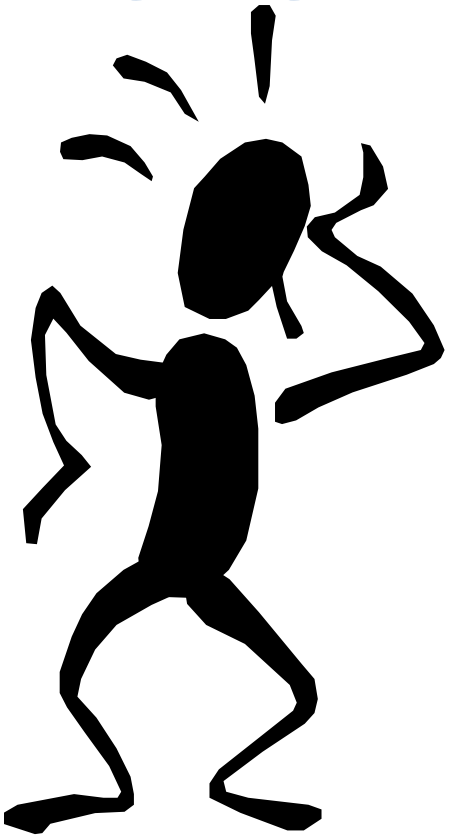
ERROR ANALYSIS



PERCENT MEASUREMENT ERROR

Every measurement has an error associated with it. The *absolute error* is decided by the experimenter who made the measurement based on how the measurement was obtained. This may be based on the instrument and how it was used.

For example, a metre stick might measure 23.4 cm ± .5 cm or ± .2 cm depending on its accuracy.

If the measurement is a given value and no error has been stated, then assume the error to be ½ of the most precise digit position given.

For example, 23.2 cm is a given measurement, then assume the absolute error is ± .05 cm.

Percent measurement error is calculated using the formula

$$\% \, Measurement \, Error = \frac{absolute \, error}{measured \, value} x100\%$$

Example: 47.31 ± 0.05

$$\frac{0.05}{47.31} \times 100 = 0.1$$

In a calculation using addition or subtraction, the % measurement error of the calculated value is the ***sum*** of the measurement errors of all the values used in the calculation, made into a percent at the end.

Actual	Error
$d_1 + d_2$	$5 + 22$
$= 1640\ m$	$= \pm 27\ m$

Example:

$d_1 = 523\ m \pm 5\ m$

$d_2 = 1117\ m \pm 22m$

Only if doing another calculation:

$$\frac{27}{1640} \times 100 = 1.64\% \approx 2\%$$

In a calculation using multiplication or division, the % measurement error of the calculated value is the ***sum*** of the % measurement errors of all the values used in the calculation.

Example:

100 000 m 1000 m

Distance = 100 km ± 1 km, time = 10.05 s ± 0.02 s, find the speed

Actual

$v = \frac{d}{t} = 9950.25 \, m/s$

$$\%d = \frac{1000}{100000} \times 100$$

$$= 1\%$$

$$\%t = \frac{0.02}{10.05} \times 100$$

$$= 0.2\%$$

Total Error $= 1 + 0.2 = 1.2\%$

$\therefore v = 9950.25\,m/s \pm 1.2\%$

$9950.25 \times 0.012 = 119\,m/s$

$\therefore V = 9950\,m/s \pm 100\,m/s$

Percent Difference Error

The percent difference error is used when two values of the same quantity have been determined and are to be compared.

$$\% \, Difference \; Error = \frac{difference \; between \; 2 \; values}{average \; of \; 2 \; values} x100\%$$

Example: Two values of gravity were found to be 9.72 m/s^2 and 9.93 m/s^2

Difference: $9.93 - 9.72$

$= 0.21$

$$\text{Avg} = \frac{9.72 + 9.93}{2}$$

$= 9.825\ m/s^2$

% Diff Error =

$$\frac{\text{Diff}}{\text{Avg}} \times 100$$

$$= \frac{0.21}{9.825} \times 100$$

$= 2.14\%$

Percent Accuracy Error

This percent error is used to compare an experimentally determined value to an accepted value. For this percent error, a *negative value* indicates that the experimental value is *lower* than the accepted value and a *positive* percent accuracy error indicates that the experimental value is *higher* than the accepted value

$$\% \, Accuracy \, Error = \frac{(experimental \, value - accepted \, value)}{accepted \, value} x100\%$$

Example: If the measured value of the speed of light is 2.55×10^8 m/s and the accepted value is 3.00×10^8 m/s, what is the percent accuracy?

$$\frac{2.55\times10^8 - 3.00\times10^8}{3.00\times10^8} \times 100$$

$$= -15.0\%$$

Percent Mean Deviation

This error expresses the precision of a set of experimentally obtained values. The calculation of this error is done through a combination of steps.

1. Calculate the mean value
2. Calculate the deviation of each value from the mean value (experimental – mean)
3. Calculate the mean deviation

   (sum of absolute value of deviations ÷ number of values)

4. Calculate the percent mean deviation

$$\% \, Mean \, Deviation = \frac{mean \, deviation}{mean \, value} x100\%$$

Example: Values 14 m, 15 m, 12 m, 17 m, 14 m

1. Avg: $\frac{(14+15+12+17+14)}{5} = 14.4$

2. Dev: 0.4, −0.6, 2.4, −2.6, 0.4

3. Avg Dev: $\frac{0.4+0.6+2.4+2.6+0.4}{5} = 1.28$

$$\% \text{ Mean Dev} = \frac{\text{Avg Dev}}{\text{Avg}} \times 100$$

$$= \frac{1.28}{14.4} \times 100$$

$$= 8.9\%$$