Physics

Errors in a scientific investigation

Mr. A Chafukira
KBCDSS Form 3

DEFINITION AND RELATED TERMS

- An **error** is the variance between a measurement and the true or accepted value.
- Terms related to errors in a scientific investigation:
  - **Uncertainty** – the interval around a value such that any repetition of the measurement will produce a new result that lie within this interval.
  - **Precision** – this is the degree to which repeated measurements under unchanged conditions shows the same results.
  - **Accuracy** – this is the degree of closeness of a measurement to the actual value.

TYPES OF EXPERIMENTAL ERRORS

- Experimental errors can be grouped into:
  a. **Absolute errors**
  b. **Relative errors**
  c. **Parallax errors**
  d. **Random errors**
  e. **Systematic errors**

ABSOLUTE ERRORS

- An absolute error is the difference in magnitude between the value of measurement obtained and the actual value.
- **For example:** The actual length of a bench is 2.3 m. A student measured and obtained the length of the bench as 2.35 m. Find the absolute error.
- Absolute error = obtained measurement – actual measurement

  = 2.35 m – 2.3 m = 0.5 m
- **Note:** Sometimes the absolute value is taken as half of the Least Count (LC) that can be measured using a given instrument.

ABSOLUTE ERRORS

Minimizing Absolute Error

- This is a procedural error that can be corrected by being more accurate when taking the measurements.

RELATIVE ERRORS

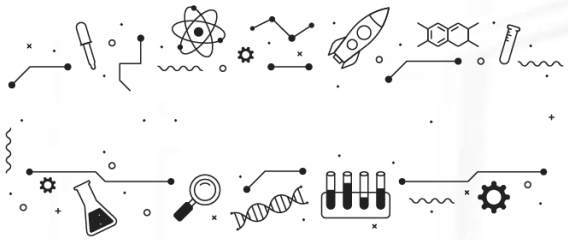
- This is the ratio of the absolute error to the true value.
- This error is usually expressed as a percentage.
- Relative error = $\frac{Absolute\ error}{Actual\ value}$ x 100%
- **For example:** A student measured the length of her pig bank as 12.1 cm. Calculate the relative error, if the actual length of the pig bank is 12.0 cm.

Actual length = 12.0 cm

Obtained length = 12.1 cm

Absolute error = 12.1 cm – 12.0 cm = 0.1 cm

RELATIVE ERRORS



Therefore: Relative error = $\frac{0.1\ cm}{12.0\ cm}\ x\ 100\%$

$= 0.83\%$

Minimizing Relative Errors

- These errors are automatically minimized when the absolute errors are minimized.

SYSTEMATIC ERRORS

- Systematic error is an error that remains constant in a series of repetitions of the same experiment or observation.
- These kind of errors arise form the errors in measuring instruments.
- Examples of these measuring instrument errors include:
  - Zero errors
  - Calibration errors

Minimizing Systematic Errors

Can be minimized by correct the zero errors in measuring instruments by using error-free instruments.

Zero ERRORS

- This is the reading that an instrument gives when it is supposed to give a reading of zero.

Sources of Zero Errors

- Using maladjusted instrument – this is an instrument that has not been reset to zero before using it to measure.
- Using wrongly calibrated instruments.
- Using a damaged measuring instrument.

Minimizing Zero Errors

- Resetting measuring instruments to zero reading before using them.
- Using instruments that are correctly calibrated.

Zero ERRORS

- **Note:**
  - When the zero error is negative, we determine the actual reading by adding the error to the reading given by the instrument.
  - When the zero error is positive, we determine the actual reading by subtracting the negative error from the reading given by the measuring instrument.

For example: A voltmeter had a zero error of -0.2v. It was used to measure the voltage across the terminals of a dry cell and gave a reading of 1.3v. What was the actual voltage of the dry cell?

ENVIROMENTAL ERRORS

- These are errors that arise due to conditions that are external to the measuring instruments.

Conditions that cause Environmental Errors

- Temperature
- Humidity
- Magnetic fields
- Pressure
- Electric fields

Minimizing Environmental Errors

- Controlling external environment where possible.
- Performing the experiment in an environment free from interfering factors.

RANDOM ERRORS

- These are errors that arise from inconsistency in the repeated measurement of a constant quantity.

Causes of Random Errors

- Unpredictable fluctuations in the readings of a measuring instrument.
- Inaccurate taking of readings from a measuring instrument.

Minimizing Random Errors

- Taking the average of a number of repeated observations.

PARALLAX ERRORS

- These are errors that arise from reading the wrong value on an instrument as a result of either wrong positioning of the eye relative to the correct reading on the instrument or poor vision of the observer.
- Also called **observational** errors

Minimizing parallax Errors

- Always position the eye perpendicular to the correct value mark on the instrument.
  - If the instrument is placed horizontally, the eye should be vertically above the correct mark on the instrument.
  - If the instrument is placed vertically, the eye should be horizontally above the correct mark on the instrument.