# Lab Tutorial: Statistical Treatment of Errors

## Objective:

To understand and apply statistical methods for the treatment of errors in a physics experiment. The lab will focus on calculating the sample mean, sample standard deviation, population mean, population standard deviation, and using the principles of least squares to analyze data.

## Experiment Setup:

\*Measurement of the acceleration due to gravity (g) using a simple pendulum.\*

### Apparatus:

1. Simple pendulum (string, bob)  
2. Meter scale  
3. Stopwatch  
4. Clamp stand  
5. Data sheet for recording observations

## Procedure:

1. Set up the simple pendulum with a fixed length (e.g., 50 cm).  
2. Displace the pendulum slightly and release it to allow it to oscillate freely.  
3. Measure the time for 10 complete oscillations using a stopwatch. Repeat this measurement five times and record the results.  
4. Calculate the period of one oscillation (T) by dividing the recorded time for 10 oscillations by 10.  
5. Repeat the experiment for three different lengths of the pendulum (e.g., 50 cm, 70 cm, 90 cm).  
6. Record all observations in a table.

## Observation Table:

| Length (L) | Time for 10 Oscillations (s) | Period (T) (s) | Mean T (s) | Standard Deviation of T (s) |  
|------------|------------------------------|----------------|------------|----------------------------|  
| 50 cm | | | | |  
| 70 cm | | | | |  
| 90 cm | | | | |

## Data Analysis:

1. \*\*Sample Mean (\( \bar{x} \)):\*\*  
 - Calculate the mean period of oscillation for each pendulum length using the formula:  
 \[ \bar{x} = \frac{1}{n} \sum\_{i=1}^{n} x\_i \]  
 where \( x\_i \) represents each observation, and \( n \) is the number of observations.  
  
2. \*\*Sample Standard Deviation (\( S \)):\*\*  
 - Compute the standard deviation for each length using:  
 \[ S = \sqrt{\frac{1}{n-1} \sum\_{i=1}^{n} (x\_i - \bar{x})^2} \]  
  
3. \*\*Population Mean and Standard Deviation:\*\*  
 - Discuss the difference between sample and population statistics. If all possible measurements were taken, these would represent the population mean and standard deviation.  
  
4. \*\*Principles of Least Squares:\*\*  
 - Use the formula for the period of a simple pendulum:  
 \[ T = 2\pi \sqrt{\frac{L}{g}} \]  
 - Rearrange to obtain:  
 \[ T^2 = \frac{4\pi^2}{g} L \]  
 - Plot \( T^2 \) (y-axis) against \( L \) (x-axis).  
 - Fit a straight line using the least squares method. The slope of the line is \( \frac{4\pi^2}{g} \).  
  
5. \*\*Calculating \( g \):\*\*  
 - From the slope of the line, calculate \( g \):  
 \[ g = \frac{4\pi^2}{\text{slope}} \]

## Analysis and Discussion:

- Compare the calculated value of \( g \) with the standard value (9.8 m/s\(^2\)).  
- Discuss the significance of statistical measures in evaluating the precision and accuracy of experimental results.  
- Highlight sources of error and their impact on the measurements.

## Conclusion:

By completing this lab, students will gain hands-on experience in:  
- Treating experimental data statistically.  
- Applying the principles of least squares to analyze physical data.  
- Understanding the importance of error analysis in physics experiments.

## Assignment:

1. Calculate the sample mean and standard deviation for each pendulum length.  
2. Plot \( T^2 \) vs. \( L \) and determine the value of \( g \) using the least squares method.  
3. Write a short report summarizing your results and observations.