V. SIGNIFICANT FIGURES IN CALCULATIONS:
Follow along and complete these notes as you view video "#5: Significant Figures in Calculations" at
https://youtu.be/AhDiU4x67Pc.

- Scientific calculations involve measurements that have **communicated uncertainty (significant figures)**
- Calculated result can not be more precise than the **least precise input**
- Must determine number of significant figures for result, then **round to appropriate digits**.

A. Rounding

- Largest non-zero digit is **most significant**. Starting there, count to right the **number of sig figs desired.**
- Look at the digit **following the last significant digit**
  a. If the digit is less than 5, **drop it and everything following it (round down)**
  b. If the digit is greater than 5, **round the last significant digit up one and drop everything following it (round up)**
  c. Size of number MUST **stay the same**
     i. If the number is < 1, **keep all leading 0's for magnitude**
     ii. If the number is > 1 and you have removed any digits above the ones place, **replace them with a 0 for magnitude—the magnitude of the number can't change**
  d. If unable to have the correct # of 0's, you **must use scientific notation**

Examples: Round the following number to 3 significant figures:

Original #	Rounded	Original #	Rounded
77.0653 g	**77.1 g**	6,300,178.2 cm^3	**6.30×10^6 cm^3**
0.00023350 mL	**0.000234 mL**	102,030 ft	**102,000 ft**
2.895×10^{21} km	**2.90×10^{21} km**	759.9 ns	**760. ns**

B. Using Significant Digits with multiplication and/or division...

- The result has the same number of significant digits as the **original number** used in the problem that has the **least number** of significant figures. **ROUND** your answer to this number of sig figs.
- The result can be no more precise than the **least precise number used to calculate it.**
  ➢ Perform the following calculations. Remember **units can multiply or divide!**
     ▪ 4.32 mm×1.7 mm = **7.3|44 mm^2** → **7.3 mm^2**
     ▪ 38.742 g ÷ 0.421 g = **92.0|238** → **92.0**
     ▪ 5.40 m×3.21 m×1.871 m = **32.4|319 m^3** → **32.4 m^3**

- ➢ Do the calculation first, then round!
- ➢ You are NOT throwing away important information—you are indicating **the last digit that you have any knowledge of**

- ➢ Perform the following mathematical operations, indicate the correct number of significant figures needed in the answer, and round your answer correctly. Be sure to include the correct units in your final answer.

OPERATION	RAW ANSWER	SF	ROUNDED ANSWER
89.5540 cm × 43.10 cm	**3859|.7774**	**4**	**3860. cm^2**
3380 m^2 ÷ 457.0 m	**7.39|60612691**	**3**	**7.40 m**
0.006750 g ÷ 32 specks	**2.109|375×10^{-4}**	**4**	**2.109×10^{-4} g/speck**
278.4 mm^2 × 25.2 mm	**701|5.68**	**3**	**7020 mm^3**

C. Determining Significant Figures using addition/subtraction…

- • All numbers **MUST have the same units!**
  - ➢ e.g. 85.1 g + 91.8 km = ???
- • The result is rounded to the **decimal place of the input with the least precise decimal place**
  - ➢ e.g. when adding 11.234 g + 2.8 g + 9.57g, the result would be rounded to the **tenths spot** since 2.8 has the least precise decimal place
  - ➢ It is helpful to see this in columnar form:

```
        11.2|34    g          Another example:
         2.8|      g              75|32    m
    +    9.5|7      g          +  4|00     m
    _____                   _____
        23.6|04    g → 23.6 g     79|32    m → 7900 m
```

Perform the following additions and subtractions, indicate the correct number of significant figures needed in the answer, and round your answer correctly. Be sure to include the correct units in your final answer

OPERATION	LAST SIG DIGIT	COLUMNAR	ROUND ANSWER
2.77 cm + 83.018 cm + 5.3 cm	**Tenths Place**	**2.7|7 cm** **83.0|18 cm** **+ 5.3| cm** **91.0|88 cm**	**91.1 cm**
25.89 mL − 22.49 mL	**Hundredths Place**	**25.89|mL** **− 22.49|mL** **3.40|mL**	**3.40 mL**
250. m + 0.67 m	**Ones Place**	**250| m** **+ 0|67 m** **250|67 m**	**251 m**

D. Combined Calculations

- If you have a calculation involving a combination of addition/subtraction and multiplication/division, **determine sig figs by the order of calculations**

  ➤ e.g. when computing % error:

  $$\% \text{ Error} = \frac{\left|\left(8.42 \text{ g/cm}^3 - 8.92 \text{ g/cm}^3\right)\right|}{8.92 \text{ g/cm}^3} \times 100\%$$

  ➤ The subtraction is first calculated, with precision to the **hundredths place**:

  $$\left|\left(8.42 \text{ g/cm}^3 - 8.92 \text{ g/cm}^3\right)\right| = 0.50 \text{ g/cm}^3$$

  ➤ This now has **2 sig figs for the multiplication/division**:

  $$\% \text{ Error} = \frac{0.50 \text{ g/cm}^3}{8.92 \text{ g/cm}^3} \times 100\% = \boxed{5.6\%}$$

Example

- A student finds puts a sample of palladium (Pd) with a mass of 39.07 g into 5.35 mL of water in a 10.00-mL graduated cylinder and records the final volume as 8.6 mL. Calculate the density of Pd to the proper number of significant figures allowed by these measurements.

  ➤ First determine the volume by water displacement:

  $$\text{V}_{\text{Pd}} = 8.6 \text{ mL} - 5.35 \text{ mL} = \underline{\textbf{3.2}}|5 \text{ mL} \boxed{\rightarrow 3.3 \text{ mL} = 3.3 \text{ cm}^3}$$

  ▪ This is subtraction, so the result is precise to the tenths place

  ➤ Next use the volume of the metal in the density equation:

  $$\text{D}_{\text{Pd}} = \frac{\text{mass}}{\text{volume}} = \frac{39.07 \text{ g}}{3.3 \text{ cm}^3} = \underline{11}.8394 \text{ g/cm}^3 \boxed{\rightarrow \textbf{12 g/cm}^3}$$

  ▪ This is division, so the result is precise to 2 sig figs.

  ➤ Recording the final volume to one more dec. place would allow one more sig fig!