive the relationship between the acceleration a, the gravitational acceleration g, and the inclination angle θ.**(5%)**

c- Find g along with its error. **(5%)**

3. What are the different parts of a spectrometer and what are the functions of each? **(15%)**