Measurement Techniques

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Errors and uncertainities

Errors are uncertainties in readings which arise from sources such as
- limitations of the observers measurement skills
- limitations of the ~~natural~~ instruments
- limitations of the method or procedure
- Randomly varying factors of the Physical environment eg. Temp, Pressure, wind speed etc

These errors/uncertainities causes the reading to deviate from their True value.

Errors can be classified as systematic errors or random errors.

Systematic errors are constant deviation of the reading in ONE DIRECTION of the true value such as.

- Zero error { eg. +ve zero error or −ve zero error in V.C and M.M, Background count rate in G.M Tube, losses of heat into the surroundings in experiments to measure specific heat capacity.
- Incorrectly calibrated instruments eg. a slow running stopwatch or a fast running stop watch
- Observer persistently carrying out a mis-timed action (eg: in starting or stopping the stopwatch) or for eg using g as $10 m/s^2$ instead of $9.81 m/s^2$, which is the exact value

• How systematic errors affect the shape of the graph

Random errors refers to the scatter of readings about a mean value. These include

- ~~Flawed observations or actions (eg. in locating the image of the Pins through glass block in Light exp, or human reaction time in starting or stopping a stop watch)~~

Random errors are of varying signs and magnitude and generally cannot be eliminated however they can be reduced by taking the average of repeated readings. Systematic errors cannot be reduced or eliminated by obtaining averages.

Precision and Accuracy

Precision is the degree of agreement among a series of measurements of the same quantity. It is a MEASURE OF THE REPRODUCIBILITY OF THE RESULTS ~~RATER~~ RATHER THAN THEIR CORRECTNESS.

Accuracy is the DEGREE OF AGREEMENT b/w ~~TE~~ THE EXPERIMENTAL RESULT AND THE TRUE VALUE.

Quoting a Physical quantity

Whenever a Physical quantity is expressed its value is generally quoted in the form.

$x \pm \Delta x$ where x = absolute value and Δx = absolute uncertainity

for eg
$L = 18.5 \pm 0.5$ mm.
$I = 1.0 \pm 0.2$ A
$M = 25.0 \pm 0.1$ g.
$T = 2.50 \pm 0.05$ s.

fraction error is defined as $\frac{\Delta x}{x}$ and % error or % uncertainity is defined as $\frac{\Delta x}{x} \times 100$.

for derived Quantities uncertainities can be estimated as follows.

- FOR THE SUM OR DIFFERENCE OF 2 QUANTITIES the absolute uncertainity is the SUM OF THE INDIVIDUAL uncertainities.
eg.
Two lengths are given as.

$x = 18.5 \pm 0.5$ mm $y = 12.5 \pm 0.5$ mm.

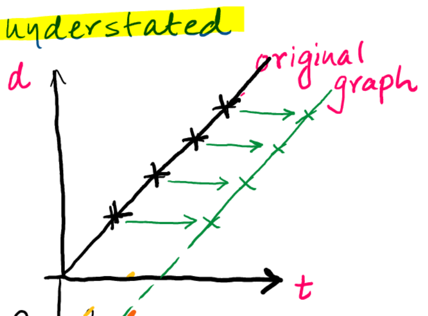
$x + y = 31 \pm 1$ mm.

$x - y = 6 \pm 1$ mm.

- FOR THE PRODUCT OR QUOTIENT OF 2 QUANTITIES THE FRACTIONAL UNCERTAINITY is the sum of the fractional uncertainties of those 2 quantities eg.

$x = 18.5 \pm 0.5$ mm $y = 12.5 \pm 0.5$ mm

Systematic errors will either cause all values to be overstated or all values to be understated



Q: Construct new shape of graph if all values of time are Overstated

Conclusion :- graph remains parallel but shifts, so it now has a Y-int

• Systematic errors eg zero error can be removed either by changing the instrument or by noting down the zero error & either adding or subtracting it from the observed value

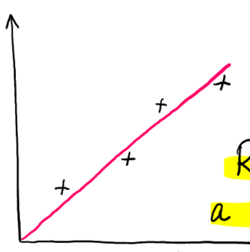
• Systematic errors, however cannot be eliminated by averaging repeated trials.

Random errors will cause some values to be overstated & some values to be understated

eg: Trying to measure the speed of sound in Air while the direction of wind changes continuously

OR

eg Human Reaction Time



scatter of Reading about a mean value indicates Random error

• They can be reduced by averaging repeated trials OR in case of graph, by constructing a Line of Best fit.