**PHYS 101 - Measurement and Uncertainty in Scientific Experiments**

Final Grade: 25.5/34 = 75%

**Worksheet**

*Complete the worksheet as a group and turn in a single document with your names.*

\_\_\_\_\_\_\_Lulu Girroir\_\_\_\_\_\_\_\_\_\_\_\_\_\_ \_\_\_\_\_Evan Gallagher???\_\_\_\_\_\_\_\_\_\_\_\_\_

\_\_\_\_\_\_\_\_Le Phu\_\_\_\_\_\_\_\_\_\_\_\_\_ \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

*Show all work and calculations to receive full credit! You may use additional sheets.*

1. Significant Figures
   1. Suppose you are measuring the mass of a pendulum bob on an electronic mass balance. The mass balance reads “10.4 g”. How many significant figures does this reading have?

This reading has 3 significant figures.

* 1. What is the relative uncertainty of this measurement, expressed as a percent error? (recall that the precision of an electronic instrument is usually equal to the smallest difference it can detect, 0.1 g in this case)

The relative uncertainty for this case is plus or minus 0.1 grams.

3/8; b: relative uncertainty as percent error is 0.1/10.4\*100%, c: write as 1.040 \* 10^1 m to make not ambiguous

* 1. Suppose you measure the mass with a more precise electronic mass balance, that can measure mass with a precision of 0.01 g. If the mass balance reads “10.40 g”, how many significant digits are there? Write this value so that the number of significant digits is not ambiguous.

There would be 4 in 10.40, but to adjust this so that it is not ambiguous, it would be 10.4 plus or minus 0.01.

1. Propagation of Uncertainty

You are asked to measure the volume of a spherical object. Knowing that the volume, V, is related to the radius, R, by , you measure the radius to be 2.2 cm ± 0.1 cm.

* 1. Convert the measurement of the radius to meters and express the radius in scientific notation.

The conversion from cm to m would be 2.2 \* 10^-2 meters

1/2; error?

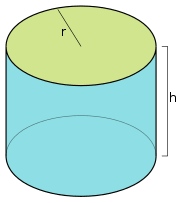
* 1. Calculate the volume of the sphere (in cubic meters) using the measured radius and determine the **maximum relative uncertainty**

= 4.5 \*

=

4.5/5; max relative uncertainty is ∆V/V, not V/∆V

* 1. You now calculate the volume of a cylindrical object. The height is measured to be 5.2 cm ± 0.05 cm and the radius is measured to be 2.5 cm ± 0.05 cm. Calculate the volume and the **maximum relative uncertainty** of the volume calculation.



4/5; max relative uncertainty?

V = (

= 102.1

*((2*

1. Statistical Errors

*Watch “Video 4 – Ramp Experiment” before doing these exercises*

Your use a compressed spring to launch a wheeled cart up an inclined ramp (see video). We wish to know how far the cart is launched up the ramp, and this displacement can be measured using the ramp’s built-in ruler. The starting position of the cart is measured, and the displacement is then the difference between the starting and ending positions. To determine the precision of this measurement, you repeat and record your measurements 10 times.

Use the data to report an **average value** of the displacement and calculate the **standard deviation** and **standard error** in this value. Convert your standard error to a **percent error.** If you use Excel or some other program to automate these calculations, please include the Excel file or a screenshot of your work.

DATA:

|  |  |  |
| --- | --- | --- |
| Trial | End position (cm) | Displacement (cm) |
| 1 | 44.1 | 10.9 |
| 2 | 44.5 | 11.3 |
| 3 | 44.4 | 11.2 |
| 4 | 44.9 | 11.7 |
| 5 | 43.8 | 10.6 |
| 6 | 44.2 | 11.0 |
| 7 | 46.9 | 13.7 |
| 8 | 44.1 | 10.9 |
| 9 | 44.8 | 11.6 |
| 10 | 44.4 | 11.2 |

Average Value = (10.9+11.3+11.2+11.7+10.6+11.0+13.7+10.9+11.6+11.2)/10 = 11.4

Standard Deviation = (10.9-11.4)^2 + (11.3-11.4)^2 + (11.2-11.4)^2 + (11.7 – 11.4)^2 + (10.6 – 11.4)^2 + (11.0 – 11.4)^2 + (13.7-11.4)^2 + (10.9 – 11.4)^2 + (11.6 – 11.4)^2 + (11.2 – 11.40)^2 = 6.81/10 = 0.681 sqrt(0.681) = 0.825

Standard Error = 0.825/sqrt(10) = 0.261

7/8; % error is (stderror/avg)\*100%

Percent Error = 0.261\*100 = 26.1%

* 1. Comment on the “spread” of the data and what it says about the precision of your measurements.

The range of the data is 3.1 cm with over the course of the max and the min. Given the standard error, the percent error is 26.1%. Based on this fact, the measurements are not very precise since the percent error is so high. Regardless of the small range, the majority of the data values are a distance away from the average which yields a larger standard deviation which means a more widely spread data set. Therefore, the percent error will be larger.

* 1. Identify specific sources of uncertainty in this experiment. Then, suggest some ways to reduce uncertainty and improve the precision.

In order to make the uncertainty smaller, a more precise way of measuring the displacement is needed. Therefore, the spread of the data will be smaller. A way to do this would be to use a motion sensor and timer to measure the displacement of the cars starting and stopping points more precisely. This will therefore decrease the spread of the data and lower the uncertainty.

13/14 total