**PHSX 101L** **Experiment 2** **Name:**______________________

Title: Accuracy and Precision: Mass and Speed

Object: To learn how to improve accuracy and precision of measurements by determining the speed of sound with simple distance and time measurements, and by measuring the mass of some pennies.

Introduction: Precision is indicated by how well a group of measurements of the same quantity agree. The more precise the measurements, the more significant figures there will be and the closer they will agree. Accuracy is an indication of how well a measurement agrees with a "true" or accepted value (usually a consensus of many measurements by expert scientists).

Mass of Pennies: The mass of objects can be determined with the equal-arm balance, as in the previous lab, or with a beam balance. The beam balances we have allow for more precision than the equal-arm balances you used last week. They both work by comparing the object to a standard mass, and both would work in regions of different gravitation. A spring scale, on the other hand, would give different readings on the moon than on the earth because it measures weight, not mass. Careful measurement of 20 pennies, provided by the instructor, may reveal some interesting results.

Speed of Sound: The average speed of an object is the distance it travels divided by the time it takes to do so. The average speed of an olympic sprinter could be determined by dividing the distance of the race, 100 m, by the time it takes, 10 s, giving a speed of 10 m/s. If your hair grows 3/4 inch in a month, then the speed of the end of your hair is 0.75 inch/month. If you could measure the amount of time needed for light to travel one foot, you would find that it would take about 1 ns, so the speed of light is about 1 ft/ns which is equivalent to about $3.00 \times 10^8$ m/s.

By measuring a certain distance and the time it takes sound to travel that distance you can determine the speed of sound. (Because the speed of light (cited above) is so much greater than the speed of sound, you can ignore the time it takes for the light to travel the distance.) The precision of your measurement can be increased by measuring the same quantities a number of times and averaging the results. You should also try to improve the accuracy of your value by repeating the experiment for various distances and techniques.

Procedure and Results:

Mass of Pennies:

1. *Zero* the beam balance by adjusting it to read zero with zero load.
2. Find the mass of each penny to the nearest hundredth of a gram and record it in the table.
3. Zero the balance again after you are through.
4. Make a histogram (bar graph) of your measurements by plotting the frequency (number of coins) in each mass interval (bin) in your series of measurements.

| Penny Number | Mass (g) | Year Made |
|---|---|---|
| 1 | | |
| 2 | | |
| 3 | | |
| 4 | | |
| 5 | | |
| 6 | | |
| 7 | | |
| 8 | | |
| 9 | | |
| 10 | | |
| 11 | | |
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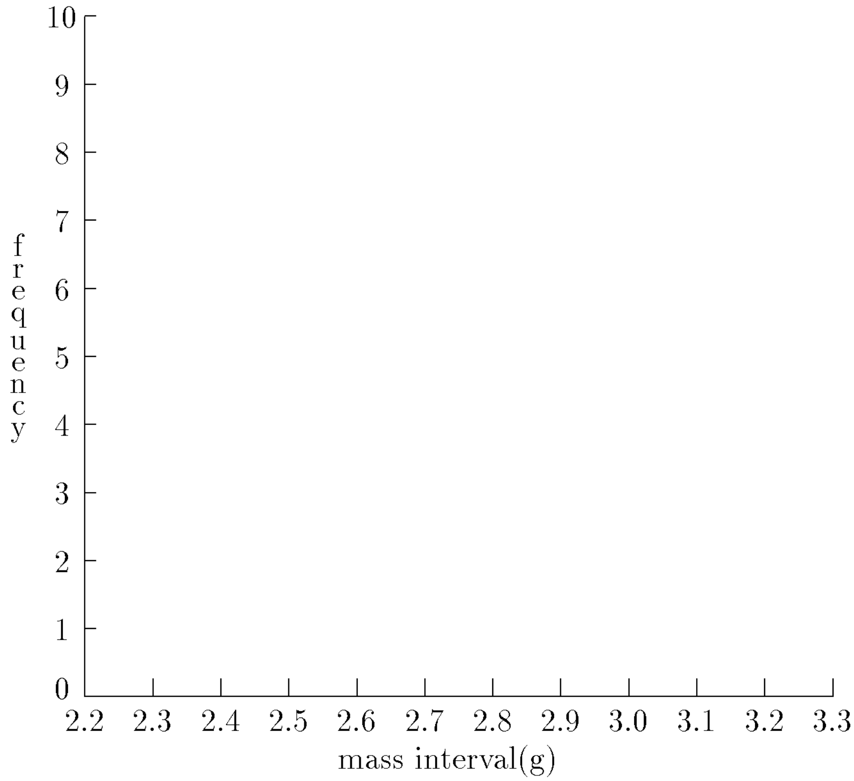
| 17 | | |
| 18 | | |
| 19 | | |
| 20 | | |




Speed of Sound: Carefully design your own experiment to measure the speed of sound and write the procedure (including a description and diagrams of the apparatus you will need). Include multiple trials that demonstrate the principles in the introduction above. You might want to utilize an echo from a flat wall of a building. Use well-labeled tables and graphs where appropriate to record and display your data. A graph of distance (vertical axis) vs. time (horizontal axis) should produce a straight line whose slope is the speed. Be sure to compare your value for the speed of sound with accepted value given by $v \approx 20.0\sqrt{T}$, where $T$ is the air temperature in Kelvin (Celsius plus 273); *i.e.*, compute your percent error. Write your procedure here:

Put your data and results here:

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Discussion:

Mass of Pennies:

1. Did your histogram reveal information about the pennies that was not apparent just by looking at them?

2. How do you account for the two-humped (bi-modal) nature of the histogram?

3. Discuss the validity of measuring all 20 pennies at once and dividing by 20 to get the mass of an average penny.

Speed of Sound:

1. How many measurements did you make? Why this number? If precision gets better with more measurements, how do you know how many measurements you should make?

2. How could you have done this experiment before the invention of the clock, and how would the precision compare?

3. How much of a role did human reaction time play in your results? (Try to be quantitative here, don't just say "a lot" or something.)

Conclusions: