Evaluating Data

- approx. 20% marks allocated to AOS3 in VCE Physics exam
- key terms; systematic error, random error, precision, accuracy, bias, repeatability, reproducibility, validity, uncertainty, outliers

PHYSICS TopUp Tools

SYSTEMATIC ERROR ← TOTAL ERROR → RANDOM ERROR

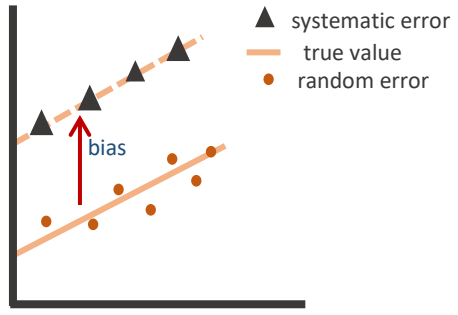
Systematic error

measurement error that in replicates remains constant or varies in predictable way

Caused by errors in the experimental design

Reduce effect on data by changing the experiment

Bias is the estimated effect of systematic errors on the data



Random error

measurement error in replicates that varies in unpredictable way

Caused by random variations such as in equipment (mass balance) or environmental conditions (temperature of room)

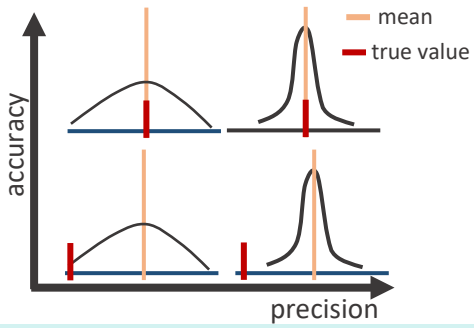
Reduce effect on data by repeating experiment many times and finding the average of the results

Accuracy

closeness of agreement between measured value and true value

Accuracy is improved by removing systematic errors. E.g. calibrating equipment.

Test for accuracy by calculating the measurement error; measured value – true value



Precision

closeness of agreement between repeated measurements

Precision is improved by increasing the sample size (e.g. repeat experiment or use results from other groups) or improving experimental technique

Quantify precision by calculating the range of values, standard deviation or confidence intervals

Validity

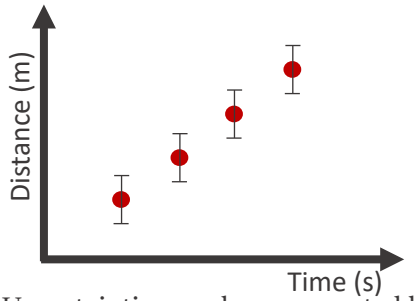
whether the experimental design produces results that answer the hypothesis and/or aim

Internal validity refers to whether the experimental design followed correct scientific process

External validity examines whether any factors other than the independent variable influenced results

A method is valid if

- it tests the hypothesis
- controlled variables are held constant
- uses equipment that gives accurate results
- data collected under correct environmental conditions



Uncertainties can be represented by error bars on a graph.

Uncertainty in measurements

range of values that the true value is likely to be within. E.g., 2.0 ±0.1 mL, true value could lie between 2.1 and 1.9 mL

Values with smaller uncertainties are more precise. E.g., 2.00 ±0.01 mL is more precise than 2.0 ±0.1 mL

Can also be represented as % uncertainties. E.g. 2.0 ±5.0% mL

Outliers are results that are outside the expected range.

Repeatability is the closeness of repeated measurements obtained using same method, person, location within short time frame

Reproducibility is the closeness of measurements using the same method and test material but under different conditions

Reliability

- consistent results are obtained in a reliable experiment
- refers to whether another person can achieve same results for same experiment under the same conditions

Improve reliability by repeating experiment and averaging results. This minimises effect of random errors and removes outliers

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