Physics 204L 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.

Useful Information:

The speed of sound in air is v= (331m/s)$\sqrt{\frac{T}{273K}}$

The mechanical equivalent of heat is 4.186J/cal

Energy needed to raise the temperature of mass m by ΔT is Q=mcΔT

I. **(50%)**

In the mechanical equivalent of heat experiment several trials were done, each time increasing the mechanical work produced by increasing the number of turns of the calorimeter and as a result increasing the temperature of the calorimeter. The following measurements were taken:

Number of turns n	ΔT			
200	7.9			
250	10.1			
300	13.0			
350	14.3			
400	16.8			

Given that: The diameter of the frictional surface of the calorimeter is d= (5.8 $\pm$ 0.2) cm and the mass of the empty calorimeter is m= 653 g. The hanging mass is M=6 Kg $\pm 2\%$. The change in heat of the water and the thermometer in the calorimeter is $2\Delta T$.

Neglect in your analysis the error on m.
You may find the formulae on page 4 useful.

1. Write down the necessary equation. **(10%)**

2. Choose your variables so that you obtain a linear relationship between them. **(10%)**

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

4. Determine the specific heat of the material from which the calorimeter is made 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

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

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

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

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

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

and

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

where

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

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

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

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.

1. (20%) In the heat engine experiment,

a- What instruments/sensors did we use to measure the variables: pressure, volume and temperature? **(8%)**

b- Was the heat engine we worked with a Carnot engine? Explain. **(8%)**

c- Using the same equipments that were available in the lab, explain how we can perform Boyle's law experiment? How do you measure the variables? (Specify sensors and instruments used) **(4%)**

2. Explain briefly the procedure that was followed in the "Interference and Diffraction" experiment. Include all equations that were used. **(15%)**

3. (15%) Standing sound waves are produced in a plastic tube of air. The frequency is changed and for each frequency the node-to-node distance is measured. The following measurements are taken:

Frequency(KHz)	0.5	1	1.5	2	2.5	3	3.5
d(cm)	36.2	18.3	10.8	8.6	6.8	5.9	4.4
v( )							

a- Using the above information determine the average value of the speed of sound along with its error. **(10%)**

b- Compare to the theoretically accepted value of the speed of sound in air if the experiment was done in an atmospheric temperature of 25^oC. **(5%)**