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

**Worksheet**

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

\_Talia Spolansky \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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*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?

3 significant digits

* 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)

0.4/10= 4% uncertainty

* 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.

4 significant figures- 1.040\*10^1

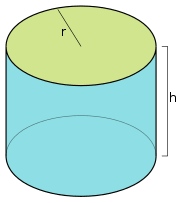
1. Propagation of Uncertainty

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.

2.2 cm 1m/100 cm = **0.022 m , 2.2 \* 10^2 m**

* 1. Calculate the volume of the sphere (in cubic meters) using the measured radius and determine the **maximum relative uncertainty**.
  2. 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.



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 = 11.41

Standard Deviation = 0.825

Standard Error = 0.276

Percent Error =

Graphical user interface, application, table, Excel

Description automatically generated

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

Since we don’t know the relevance of the standard deviation value, we can look at the percent error for accuracy. The percent error is >20%, implying that the data is fairly inaccurate.

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

Sources of uncertainty can vary from environmental causes, such as friction from the ramp on the cart, or air resistance as the cart moves. Narrowing down the data could be done by using different equipment, such as a motion sensor, to also detect velocity to determine displacement using kinematics.