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

32.5/34

**Worksheet**

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

Andrew Galitzer

Quy Van

Alvin Abraham

*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?

8/8

This reading has 3 significant numbers

* 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)

0.1/10.4 x 100 = **.96%**

* 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.

In this case, there should be 4 sig figs because the 0 was in the last digit. To note that the 0 is a sig fig, we can write it in scientific notation:

**1.040 x 101 g**

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.

1.5/2; error?

2.2 cm \* 1 m/ 100 cm = 0.022 meters = **2.2 \* 10-2 meter**

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

V = 4/3 \* *π (0.022)* 3

4/5; off by a factor of 100 – need to convert error to meters

V**= 4.46×10−5 m3**

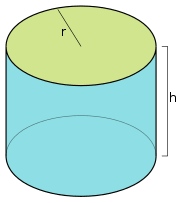
Propagation of error: dV=(dV/dR) (dR)

dV=(4pi r2) (.1) = (4pi .0222) (.1) = 6.08×10−4 = **6.1×10−4**

Maximum relative uncertainty = dv/V = (6.1×10−4 ) /( 4.46×10−5) = **13.7**

Percentage: 13.7 x 100 = **1370%**

* 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.



5/5

V = π \* r2 \* h

V = π \* (2.5)2 \* (5.2)

V = π \* 6.25\*5.2

V = π \* 32.5

V = 102.1 cm3

Work done on paper. Pasted below:

dV= 5.07 cm 3

**maximum relative uncertainty = 4.97%**

Text, letter

Description automatically generated

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.

14/14

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 =   
Displacement -

10.9+11.3+11.2+11.7+10.6+11+13.7+10.9+11.6+11.2 = 114.1

114.1 / 10 = **11.41 cm**

Standard Deviation =

Standard Error =

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 the standard deviation is less than 1, most measurments were pretty close to the average. Therefore, the measurements were precise (usually within 1 centimeter).

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

**Each of the team members decided to write their own recommendations (to be very thorough):**

The main source of uncertainty is that we have to make the measurement very quickly, basing off of our eyesight at the exact time the car reaches the climaxes. To combat this, we can record the cart in slow motion to get a more accurate measurement of the highest point, or we can make the cart bleed ink on a page, then measure the highest point of the ink. - Andrew

Some of the sources of uncertainty in this experiment would probably come from the pull of the string that launches the cart into motion. It can be difficult to determine whether the string was pulled at the same force for each trial, and this may have contributed to the uncertainty in the experience. To reduce this uncertainty, implementing a way to pull the string automatically at the same force would be helpful to eliminate uncertainty and so that the data can be formed using the same pull force of the string. - Alvin

A source of uncertainty probably must be the estimation of distance that the car is going while doing the lab. There is nothing to prevent human errors within this lab. Therefore, maybe a tool could help prevent human errors in measuring distance.

To improve the precision of the measurement, a tool could be used in order to measure the measurements more accurately. For example, the lab probably should have a tool to record the length that the car reaches instead of using our estimation and eyes in order to figure it out. - Quy