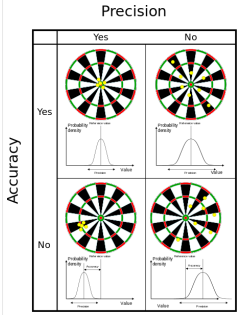
Introduction to Physical Science

Accuracy, Precision, & Significant Figures

Presented by Robert Wagner

Accuracy & Precision

- Accuracy
  - How close you are to the correct value
- Precision
  - How close together are repeated measurements



Uncertainty

- How far measured values deviate from expected values
  - All measurements contain some uncertainty
  - Ex: 250 meters with an uncertainty of 10 meters
    - Could be between 240 meters and 260 meters
    - 250 +/- 10 meters

Percent Uncertainty

- Defined as follows:
  - % %
  - δA = uncertainty in the measurement of A
  - Example: A board is measured to be 8.0 +/- 0.2 meters. What is the percent uncertainty?

8.0 +/- 0.2 meters

A = 8.0 ; δA = 0.2

$$\% \, unc = \frac{\delta A}{A} \, x \, 100\%$$

$$\% \, unc = \frac{0.2}{8.0} \, x \, 100\%$$

$$\% \, unc = 0.025 \, x \, 100\%$$

$$\% \, unc = 2.5\%$$

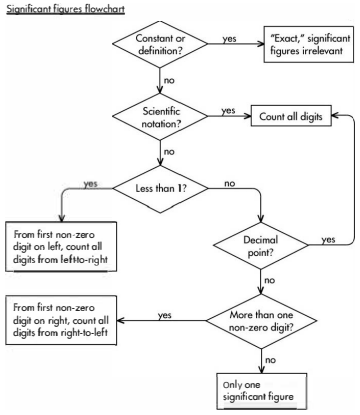
What are Significant Figures?

- Some numbers are exact
  - There are exactly 12 eggs in a dozen
  - There are exactly 2 wheels on a bicycle
  - These have as many significant figures as needed
- Some numbers are estimates
  - People using different instruments might measure a piece of paper to be:
    - 220 mm (2 significant figures)
    - 218 mm (3 significant figures)
    - 217.6 mm (4 significant figures)

Rules for Determining Significant Figures

- Non-zero digits are ALWAYS significant
- Leading zeros are NEVER significant
- Embedded zeros (zeros appearing between two non-zero digits) are significant
- Trailing zeros are significant ONLY if the decimal point is specified
- All digits to the left of the $x10^x$ in scientific notation are significant

Rules for Determining Significant Figures



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Significant Figures - Examples

- How many significant figures in:
  - 300
  - 300.0
  - 0.000052
  - 1.002504
  - 0.2000
  - $6.58x10^8$
  - 12

300 - 1 Significant figure

300.0 - 4 significant figures

0.000052 - 2 significant figures

1.002504 - 7 significant figures

0.2000 - 4 significant figures

$6.58x10^8$ - 3 significant figures

12 - 2 significant figures or an infinite number of significant figures!

Rules for Calculations in Significant Figures

- When adding or subtracting, the last digit to be retained is determined by the input number that is most estimated (ends at the highest place value)
- When multiplying or dividing, the answer can contain no more significant figures than the input number with the least significant digits

Examples

- 2.583 * 6.28x10^5 =
- 25.1 - 41.5 + 16.31 =
-

$2.583 \; x \; 6.28x10^5$

1,622,124

2.583 *has four significant figures*

$6.28x10^5$ *has three significant figures*

The answer must have three significant figures

1,620,000 or $1.62x10^6$

Examples

- 2.583 * 6.28x10^5 =
- 25.1 - 41.5 + 16.31 =
-

25.1 - 41.5 + 16.31

-0.09

25.1 Stops at the tenths place

41.5 Stops at the tenths place

16.31 Stops at the hundredths place

Answer must stop at the tenths place = -0.1

Summary

- Accuracy and precision can tell us about our measurements
- All measurements have an uncertainty this can be expressed as an error (+/-) or a percent uncertainty
- Significant figures are important in science as all measurements have an uncertainty associated with them