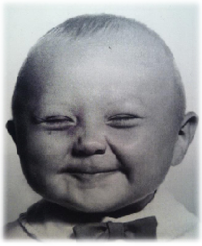
SPH3U UNIVERSITY PHYSICS

REVIEW: MATH SKILLS

☞ Error in Measurements
(P.651; 653)

Error in Measurements

*Many people believe that all measurements are **reliable** (consistent over many trials), **precise** (to as many decimal places as possible), and **accurate** (representing the actual value). But there are many things that can go wrong when measuring. For example:*



Error in Measurements

- *There may be limitations that make the instrument or its use unreliable (inconsistent).*
- *The investigator may make a mistake or fail to follow the correct techniques when reading the measurement to the available precision (number of decimal places).*
- *The instrument may be faulty or inaccurate; a similar instrument may give different readings.*

Error in Measurements

PRACTICE

1. What three things can you do during an experiment to help eliminate errors?

    1. To be sure that you have measured correctly, you should repeat your measurements at least three times.
    2. If your measurements appear to be reliable, calculate the mean and use that value.
    3. To be more precise about the accuracy, repeat the measurements with a different instrument.

Error in Measurements

PRACTICE

2. There are two types of measurement error. What are they?

    random error and systematic error

Random Error

Random error *results when an estimate is made to obtain the last digit for any measurement. The size of the random error is determined by the precision of the measuring instrument. For example, when measuring length with a measuring tape, it is necessary to estimate between the marks on the measuring tape. If these marks are 1 cm apart, the random error will be greater and the precision will be less than if the marks are 1 mm apart. Such errors can be reduced by taking the average of several readings.*

RANDOM ERROR

- results when the last digit is estimated
- reduced by taking the average of several readings

Systematic Error

Systematic error *is associated with an inherent problem with the measuring system, such as the presence of an interfering substance, incorrect calibration, or room conditions. For example, if a balance is not zeroed at the beginning, all measurements will have a systematic error; using a slightly worn metre stick will also introduce error. Such errors are reduced by adding or subtracting the known error or calibrating the instrument.*

SYSTEMATIC ERROR

- due to a problem with the measuring device
- reduced by adding/subtracting the error or calibrating the device

Accuracy & Precision

In everyday usage, "accuracy" and "precision" are used interchangeably to describe how close a measurement is to a true value, but in science it is important to make a distinction between them. ***Accuracy*** *refers to how close a value is to its accepted value.* ***Precision*** *is the place value of the last measureable digit.*

ACCURACY

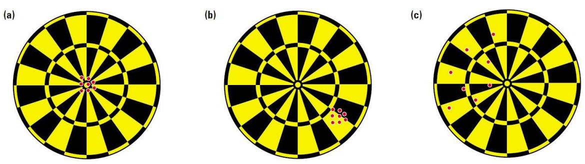
- how close a value is to its accepted value

PRECISION

- place value of last measureable digit

Accuracy & Precision

For example, the position of the darts in each of the figures are analogous to measured or calculated results in a laboratory setting. The results in (a) are precise and accurate, in (b) they are precise but ***not*** *accurate, and in (c) they are neither precise nor accurate.*



Percentage Error

No matter how precise a measurement is, it still may not be accurate. The ***percentage error*** *is the absolute value of the difference between experimental and accepted values expressed as a percentage of the accepted value.*

$$\%\ \text{error} = \frac{|\text{experimental value} - \text{accepted value}|}{\text{accepted value}} \times 100$$

NOTE!
The bars (||) in the equation above represent "absolute value". This means that, mathematically, if a = 3 and b = -3 then |a| = |b| = 3.

Percentage Difference

Sometimes if two values of the same quantity are measured, it is useful to compare the precision of these values by calculating the ***percentage difference*** *between them.*

$$\%\ \text{difference} = \frac{|\text{measurement 1} - \text{measurement 2}|}{\left(\frac{\text{measurement 1} + \text{measurement 2}}{2}\right)} \times 100$$

NOTE!
"Magnitude" is a term frequently used by physicists. The ***magnitude*** *of a quantity is the same as its absolute value.*

Error in Measurements

PRACTICE

3. At a certain location the acceleration due to gravity is 9.82 m/s^2[down]. Calculate the percentage error of the following experimental values of "g" at that location.
   (a) 8.94 m/s^2[down]
   (b) 9.95 m/s^2[down]

   (a) 8.96
   (b) 1.32

Error in Measurements

PRACTICE

4. Calculate the percentage difference between the two experimental values (8.94 m/s^2 and 9.95 m/s^2) used in question #3.

   10.7

✔ Check Your Learning

WIKI (REVIEW)

- 3UR - WS#1 (Math Skills)
- 3UR - QUIZ#1 (Math Skills - Part 1)