Exp. No 1. Random Error

Theory

A- Accuracy in Measurements

Measurement is the basic requirement of almost every science. We need measurement in all sciences to understand the basic concepts behind it. Every measurement involves some error.

Types of Error

In a general, errors are basically of two types: (*i*) Systematic errors and (*ii*) Random errors:

(i) Systematic Errors

Systematic error is known as a Repetitive Error as it occurs because of default machines and incorrect experiment apparatus. These errors take place if the device which is used to take measurements is wrongly calibrated.

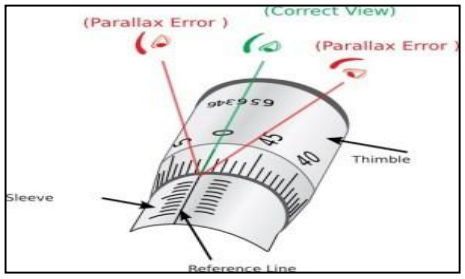
(ii) Random Errors

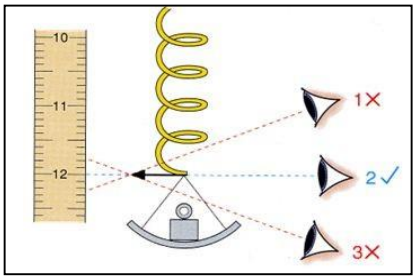
Random Errors are not fixed and varies from a measurement to another. Random errors are also defined as fluctuations in statistical readings due to limitations of precisions in the instrument. Random errors occur due to:

- Sudden and unexpected shifts in experimental conditions of the environment.
- Personal bias errors which even the person who measures is unaware of.

(iii) Human Errors

Parallax error is primarily caused by viewing the object at an oblique angle with respect to the scale, which makes the object appear to be at a different position on the scale.





B- Expressing Experimental Error and Uncertainty

Percent Error

The purpose of some experiments is to determine the value of a well known physical quantity, for instance the value g-acceleration due to gravity. The accepted or theoretical value of such a quantity is found in textbooks and physics handbooks is the most accurate value obtained through sophisticated experimental methods or mathematical methods.

The absolute difference between the experimental value X_E and the theoretical value X_T of a physical quantity X is given by the relation:

Absolute difference = $|X_E - X_T|$. Note that absolute difference is a positive quantity.

Random

The fractional error is given by

$$\text{Fractional error} = \frac{\textit{absolute difference}}{\textit{theoretical value}} = \frac{|X_E - X_T|}{X_T} \quad (1)$$

In most cases fractional difference is used to calculate percent error which is given by
Percent error = *fractional error* ×100%

$$= \frac{|X_E - X_T|}{X_T} \times 100\% \quad (2)$$

Percent Difference

It is not always possible to find theoretical value for a physical quantity to be measured. In such circumstance we resort to comparison of results obtained from two equally dependable measurements. The comparison is expressed as a percent difference which is given by

$$\textit{Percent difference} = \frac{\textit{absolute difference}}{\textit{average}} \times 100\%$$

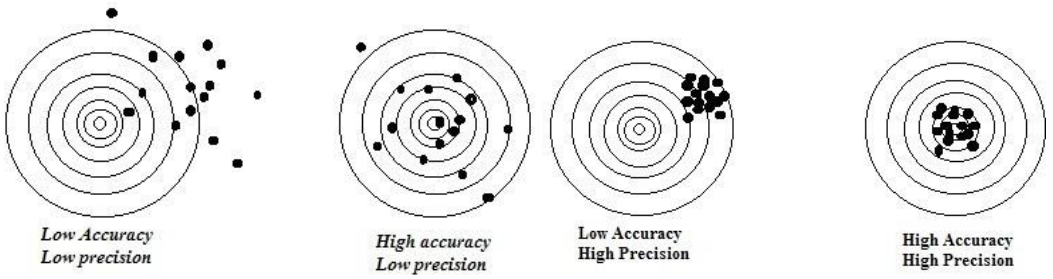
$$= \frac{|X_1 - X_2|}{\left(\frac{X_1 + X_2}{2}\right)} \times 100\%, \quad (3)$$

where X_1 and X_2 are results from the two methods.

C- Statistical Tools

Accuracy and precision

Accuracy measures how close a measured value is to the true value or accepted value.
Since a true or accepted value for a physical quantity may be unknown, it is sometimes not possible to determine the accuracy of a measurement.
Precision measures how closely two or more measurements agree with other. Precision is sometimes referred to as repeatability Or reproducibility. A measurement which is highly reproducible tends to give values which are very close to each other.

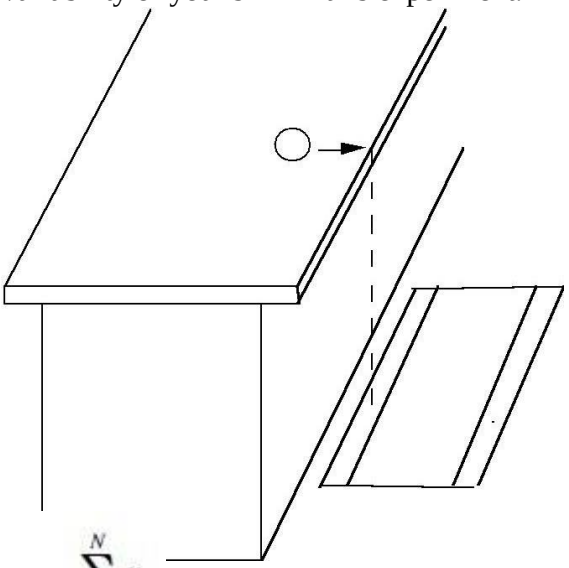


Random

Objective

Equipment:
Pencil
Paper ruler (Graph paper)

Procedure:
1- Place the paper ruler with the edge of the table on the laboratory floor. Mark a line on the paper which is vertical to the edge of the table figure 1.
2- Attempt to hit the line on the paper as the pencil strikes the floor.
***3*- Determine the distance (in centimeter intervals) from the position of the line to the actual impact point, call it *xi*. In both x-axis directions.**
4- Determine the number of hits with specific distance ***xi***
5- Plot of the distribution of hits versus position (i.e., a histogram):
6- Draw a graph of the number of times the pencil hit within a specified distance from the line versus the distance in centimeter intervals.
7- We will now obtain two numbers which will give a measure of the variability of your skill in this experiment.



ncil shown on table with paper beneath.

$\bar{x} = \frac{\sum_{i=1}^{N} x_i}{N}$ ation of the average value (**ẍ**):

$$\bar{x} = \frac{\sum_{i=1}^{N} x_i}{N}$$

The *x*i's are simply the measured values for *x* for the different trials. A comparison of this value with the true distance from the table edge to the line shows whether or not the results are consistently too short

or too long.

2) Calculation of the standard deviation (**σ)**; This quantity gives an indication of the consistency of the trials.

Write your result as:

$$\sigma^2 = \frac{\sum_{i=1}^{N}\left(x_i - \bar{x}\right)^2}{N-1}$$

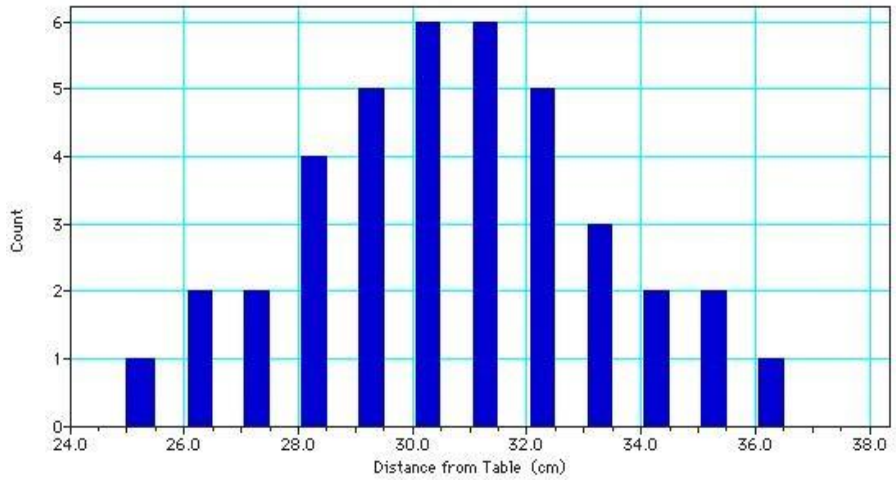


Figure 2 histogram for distribution of hits.

Where **ẍ** is the average value of the measured value of x_i (the arithmetic average).
$x = \ddot{x} \pm \sigma$

where x is the true value (actual position of the line).

Questions:

1. Compare the graph of your data with the sample graph. Explain the differences in the distributions observed. How could you reduce the value of **(**σ) if the experiment were repeated?

2. If a die were tossed twice, what can you say about the average value of the number thrown? If the die were tossed 100 times, what would be the average value of the number thrown?
   Why are your answers different?

3. What can you say about the dose delivered by a pill (e.g. Blood pressure) in your measurement set. How does this experiment help to describe the variability or consistency of the production process producing this medication?