Significant Figures and Uncertainties

Significant Figures

- It is important to be honest when reporting a measurement, so that it does not appear to be more accurate than the equipment used to make the measurement allows.
- We can achieve this by controlling the number of digits, or **significant figures**, used to report the measurement.

Rules for Significant Figures

- All non-zero numbers are significant
  - 24 has 2 sig figs
  - 462 has 3 sig figs
- Zeros within a number are always significant
  - 1024 has 4 sig figs
  - 100 000 005 has 9 sig figs

- Zeros that do nothing but set the decimal point are not significant
  - 1200 has 2 sig figs
  - 0.003 has 1 sig fig
- Trailing zeros that are not needed to hold the decimal point are significant
  - 2.10 has 3 sig figs
  - 1.000 has 4 sig figs

Examples

- 120.030
  - 6 sig figs
- 0.00230
  - 3 sig figs
- 350
  - 2 sig figs
- 6.02×10^{23}
  - 3 sig figs

Propagating Uncertainties

- When number with uncertainties are combined, the uncertainty increases
- Addition and Subtraction
  - Uncertainties add
- Multiplication and Division
  - Percent uncertainties add

Example

- A 25.0 ± 0.3 g block of wood has the following dimensions:
  - Length: 5.00 ± 0.05 cm
  - Width: 3.00 ± 0.05 cm
  - Height: 3.00 ± 0.05 cm
- Calculate the density of the block of wood

$$Density = \frac{mass}{volume}$$

- Volume:

$$V = 5.00 \times 3.00 \times 3.00 = 45.00 \text{ cm}^3$$

- Uncertainty in Volume:
  - Calculate percent uncertainties

$$\frac{0.05}{5.00} = .01 \qquad \frac{0.05}{3.00} = .0167$$

  - Add percent uncertainties

$$0.01 + 0.0167 + 0.0167 = 0.0434 = 4.34\%$$

- Density

$$Density = \frac{25.0}{45.00} = 0.556 \text{ gcm}^{-3}$$

- Uncertainty in Density

$$\frac{0.3}{25} = 0.012$$

$$0.0434 + 0.012 = 0.0554 = 5.54\%$$

- Convert final percentage uncertainty to absolute uncertainty (and round to 1 sig fig)

$$0.0554 \times 0.556 = 0.03$$

- Round answer to same **place value**

$$0.56 \pm 0.03 \text{ gcm}^{-3}$$