MEASUREMENTS

CHEM 251 SDSU

SAMPLE MEASUREMENTS

- When making quantitative measurements of a system (e.g. 15 g of white powder), analytical chemists typically only use a fraction of the system, a sample (0.05 g of the powder) of the substance.

- How then can the analytical chemist be certain that the results of that measurement of the sample represents the substance as a whole?

REPLICATE MEASUREMENTS

- By performing multiple sample measurements the analytical chemist can gather more data about the system.
- But what is to be done when the results of each sample measurement differ (slightly) from each other?
- Proper treatment of the collected data can provide a better understanding of the system than is available from a single measurement.

CENTRAL TENDENCY

- One way to approach the "true" quantity of the analyte in the system is to presume that the variations in the data (samples) are due to **random errors**.
- This presumes that the "true" value is likely in the center of the collected data. This is termed the **central tendency**.
- The "true" value can then be estimated by a pair of measurement characteristics - the **mean** and the **median**.

MEASUREMENT CHARACTERISTICS

- The **mean** ($\bar{x}$) is the numerical average for a set of data.

$$\bar{X} = \frac{\sum_i X_i}{n}$$

- The **median** is the middle value of the set of data, when arranged from smallest to largest.

- From the table:
  - Mean = 2.764
  - Median = 2.762

Sample	Value
1	2.785
2	2.746
3	2.756
4	2.762
5	2.777
6	2.751
7	2.773

MEASUREMENT CHARACTERISTICS

- The spread of the data provides us with an estimate of the uncertainty (or variations) in the measurements.
- The range is simply the difference between the largest and smallest measurement.
  - **Range = 0.039**
- The standard deviation describes how the data spread relative to the mean value. In the equation s is the standard deviation, x_i is the individual value, $\bar{x}$ is the mean, and n is the number of measurements.
  - **Standard Dev. = 0.014**

Sample	Value
1	2.785
2	2.746
3	2.756
4	2.762
5	2.777
6	2.751
7	2.773

$$s = \sqrt{\frac{\sum_i (X_i - \bar{X})^2}{n-1}}$$

MEASUREMENT CHARACTERISTICS

- The standard deviation is often expressed as the relative standard deviation (s_r).
- This allows better comparison of measurements when the magnitudes a significantly different.
- It may also be presented as the percent relative standard deviation, by multiplying s_r by 100%.

$$s_r = \frac{s}{\overline{X}}$$

Trial	Sample A	Sample B
1	0.567	9.742
2	0.623	9.618
3	0.604	9.822
4	0.599	9.639
5	0.614	9.754
6	0.580	9.805
7	0.573	9.711
8	0.594	9.687
Range	0.056	0.204
Mean	0.594	9.722
s	0.020	0.073
s_r	0.033	0.008
$\%s_r$	3.32%	0.75%

MEASUREMENT CHARACTERISTICS

- The variance (s^2)is yet another manner to report the spread of a data set.
- The variance is simply the square of the standard deviation.
- Though the standard deviation is typically reported, as it is in the same units as the mean, the variance has a role in calculating the propagation of uncertainty.