Last Name (PRINT)_____ **First Name (PRINT)**_____

Student Number_____ **Lab Section**_____ **TA**_____

(1) **You are required to answer 4 problems.** Each problem is worth 25 points for a total of 100.
   a. **1 and 2 mandatory**
   b. **pick two** from the remaining problems

   Clearly indicate the two you wish to be graded. If not, when it comes time to calculate your score, the two questions will be randomly selected.

(2) **Questions 1 and 5 are experiment questions. Image sets have been generated for these questions. You need to read measurements and collect the data. They can in folders under appropriate names in Blackboard → Course Material → Exam 1.**

(3) Questions 2 and 4 are data analysis questions. An excel file has been generated and is placed in Blackboard → Course Material → Exam 1 → Data. Use assigned data file and conduct the lab.

(4) You need to save and submit the excel file. Before submitting your Excel file be sure to rename the file with your name and section # according to "Sec_#_Last Name" - Example: Sec_1_Smith.

(5) A portal is opened in the same folder for you to upload the answer sheets. You are required to answer on white papers and submit them as you do with your lab reports.

(6) **Show your work - formulas** and your **calculations**, numerical work, you used to arrive at your answers. The only exceptions are values produced by the DV Stats macros in *Excel*. You may just write "From macro: ###" for a number produced by it. Remember, you still need to show your work—formulas and calculations—for any results using those numbers.

(7) Make sure your work is **neat** and well **organized**. Feel free to work on the back of the page of a problem you are working on.

(8) Place your **final answer in the space provided**. For example: g = _____. Otherwise, clearly indicate with a **circle** what your final answer is for a given question.

P.1 _____

P.2 _____

P.3 _____

P.4 _____

P.5 _____

Total _____

This area is for the graders.

Problem 1: The Speed of Sound

a) **(10 points)** In the table record the appropriate data required to compute the speed of sound. Formally report your best estimate for the speed of sound in air. Test your accuracy against $v_{acc} = 342.900\ m/s$, which assumes a temperature of 18^0C and is calculated from the following: $v = 20.096\sqrt{T + 273.15}\ m/s$.

time (ms)	position (cm)

Before rounding

$\boldsymbol{v_{exp}} =$ $\pm$

$\%\ \boldsymbol{diff} =$

After rounding

$\boldsymbol{v_{exp}} =$ $\pm$

$\%\ \boldsymbol{diff} =$

b) **(5 points)** Perform your standard test comparing precision to accuracy. In a sentence or two, comment on the result. You may assume any non-temperature environmental effects are negligible.

c) **(5 points)** As previously mentioned, the speed of sound in air is dependent on the temperature. More than likely our lab room is not 18^0C. Use the appropriate equation to determine the temperature in the room using your experimental value for the speed of sound.

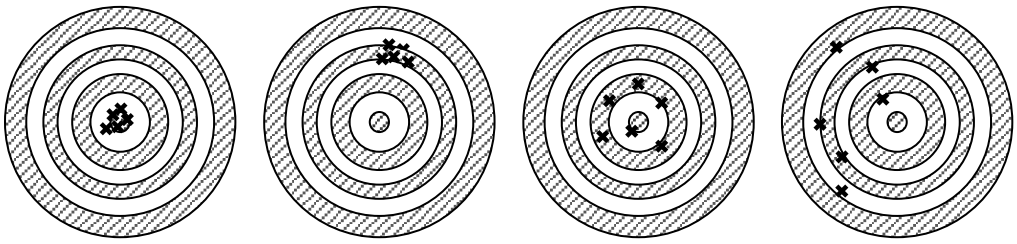
$T =$ _____ $\pm$ _____

d) **(5 Points)** Properly round and report the experimental value x_o using the data from part a.

Before rounding *After rounding*

Problem 2: (Miscellaneous)

i) (10 points) The centers of the below targets represent a true (or "accepted") physical value. Each cross represents a data point for one measurement of this value.



A B C D

***Circle your choices*:**

1. Which picture shows higher precision?	A	or	C
2. Which picture shows higher accuracy?	B	or	C
3. Which shows higher standard deviation?	C	or	B
4. Which shows a higher percent difference?	A	or	B
5. Which has stronger evidence of systematic error?	B	or	C
6. Which has stronger evidence of random error?	B	or	D
7. Which has stronger evidence of systematic error?	C	or	D
8. Which shows higher random error?	B	or	C
9. Which shows higher random error?	C	or	D
10. Which shows higher percent difference?	B	or	C

ii) (5 points) A bird flies a distance $d = 120 \pm 3$ m during a time $t = 20.0 \pm 1.2$ s. Using this information find the bird's average speed and the uncertainty in the bird's speed. Properly report your answer.

$v =$ _____ $\pm$ _____

iii) Given the following calculations, show the correct formula to propagate the specified error. Show all necessary steps. Treat barred variables (ex: a) as average values based on measurement, π should be treated as a constant.

(a) **(3 points)** $P = \bar{B} - \bar{C} - \bar{D} - 7\pi + \bar{E}$

$S_P =$

(b) **(3 points)** $W = \pi\, \bar{q}^2$

$S_W =$

(c) **(4 points)** $k = (3\bar{w}^4) - \bar{L}^2$

$S_k =$

Problem 3: (Datasheet) The Kinematics of Free Fall

The kinematics of free fall experiment was performed with a metal bob between two wires sparking at 60 Hz, released by an electromagnet. Its data is shown in the adjacent table and in the *Excel sheet provided*. The goal here will be to find the acceleration due to gravity, g.

(a) **(10 points)** Perform 2D stats on appropriate linearized data. **Show your work.**

$\boldsymbol{slope} =$	$\pm$

(b) **(5 points)** Using the results from part (a), calculate and formally report the experimental value for the acceleration of gravity. Check its accuracy using $g_{acc} = 980.35\ cm/s^2$.

Before rounding

$\boldsymbol{g} =$	$\pm$
$\%\ \boldsymbol{diff} =$	

After rounding

$\boldsymbol{g} =$	$\pm$
$\%\ \boldsymbol{diff} =$	

(c) **(10 points)** Is systematic error negligible? Why or why not? If yes, what is the most likely *physical* error?

Problem 4: (Datasheet) Density of glycerin

An experiment similar to the one you performed to find the density of water is done to find the density of glycerin. The table shows the data recorded directly from the double-pan balance and the graduated cylinder and can be found in the *Excel sheet provided*. The experimenter **forgot** to find the mass of the cylinder. At 20 ^{0}C and normal pressure, the accepted value for the density of glycerin is $\rho_{acc} = 1.26108\ g/mL$.

a) **(15 points)** Calculate and formally report the experimentally determined density of saline solution. (Please provide an explanation of how you got your answer)

Before rounding

$\boldsymbol{\rho_{exp}} =$ $\pm$

$\%\ \boldsymbol{diff} =$

After rounding

$\boldsymbol{\rho_{exp}} =$ $\pm$

$\%\ \boldsymbol{diff} =$

b) **(10 points)** Calculate and formally report the mass of the cylinder. (Please provide an explanation of how you got your answer)

Before rounding

$\boldsymbol{m_{cyl}} =$ $\pm$

After rounding

$\boldsymbol{m_{cyl}} =$ $\pm$

Problem 5: (Experiment) Density of unknown material

a) **(10 points)** Compute the density of the unknown material.

List and measure the appropriate dimensions of the object in order to compute density. For each dimension please record five measurements. Use the table below to record your data and fill in volume and density column.

	Mass, m	Height, h	Width, w	Diameter, d			
Units							
1							
2							
3							
4							
5							

b) **(12 points)** Formally report your best estimate of the density of the material. Show your work for the computation of the density $\overline{\rho_{exp}}$ and the standard error $S_{\overline{\rho_{exp}}}$.

Before rounding *After rounding*

$\boldsymbol{Density} =$ $\pm$	$\boldsymbol{Density} =$ $\pm$

c) (**3 points**) The density of plastic at room temperature is $3.9\ {}^{g}/_{cm^3}$ and the density of PLA, the plastic used in 3D printers is $0.308\ {}^{g}/_{cm^3}$. Determine what material was used for this object.