Section 5.2

Uncertainty in Measurement and Significant Figures

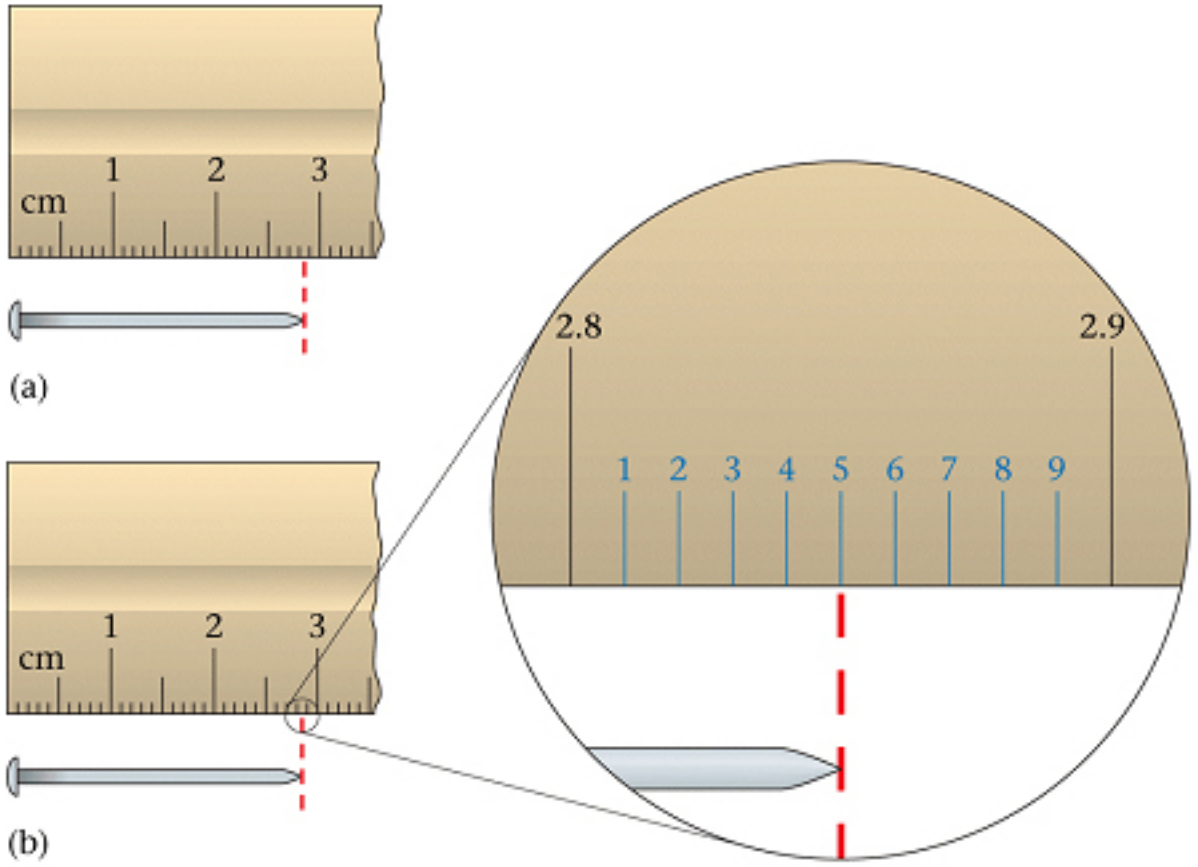
Objectives

1. To learn how uncertainty in a measurement arises
2. To learn to indicate a measurement's uncertainty by using significant figures
3. To learn to determine the number of significant figures in a calculated result

Uncertainty in Measurement and Significant Figures

A. Uncertainty in Measurement

- A measurement always has some degree of uncertainty.



Uncertainty in Measurement and Significant Figures

A. Uncertainty in Measurement

- Different people estimate differently.

Person	Result of Measurement
1	2.85 cm
2	2.84 cm
3	2.86 cm
4	2.85 cm
5	2.86 cm

- Record all **certain** numbers and one estimated number.

Uncertainty in Measurement and Significant Figures

B. Significant Figures

- Numbers recorded in a measurement.
  - All the certain numbers plus first estimated number

Uncertainty in Measurement and Significant Figures

B. Significant Figures

Rules for Counting Significant Figures

1. Nonzero integers always count as significant figures.
   1457 4 significant figures

Uncertainty in Measurement and Significant Figures

B. Significant Figures

Rules for Counting Significant Figures

2. Zeros

   a. Leading zeros - never count
      0.0025 2 significant figures

   b. Captive zeros - always count
      1.008 4 significant figures

   c. Trailing zeros - count only if the number is written with a decimal point
      100 1 significant figure
      100. 3 significant figures
      120.0 4 significant figures

Uncertainty in Measurement and Significant Figures

B. Significant Figures

Rules for Counting Significant Figures

3. Exact numbers - unlimited significant figures

- Not obtained by measurement
- Determined by counting
  3 apples
- Determined by definition
  1 in. = 2.54 cm

Uncertainty in Measurement and Significant Figures

B. Significant Figures

Rules for Rounding Off

1. If the digit to be removed
   a. is less than 5, the preceding digit stays the same. For example, 1.33 rounds to 1.3.
   b. is equal to or greater than 5, the preceding digit is increased by 1. For example, 1.36 rounds to 1.4, and 3.15 rounds to 3.2.
2. In a series of calculations, carry the extra digits through to the final result and *then* round off.* This means that you should carry all of the digits that show on your calculator until you arrive at the final number (the answer) and then round off, using the procedures in rule 1.

Uncertainty in Measurement and Significant Figures

B. Significant Figures

Rules for Multiplication and Division

- The number of significant figures in the result is the same as in the measurement with the **smallest** number of significant figures.

$$4.56 \times 1.4 = 6.384 \xrightarrow{\text{Round off}} 6.4$$

Three significant figures

Limiting (two significant figures)

Two significant figures

Four significant figures

$$\frac{8.315}{298} = 0.0279027 \xrightarrow{\text{Round off}} 2.79 \times 10^{-2}$$

Limiting (three significant figures)

Result shown on calculator

Three significant figures

Uncertainty in Measurement and Significant Figures

B. Significant Figures

Rules for Addition and Subtraction

- The number of significant figures in the result is the same as in the measurement with the **smallest** number of decimal places.