Announcements for Thursday, 05SEP2024

For those who missed yesterday's lecture:

- If you registered for this course yesterday, you should have access to Canvas today
- Check Canvas Announcements and e-mails often and read through all the posted material

For everyone:

- Week 1 Homework Assignments available on Canvas
  - ALW application survey due **Monday, 09SEP2024, at 11:59 PM (EDT)**
  - Timed Quiz 1 – Math Skills due **Monday, 09SEP2024, at 6:00 PM (EDT)**
- Chapter E Practice available on eLearning
- In-person/online recitations begin next week
  - Students interested in ALWs should attend regular recitations until officially accepted
- First Day Course Materials
  - See Canvas announcement about opting-out (deadline: 17SEP2024)

ANY GENERAL QUESTIONS? Feel free to see me after class!

International System of Units (continued)

- **be careful about what a prefix means vs. the mathematical equality between different units**
- example: 1 centimeter (1 cm)
- **the prefix "centi-" means 10^{-2} (or 0.01), so 1 cm = 0.01 m or 100 cm = 1 m**

BUT 0.01 cm ≠ 1 m nor 1 cm ≠ 100 m

(common mistake alert)

- **MEMORIZE** starred prefixes ASAP

TABLE E.2 SI Prefix Multipliers

Prefix	Symbol	Multiplier	
exa	E	1,000,000,000,000,000,000	(10^{18})
peta	P	1,000,000,000,000,000	(10^{15})
tera	T	1,000,000,000,000	(10^{12})
★ giga	G	1,000,000,000	(10^{9})
★ mega	M	1,000,000	(10^{6})
★ kilo	k	1000	(10^{3})
★ deci	d	0.1	(10^{-1})
★ centi	c	0.01	(10^{-2})
★ milli	m	0.001	(10^{-3})
★ micro	μ	0.000001	(10^{-6})
★ nano	n	0.000000001	(10^{-9})
★ pico	p	0.000000000001	(10^{-12})
femto	f	0.000000000000001	(10^{-15})
atto	a	0.000000000000000001	(10^{-18})

Derived Units

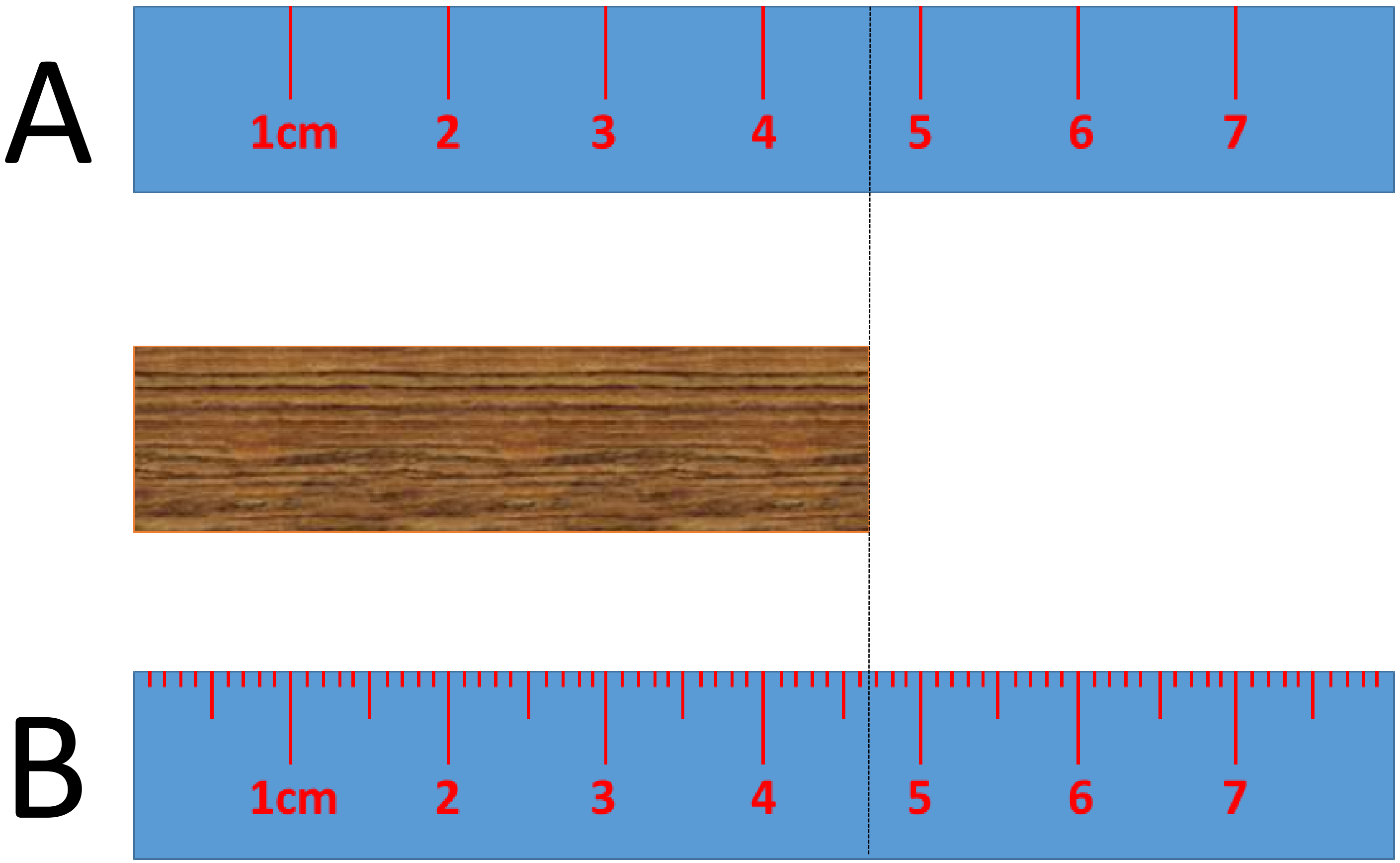
- units for a quantity made up of a combination of other units
  - derived from the equation for a given property
- for example, volume (V): a measurement of space
  - volume of a cube = (edge length)^3 = m^3 (a ***derived unit*** for volume)
  - 1 m = 100 cm **BUT** 1 m^3 $\neq$ 100 cm^3 **(COMMON ERROR ALERT!!)**
  - **1 m^3 = (100)^3 cm^3 = 10^6 cm^3**
  - common units for V in chemistry: 1 L = 1000 mL = 1000 cm^3 (so 1 mL = 1 cm^3)
- **density (d)** = $\frac{\text{mass}}{\text{volume}}$ = kg/m^3, g/cm^3, g/mL, etc.
- **velocity (v)** = $\frac{\text{distance}}{\text{time}}$ = m/s, mi/h, etc.
- **Force (F)** = mass × acceleration = kg $\frac{\text{m}}{\text{s}^2}$ = N
- **Energy (E) =** Force × distance = kg $\frac{\text{m}^2}{\text{s}^2}$ = J

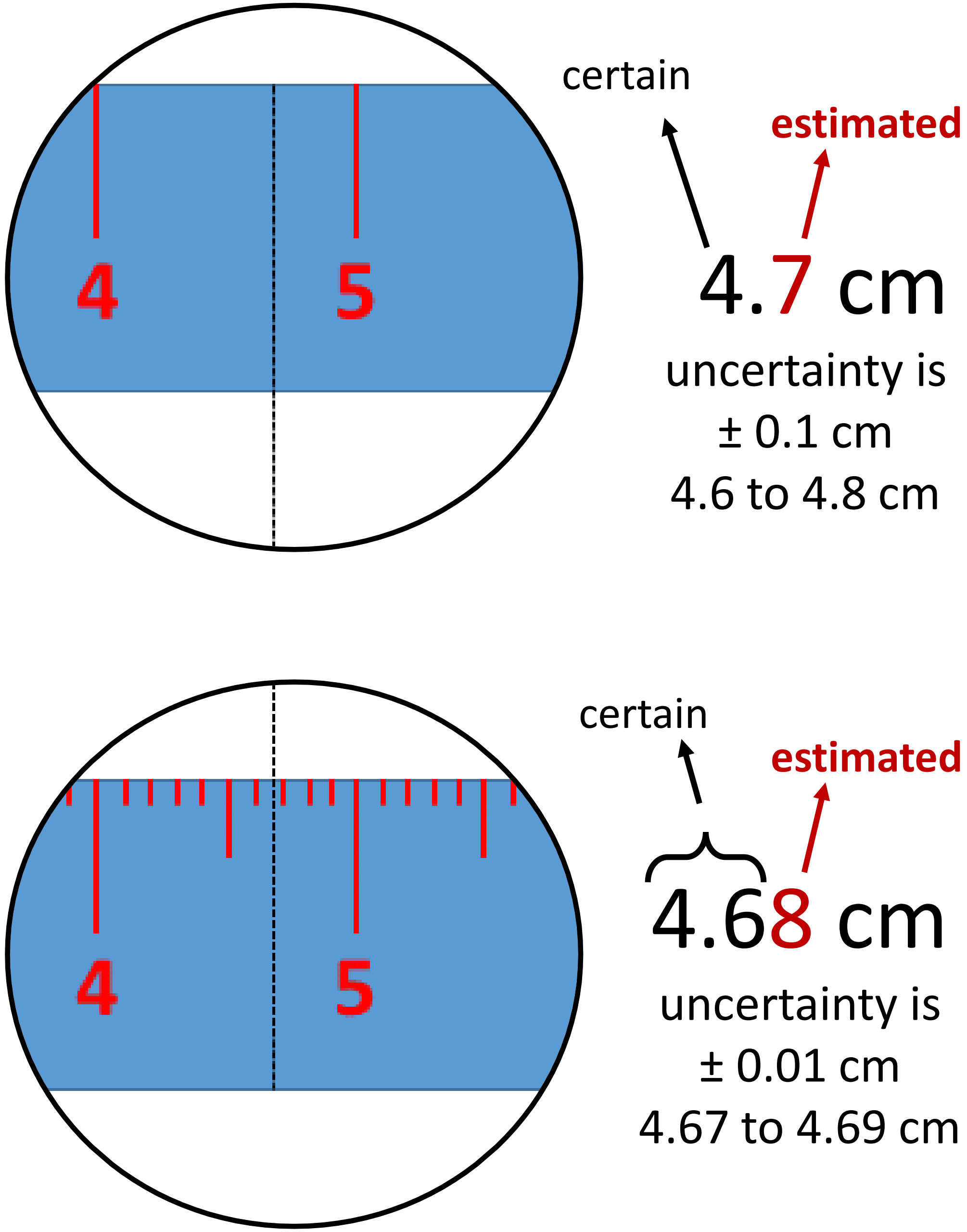
The Reliability of a Measurement

- How much can a given measurement be trusted?
  - largely depends on the instrument making the measurement: the precision, the accuracy, the sensitivity, etc.
  - is the measurement being reported responsibly and within the limits of the instrument?

- Measurements must be reported to reflect the appropriate certainty
  - in general, the more digits in a measurement, the more certainty in the measurement
  - scientific measurements should include every certain digit and *only one* estimated digit (which is uncertain)
    - these are called the **significant digits** of the measurement
  - the number of digits reported depends on the measuring device

an illustration of reliability…





- B has more significant digits than A and is more precise
- B has less uncertainty than A

Question: Why not report A as 4.70 cm or 4.700 cm?

Precision and Accuracy of ***Repeated*** Measurements

- measurements are often *repeated* to increase confidence
- **accuracy =** how close measured values are to the actual value
- **precision =** how closely a series of measurements agree with one another
  - remember that precision is also related to the number of significant digits in a given measurement

Four students repeatedly weigh a lead block standard known to have a true mass of 10.00 g

	Student A	Student B	Student C	Student D
Trial 1	10.72 g	9.78 g	10.03 g	8.07 g
Trial 2	9.89 g	9.82 g	9.99 g	12.02 g
Trial 3	8.94 g	9.75 g	10.02 g	5.03 g
Trial 4	10.41 g	9.80 g	9.98 g	1.23 g
Average	**9.99 g**	**9.79 g**	**10.01 g**	**6.59 g**
	~~**precise?**~~	**precise?**	**precise?**	~~**precise?**~~
	accurate?	~~**accurate?**~~	**accurate?**	~~**accurate?**~~

STUDENT NOTE: Cover on your own

Significant Figure Guidelines

- all measured values have a certain precision and uncertainty associated with them
- the more significant digits in a measurement, the greater the precision and ***certainty***
- How do you know if a digit in a measurement is significant? Follow these rules:

1. All nonzero digits are **significant** 28.03 0.0540 98.6

2. Interior zeroes are **significant** 28.03 7.0301 2001

★ 3. Leading zeroes (i.e., to the left of the first nonzero digit) only serve as place-holders and are **not significant** 0.0032 0.00006 0.8

Significant Figure Guidelines (continued)

★ 4. Trailing zeroes after a decimal point are **significant**

45.000 3.5600 1.000

5. Trailing zeroes ***before a decimal point*** and ***after a nonzero number*** are **significant**

140.00 2500.55 60.6

6. Trailing zeroes with a decimal point are **significant**

2600. 90. 700,000.

Significant Figure Guidelines (continued)

★ 7. Trailing zeroes before an *implied* decimal point are **ambiguous** and scientific notation should be used instead

4000

if written as:	uncertainty:	actual value lies between:
4×10^3	±1000	5000 – 3000
4.0×10^3	±100	4100 – 3900
4.00×10^3	±10	4010 – 3990
4.000×10^3	±1	4001 – 3999

Exact Numbers

- exact numbers have no uncertainty and therefore have an unlimited number of significant digits
- Three categories of exact numbers

1. numbers from accurately counting discrete objects
   - 25 pennies   230 students
2. numbers from ***defined*** quantities
   - 1000 mm = 1 m   1 foot = 12 in   1 mile = 5280 ft
3. integral numbers that are part of an equation
   - $\text{area of a triangle} = \dfrac{base \times height}{\mathbf{2}}$ diameter = **2** × radius etc.

Significant Figures in Calculations

- the precision and uncertainty of a measured quantity can't be improved simply because it's used in a calculation:
- example: 3 g + 0.00034 g = 3.00034 g

± 1 g ± 0.00001 g ± 0.00001 g?!?

- the uncertainty of the individual values must be carried through the calculations and the result of a calculation can be no more precise than the least precise value
- different rules for addition/subtraction vs. multiplication/division

Significant Figures in **Addition and Subtraction**

- the precision of the final answer is dictated by the MOST UNCERTAIN value in the calculation. Connected to the number of decimal places in a value.

example: $2.036 + (1.23\times10^{2}) - 0.502 = ?$

$$\begin{array}{rr} & 2.036 \\ + & 123. \\ - & 0.502 \\ \hline & 124.534 \end{array} = 125$$

(most uncertain)

round answer to the ones decimal place

use this digit for rounding
0 to 4 round down
5 to 9 round up

What about $357.6 - 8.5\times10^{4} + 42.4 = ?$

(ans $= -8.5\times10^{4}$)

Significant Figures in **Multiplication and Division**

- the final result should have as many significant digits as the term with the fewest significant figures.

example: $(3.6) \times (4.84\times10^3) \div 0.5020 = ?$

2 sfs 3 sfs

$$\frac{(3.6) \times (4.84\times10^{3})}{0.5020}$$

4 sfs

$= 34709.163$

$= 3.4709163\times10^4$

round to 2 sfs

$= \mathbf{3.5}\times10^4$

TO AVOID ROUNDING ERRORS IN MULTISTEP CALCULATIONS, ROUND ONLY THE FINAL ANSWER – NEVER ROUND INTERMEDIATE STEPS

What if there are different sig fig rules within the same calculation?

$$\frac{(10.6 - 0.911)}{(1.11)(0.3240)}$$

$$\begin{array}{rl} 10.6 & \pm 0.1 \\ - \quad 0.911 & \pm 0.001 \\ \hline 9.689 & \end{array}$$

2 sfs

$$= \frac{9.\underline{6}89 \text{ (don't round yet!)}}{\underset{3\text{ sfs}}{(1.11)}\underset{4\text{ sfs}}{(0.3240)}}$$

$$= 26.94083$$

$$= 26.94083 \ \textit{round to } \mathbf{2\ sfs} = 27$$