Office Hours: M 1:30pm – 3:00pm
(in Park 169) W 11:00am – 12:00pm
or by appointment (email me)
or just email me with questions!

TA Hours: TBD

Q-center: https://www.brynmawr.edu/inside/offices-services/q-center/q-center-schedule

Measurements, Uncertainty, and Unit Conversion

9/2/2026

Achieve HW #1 due Wednesday 9/9 at 10:00am

Quiz #1 in Recitation next Friday (9/11)

We need to take attendance today for registration reasons…..

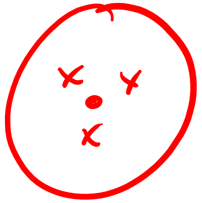
Learning Objectives

- Express quantities in scientific notation
- Explain the process of measurement
- Identify the three basic parts of a quantity
- Describe the properties and units of length, mass, volume, density, temperature, and time
- Perform basic unit calculations and conversions in the metric and other unit systems
- Define accuracy and precision and be able to explain whether a dataset is precise and/or accurate
- Distinguish exact and uncertain numbers
- Distinguish extensive vs intensive properties
- Correctly represent uncertainty in quantities using significant figures
- Apply proper rounding rules to computed quantities
- Explain the dimensional analysis (factor label) approach to mathematical calculations involving quantities
- Use dimensional analysis to carry out unit conversions for a given property and computations involving two or more properties

Accuracy vs Precision

Accuracy is a measure of closeness to "true" value

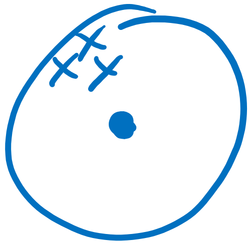
accurate - close to bullseye



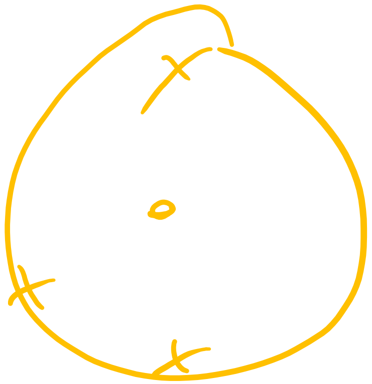
accurate & precise

Precision is a measure of reproducibility

precise - values are close together

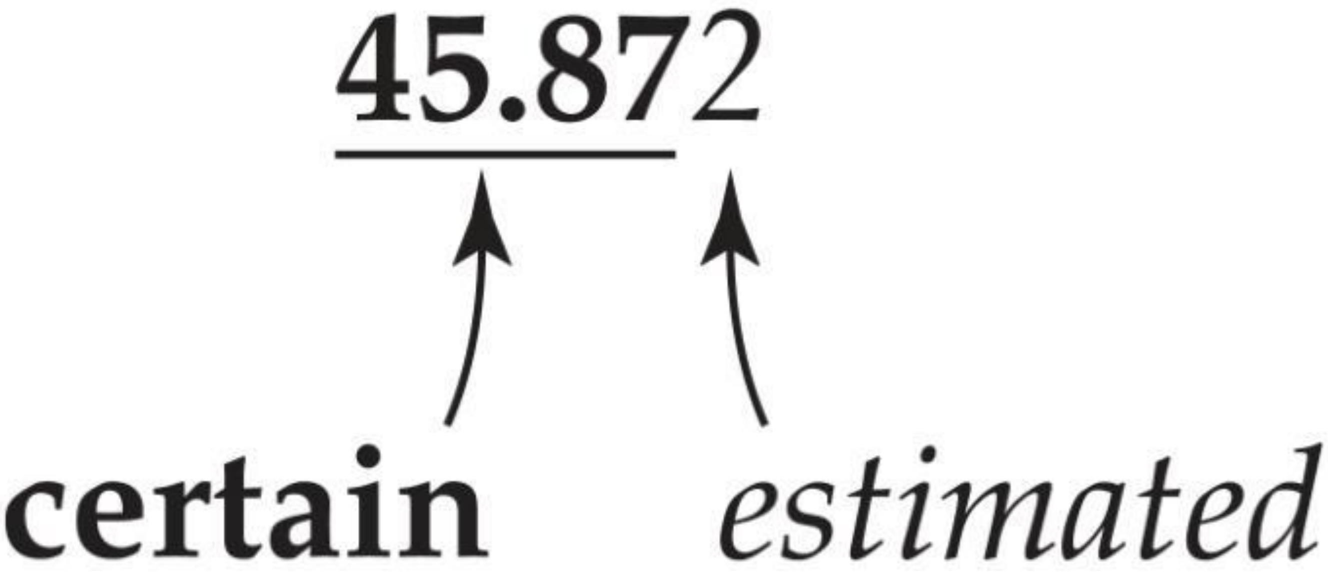


precise, not accurate



not accurate or precise.

Reporting Uncertainty in Measurements



The first four digits are certain; the last digit is estimated.

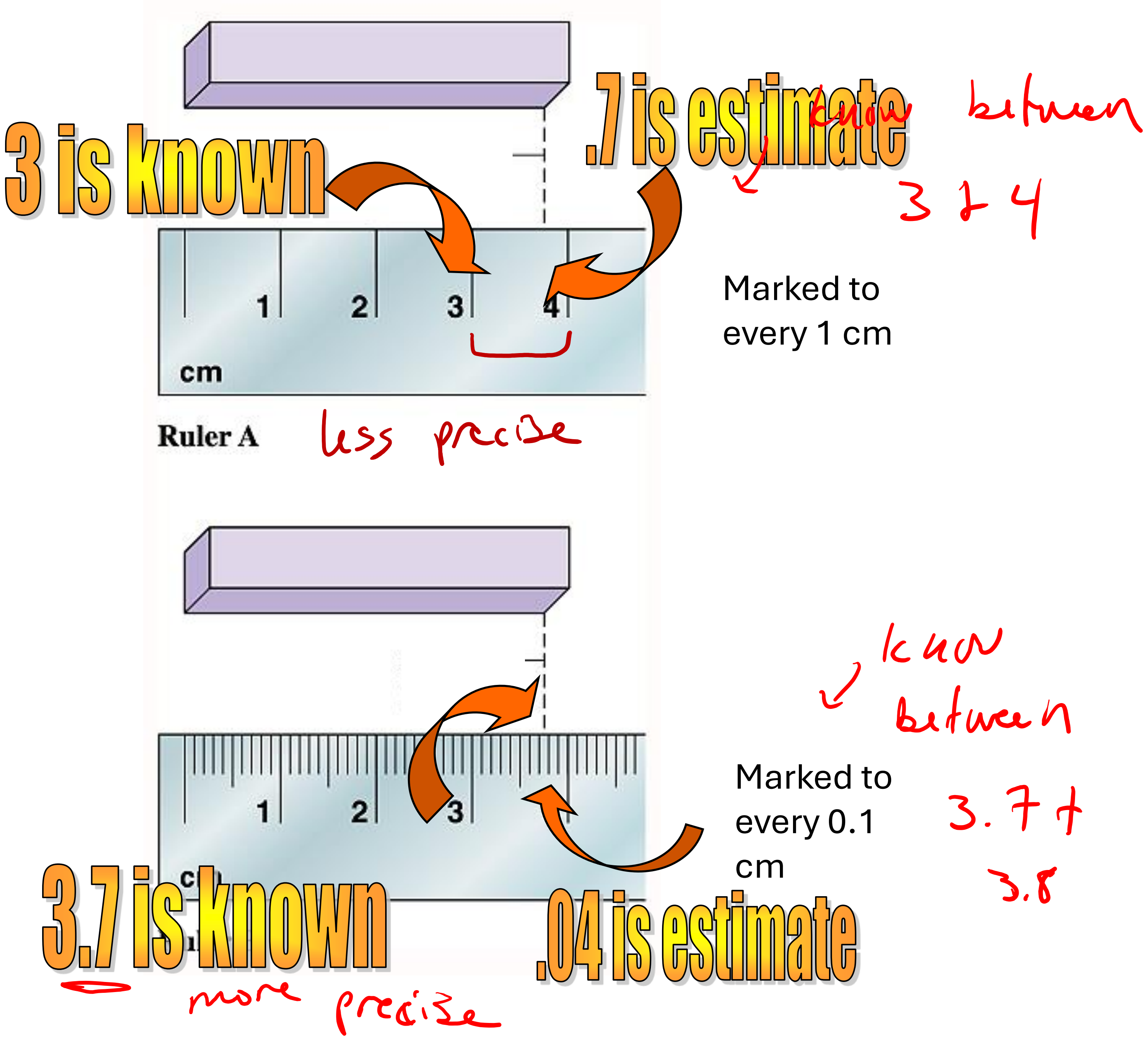
The greater the precision of the measurement, the greater the number of “significant figures.”

Significant figures are important!! They communicate the precision of a measurement!!

Measurement =

known digits

+ 1 estimated digit



1.7×10^{-n}

SIGNIFICANT FIGURES

The digits in a measurement known with certainty plus one estimated digit.

Nonzero Digits

The digits 1, 2, 3, 4, 5, 6, 7, 8, and 9 are always significant.

The Digit Zero

Zeros may or may not be significant, depending on whether they mark the decimal point or indicate a measured value.

Leading Zeros

Zeros located at the beginning of a number are NEVER significant.

Confined Zeros

Zeros located between nonzero digits are ALWAYS significant.

Trailing Zeros

Zeros located at the end of a number are significant only if the number has an explicitly shown decimal point.

$$\underbrace{0.00}_{\text{Not significant}}\underbrace{7000}_{\text{Significant}}\underbrace{2000}_{\text{Significant because of decimal point}}$$

#'s in sci. notation do not have leading zeroes.

sci notation always has decimal.

Which digits are significant in 0.0830 ?

x x

not significant

Identifying “Exact” Numbers

“Exact” numbers have unlimited significant figures.

- Exact counting of discrete objects

  Ex: 7 apples

- Integer numbers (whole numbers) that are part of an equation

  Ex: Radius = Diameter/2

- Defined quantities
  - *Some conversion factors are defined quantities, while others are not.*
  - *Treat conversion factors as defined quantities unless specified otherwise.*

  1 in = 2.54 cm exact

12 in = 1 ft

Counting Significant Figures

How many significant figures are in each number?

0.0035	2 s.f.	
1.080	4 s.f.	
2371	4 s.f.	
2.97×10^5	3	
$\boxed{\textbf{1 dozen = 12}}$	"things"	unlimited
100.00	5 s.f.	
100,000	(1)	
2500	(2)	

ambiguous. → sci notation preferred.

otherwise must assume trailing 0's are not s.f.

Significant Figures in Calculations

Rules for Rounding:

- When numbers are used in a calculation, the result is rounded to reflect the significant figures of the *data*. (measurements)
- For calculations involving multiple steps, round only the final answer— ***do not round between steps.*** keep a few "extra" digits in intermediate answers
- Use only the *leftmost digit being dropped* to decide in which direction to round —ignore all digits to the right of it.
- Round down if the last digit dropped is 4 or less;
  round up if the last digit dropped is **5 or more**.

Accuracy vs Precision

Accuracy is a measure of closeness to the true value

Precision is a measure of reproducibility

We use significant figures so that the least precise measurement is reflected in a calculation

- Final answer can only be as precise as the weakest link!

Multiplication and Division Rule

In multiplication or division, the result has the same number of *significant figures* as the quantity with the fewest *significant figures*.

Multiplication

$$5.02 \times 89.665 \times 0.10 = 45.0118 \rightarrow 45 \quad (2 \text{ s.f.})$$

(3) (5) (2)

Division

9 so
round up

$$5.892 \div 6.10 = 0.96590 = 0.966$$

(4) (3)

3 s.f.

Addition and Subtraction Rule

For addition or subtraction, the answer has the same number of **decimal places** as the quantity with the fewest **decimal places**.

hundredths digit is last significant dec. place.

$$
\begin{array}{r}
2.345 \\
0.07 \\
+\ 2.9975 \\
\hline
5.4125
\end{array}
= \boxed{5.41}
$$

5.7

round to hundredths

Rules for Rounding:

- When rounding to the correct number of significant figures,
  - Round down if the leftmost digit being dropped is four or less.
  - Round up if the leftmost digit being dropped is five or more.

Round to two significant figures:

5.37 rounds to 5.4
5.34 rounds to 5.3
5.35 rounds to 5.4
5.349 rounds to 5.3

Both Multiplication/Division and Addition/Subtraction

Follow order of operations

$3.489 \times (5.67 - 2.\underline{3})$

3.37

Use the subtraction rule to determine that the intermediate answer has only one significant decimal place.

$5.67 - 2.3 = 3.\underline{3}7$

keep track of last sig. fig in intermediate calculation.

Use the multiplication rule to significant figures

$3.489 \times (3.\underline{37}) = 1\underline{1}.758 = \boxed{12}$

4 s.f. 2 s.f.

The Basic Units of Measurement

The unit system for science measurements, based on the metric system, is called the **International System of Units** (*Système International d'Unités*) or ***SI* units**.

Base Units of the SI System

Property Measured	**Name of Unit**	**Symbol of Unit**
length	meter	m
mass	kilogram	kg
time	second	s
temperature	kelvin	K
electric current	ampere	A
amount of substance	mole	mol
luminous intensity	candela	cd

see often

later

Intensive vs Extensive Properties

Intensive properties do **not** depend on amount of substance in a sample.

- color
- smell
- density
- melting point
- boiling point

Extensive properties do.

- mass
- weight
- volume

Weight vs. Mass

- The kilogram is a measure of mass, which is different from weight.

- The **mass** of an object is a measure of the quantity of **matter** within it.

- The weight of an object is a measure of the gravitational pull on that matter.

- **Weight** depends on **gravity** while mass does not.

Unit Prefixes

Prefixes are used to scale units up or down by powers of 10.

Example: kilograms (kg) 1 kg = 1000 grams

kilo = 10^3 so 1 kg = 10^3 g

know these

Prefix	Symbol	Factor	Example
femto	f	10^{-15}	1 femtosecond (fs) = 1 × 10^{-15} s (0.000000000000001 s)
pico	p	10^{-12}	1 picometer (pm) = 1 × 10^{-12} m (0.000000000001 m)
nano	n	10^{-9}	4 nanograms (ng) = 4 × 10^{-9} g (0.000000004 g)
micro	μ	10^{-6}	1 microliter (μL) = 1 × 10^{-6} L (0.000001 L)
milli	m	10^{-3}	2 millimoles (mmol) = 2 × 10^{-3} mol (0.002 mol)
centi	c	10^{-2}	7 centimeters (cm) = 7 × 10^{-2} m (0.07 m)
deci	d	10^{-1}	1 deciliter (dL) = 1 × 10^{-1} L (0.1 L)
kilo	k	10^3	1 kilometer (km) = 1 × 10^3 m (1000 m)

1 mL = 10^{-3} L

1 cm = 10^{-2} m

Derived Units

A derived unit is formed from other units.

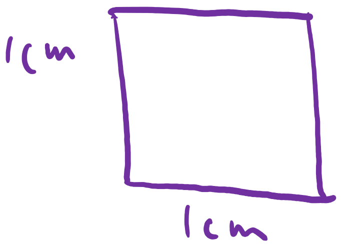
composed of multiple units multiplied or divided by each other

Many units of **volume**, a measure of 3D space, are derived units.

Any unit of length, when cubed (raised to the third power), becomes a unit of volume.

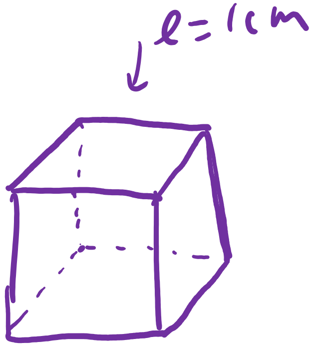
- Cubic meters (m^3), cubic centimeters (cm^3), and cubic millimeters (mm^3) are all units of volume.

$l = 1cm$



area also is a derived unit.

$\text{area} = (1cm)^2 = 1cm^2$



$V = 1cm \times 1cm \times 1cm$

$V = 1cm^3$

$\boxed{1cm^3 = mL}$