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**NATIONAL UNIVERSITY OF SCIENCES AND TECHNOLOGY**

**Applied Physics (PHY-102)**

**Instructor: Muhammad Imran Malik**

**Lab 1: Error Analysis**

**Class: BEE-12C**

**Dated: 5/11/2020**

**Group 2**

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**ABSTRACT:**

The purpose of this experiment is to:

* Verify the inclusion of uncertainty in every real-world reading.
* Calculating total uncertainty in a reading using statistical analysis.

**THEORY:**

Every practical reading has an uncertainty up to some extent. Factors leading to higher percentage of uncertainty include ineptness of the experimenter, faulty equipment and/or sudden change in environment. **Such uncertainty can be calculated using the following steps:**

1. Calculating ***mean value*** of all measured factors using:
2. Calculating the ***average deviation*** using:
3. Calculating the ***standard deviation*** using:
4. Calculating the ***standard error*** using:
5. Calculating the ***propagation of uncertainty*** using:

**EXPERIMENT 1:**

**Objective:**

Finding the area and perimeter of a table

**Equipment:**

* Meter Rule
* Table

**Procedure:**

* Measure the length and width of the table thrice using a meter rule.
* Calculate the area and perimeter of the table.
* Calculate the uncertainty in the values of area and perimeter.

**Data Analysis:**

**Area =** Length \* Width

**Perimeter =** 2 \* (Length + Width)

**Table 1**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Reading No.** | **Length/cm** | **Width/cm** | **Area/cm2** | **Perimeter/cm** |
| **1** | 60 | 55 | 3300 | 230 |
| **2** | 59.8 | 54.8 | 3277.04 | 229.2 |
| **3** | 60.3 | 55.4 | 3340.62 | 231.4 |
| **Mean** | 60.03 | 55.06 | 3305.89 | 230.2 |

**Results and Calculations**

Average deviation of **Length**: [(0.03) + (0.23) + (0.27)] / 3

= **0.176cm**

Average deviation of **Width:** [(0.06) + (0.26) + (0.34)] / 3

= **0.22 cm**

Standard deviation of **Length:** = **0.251cm**

Standard deviation of **Width:** = **0.305 cm**

Standard error of **Length:** (0.251) / √3

**= 0.145 cm**

Standard error of **Width:** = (0.305) / **√**3

**= 0.176 cm**

Propagation of Uncertainty for **Area**:

Since, **Area** = **Length** x **Width**

And

Thus,

*Where “W” and “L” are averages of the measured widths and lengths respectively.*

Uncertainty in **Area** = **13.24 cm2**

**Area = (3305.89 ± 13.24) cm2**

**Percentage Error** = (13.224 / 3305.89) x 100

**= 0.4%**

Propagation of Uncertainty for **Perimeter:**

Since, Perimeter = 2 \* (Length + Width)

*And*

Thus,

Uncertainty in **Perimeter** = **0.456 cm**

**Perimeter = (230.2± 0.456) cm**

**Percentage Error** = (0.456 / 230.2) x 100

**= 0.198%**

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**EXPERIMENT 2:**

**Objective:**

Finding the Earth’s gravitational acceleration

**Equipment:**

1. A simple pendulum
2. Stop watch
3. Meter rule

**Procedure:**

* Take a simple pendulum.
* Measure the length of the pendulum thrice, using a meter rule.
* Measure the time taken for the pendulum to complete 20 oscillations thrice, using a stopwatch.
* Calculate the time period of the oscillations.
* Calculate the acceleration due to gravity and the uncertainty in the value obtained.

**Data Analysis:**

**T = \* √(L/g)**

**,** where “g” is acceleration due to gravity, “L” is length of pendulum and “T” is time period of oscillations.

**Table 2**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Serial number** | **Length/cm** | **Time for 20 vibrations / s** | **Time period T**  **/s** | **Gravitational acceleration ‘’/ m/s2** |
| 1 | 25.3 | 20.2 | 1.01 | 979.12 |
| 2 | 25.2 | 20.1 | 1.005 | 984.98 |
| 3 | 25.4 | 20.5 | 1.025 | 954.43 |
| Average | 25.3 | 20.27 | 1.013 | 973.33 |

**Results and Calculations**

Average deviation of **Length:** [(0.0) + (0.1) + (0.1)] / 3

= **0.067 cm**

Average deviation of **Time Period**: [(0.003) + (0.008) + (0.012)] / 3

= **0.00767s**

Standard deviation of **Length** = **0.1** **cm**

Standard deviation of **Time Period** = **0.208 s**

Standard error of **Length:** (0.1) /

**= 0.0577cm**

Standard error of **Time Period:** (0.0176) /

**= 0.0104 s**

Propagation of Uncertainty for **‘g’:**

Since,

***And***

Thus,

Uncertainty in **‘g’** = **20.1 cm/s2**

**Gravitational Acceleration ‘g’ = 973.33 ± 20.1 cm/s2**

Percentage uncertainty = (20.1 / 973.33) x 100

= **2.06%**

**Conclusion:**

These experiments prove that, practically, readings are bound to have uncertainty in them. Since, the percentage error in our results is quite less, we can say that the biggest factor contributing to the uncertainty was the limitations of equipment. We have also learnt the procedure to calculate the propagation of uncertainty in a function through statistical analysis.