Physics 205L

**Experiment**

**1**

# Measurement Error and Graphing©

**25pts**

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**Introduction:** This preliminary exercise (**Individualized, No Lab Partners)** is designed to introduce error in measurements and why we graph data. Before beginning this important exercise, please read the "Graphical Analysis Handout", “The Lab Manual Handout”, StatHandoutLab and “The Vernier & Micrometer” handouts. **THIS DOCUMENT MUST BE TYPED OUT DO NOT WRITE IN THE MARGINS. NEATNESS COUNTS!**

**Part 1: Dimensions and Volume of a Block**

This exercise is designed to provide practice of data analysis which include uncertainties, error propagation, and interpretation of results. Enter the corresponding values below. WATCH UNITS!!!  **THIS DOCUMENT MUST BE TYPED OUT (10pt penalty if it is not). DO NOT WRITE IN THE MARGINS. NEATNESS COUNTS!**

**Part 1A:**

**Directions:** Measure the dimensions of the block with a ruler, calculate their average dimensions , , along with their associated uncertainty, and calculate the average volume of the block. Please note that the resolution (distance between two closest divisions) of the ruler is 0.1cm. Don’t forget to apply error propagation to determine the associated uncertainty in the average volume. Enter your results in Table 1. Show a sample of each type of calculation below the table. Note cells in Volume column are blacked out for a reason!

**Table 1. Dimensions of Block Number \_\_\_\_4\_\_\_\_\_ Using a Ruler**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Trial Number** | **Length (cm)** | **Width (cm)** | **Height (cm)** | **Volume (cm3)** |
| 1 | 2.3 | 2.4 | 2.2 |  |
| 2 | 2.3 | 2.3 | 2.3 |  |
| 3 | 2.2 | 2.3 | 2.3 |  |
| 4 | 2.3 | 2.3 | 2.3 |  |
| 5 | 2.2 | 2.3 | 2.2 |  |
| **AVERAGE** | 2.26±.0273 | 2.32±.0223 | 2.26±.0273 | 11.89±.2 |

Sample calculations

**Sample average calculation:**

**Sample calculation for length uncertainty:**

**Sample Volume Calculation:**

**Sample uncertainty calculation:**

**Sample volume error propagation:**

**Part 1B:**

**Directions:** Repeat part 1A with the same block, but this time use a vernier caliper instead of the ruler. Please note that the resolution of the vernier caliper is 0.002cm. Show a sample of each type of calculation below the table (2pts)

**Table 2. Dimensions of a Block Number \_\_\_4\_\_\_\_\_ Using Vernier Calipers**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Trial Number** | **Length (cm)** | **Width (cm)** | **Height (cm)** | **Volume (cm3)** |
| 1 | 2.35 | 2.37 | 2.31 |  |
| 2 | 2.36 | 2.37 | 2.35 |  |
| 3 | 2.33 | 2.34 | 2.37 |  |
| 4 | 2.37 | 2.32 | 2.34 |  |
| 5 | 2.34 | 2.37 | 2.35 |  |
| **AVERAGE** | 2.35±.0079 | 2.354±.0115 | 2.344±.0109 | 12.966±.8 |

Sample calculations

**Sample average calculation:**

**Sample calculation for length uncertainty:**

**Sample Volume Calculation:**

**Sample uncertainty calculation:**

**Sample volume error propagation:**

**Part 1C**

**Directions:** Repeat part 1A with the same block, but this time use a micrometer instead of the ruler. Please note that the resolution of the micrometer is 0.01mm. Show a sample of each type of calculation below the table (2pts).

**Table 3. Dimensions of a Block Number \_\_\_\_\_\_\_\_ Using Micrometer**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Trial Number** | **Length (cm)** | **Width (cm)** | **Height (cm)** | **Volume (cm3)** |
| 1 | 23.164 | 23.271 | 23.171 |  |
| 2 | 23.212 | 23.372 | 23.293 |  |
| 3 | 23.191 | 23.314 | 23.281 |  |
| 4 | 23.203 | 23.068 | 23.232 |  |
| 5 | 23.227 | 23.292 | 23.311 |  |
| **AVERAGE** | 2.3199±.0118 | 2.3263±.0577 | 2.3257±.0185 | 12.55± |

Sample calculations

**Sample average calculation:**

**Sample calculation for length uncertainty:**

**Sample Volume Calculation:**

**Sample uncertainty calculation:**

**Sample volume error propagation:**

**Questions (answer in complete sentences)**

1. Do the measured volumes agree with each other? If the values don’t agree identify the cause of the disagreement.
   1. Yes, my values are very closely measured and represent a case where the height, width, and length are similar in dimension.
2. Did the more precise tool give more consistent results for the block dimensions and volume? Explain your answer.
   1. The precision this tool provided increased the accuracy of my measurements. In previous measurements, there was variability between the second digit of the length. For example, other tools may have reported 22 cm for the width in a certain case. With our improved tools we are able to find the width, height, and length to all be within the range of 23-24 cm.

**Part 2: Graphical Analysis of Data**

For many spring-mass systems, the amount a spring stretches when it suspends a mass is proportional to the amount of mass supported by the spring. This is called Hooke’s law. We will test that here.

**Directions:** Suspend a hanger on a spring and record the position of the bottom of the hanger. Add a known mass to the hanger and record the position of the hanger. WATCH SIG. FIGS.!

**Table 4- Mass vs. Position**

|  |  |  |
| --- | --- | --- |
| **Mass (grams)** | **Position (cm)** |  |
| 19.96 | 56.5 | .352 |
| 39.95 | 53.25 | .746 |
| 59.91 | 50.25 | 1.19 |
| 79.81 | 47.50 | 1.68 |
| 99.75 | 44.75 | 2.23 |
| 119.74 | 41.5 | 2.88 |
| 139.74 | 38.6 | 3.62 |
| 159.65 | 35.6 | 4.48 |
| 179.61 | 32.5 | 5.51 |
| 199.61 | 29.5 | 6.76 |

**Chart, line chart

Description automatically generated**

**Analysis**

1. Plot mass of spring versus displacement of spring (y vs. x). Perform a fit using y=mx+b and correctly report the slope and y-intercept. Copy and paste the graph below. Don’t forget a figure caption.

**Slope=\_\_6.583\_\_\_\_\_\_±\_\_.05\_\_\_\_\_ y-intercept=\_\_\_-2.419\_\_\_\_\_±\_1.06\_\_\_\_\_\_**

**Questions (answer in complete sentences)**

1. The spring is characterized by the spring constant, moreover, the force per displacement. How is the slope related to the spring constant?
   1. The slope is the deformation of the spring. As the slope increases the spring becomes more and more distorted.
2. How does the ratio of mass/position in Table 4 compare with the slope of the graph as the mass of on the spring increases? How is the last column in Table 4 related to the spring constant? Please explain your responses.
   1. The mass vs position increases as spring continues to stretch and take on more weight. The spring constant is multiplied by x which is the total deformation of the spring as the spring becomes more deformed due to the mass that it is holding.
3. What is the meaning y-intercept? Do you understand why it is always better use y=mx+b as opposed to y=mx in performing a curve fit?
   1. The y intercept is where the spring would be be if there was no weight added onto it.