

Chapter 2 –Math Skills

2.1 Measurements

Measurement – number with a unit

- Units are *very* important
 - A student wouldn't ask a teacher "Could you please hand me 6?" The student would instead ask, "Could you please hand me 6 **test tubes**?" (Test tubes is the unit in this example)
 - The unit describes the **type** of measurement being made (e.g. length, mass, volume) and the **magnitude** of the measurement being made.
- Uncertainty in measurements.
 - An instrument must be used to obtain a measurement, so some error or uncertainty is involved.
 - All measurements have some uncertainty involved since instruments can never give exact measurements!

Length: measures distance, units are meters (m, cm, mm, km...)

⇒ Length is measured using a ruler or caliper.

⇒ Always record answer to the correct decimal place based on the given increment marks on the instrument *plus* one more "guessed" digit.

- **The bullet measures 4.10 cm**
-it does NOT measure 4.10235 cm!



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Mass: measures the amount of matter an object possesses; mass is not affected by gravity.

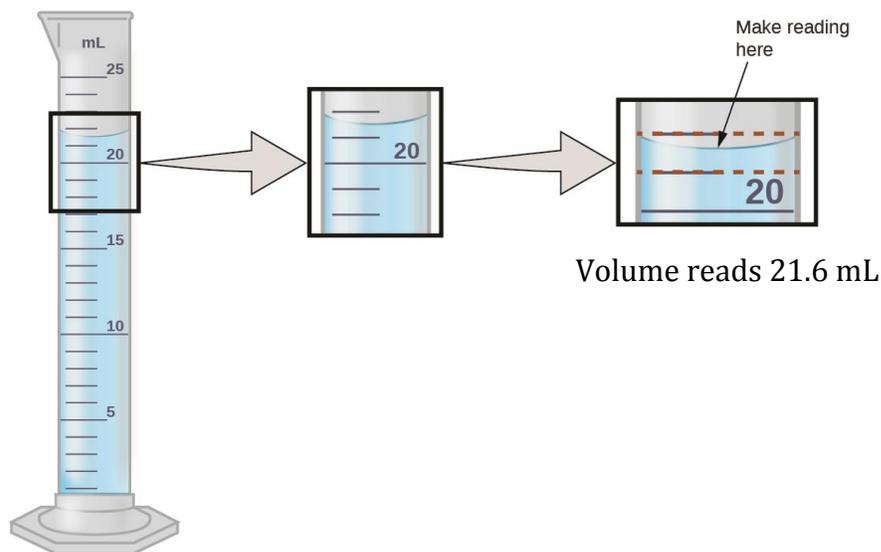
- ⇒ Mass is usually reported in grams or kilograms
- ⇒ Mass is measured using a balance.

Weight: a measure of the force of gravity. Mass is same anywhere, but weight may differ.
E.g. An astronaut may weigh 170 lbs on earth, but only 29 lbs on the moon.

Volume: amount of space occupied by a substance.

- ⇒ Volume is measured using beakers, graduated cylinders, burets and pipets.
- ⇒ Volume units are usually liters (L), milliliters (mL), or cubic centimeters (cm³)

NOTE: 1 mL = 1 cm³ = 1 cc



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2.2 Significant Figures

What is the point of determining significant figures in a calculation? The point is when we add 2 plus 2 we cannot say the answer is 4.0045912. We cannot report our answer with more precision than the original numbers we are adding together.

So what are significant figures (aka sig figs!)?

1. **Nonzero integers** (1, 2, 3, 4, 5, 6, 7, 8, 9) are ALWAYS considered significant figures.
 - 45.6 g has 3 sig figs
 - 2356 L has 4 sig figs
 - 12 m has two sig figs

2. **Zeros.** There are three types of zeros to consider when determining significant figures.
 - a. **Leading Zeros:** These are NEVER considered significant. They are only placeholders.
 - 0.000123 g has 3 sig figs
 - 0.0000000009 L has 1 sig fig

 - b. **Captive Zeros:** These are zeros trapped between two nonzero digits. Captive zeros are ALWAYS considered significant.
 - 2015 has 4 sig figs
 - *It is known with certainty that there is a zero in the hundreds place in the year 2015.*
 - 189.023 m has 6 sig figs.

 - c. **Trailing Zeros:** These zeros are tricky. The key is that there is an integer and a decimal before the zero is considered significant.
 - 50,000 L has only 1 sig fig as written. It is not known if the number was 49,999 rounded up to 50,000 or if the number was precisely 50,000.
 - 600.00 g has 5 sig figs. Since there is an integer and a decimal it is certain that the tenths place and hundredths place both have zeros as the recorded values for this number.

3. **Exact Numbers.** Exact numbers are numbers determined by counting or by definition. Exact numbers are *NEVER* considered when determining significant figures in a calculation. They are considered to have infinite sig figs.

29 students is an exact number. (*You can't really have half a student!*)

1000 mL = 1 L is an exact value

2.54 cm = 1 inch is an exact value

16 test tubes is an exact value obtained by counting.

YouTube Videos: [Significant Figures and Zeros by Tyler DeWitt](#)
[Significant Zero Practice Problems by Tyler DeWitt](#)

2.3 Rounding

Rules for rounding numbers:

1. < 5 , don't round up
2. ≥ 5 , round up
3. Don't change the magnitude of the number – *use placeholder zeroes*

Consider the value \$35,699. Rounding this value to three significant figures would result in the value \$35,700, not \$357. If this were your money in the bank would you want the bank teller to make such an error? The magnitude of the value must always be maintained when rounding.

Example: Round these numbers off to 3 significant figures.

1) $1.42752 = 1.43$

2) $6432.3 = 6430$ NOT 643

3) $22.75 = 22.8$

2.4 Addition/Subtraction Rules

Addition and subtraction: Your final answer is limited by the number with the **fewest decimal places**. Round off your final answer based on the number with the fewest decimal places.

Example:

20.4

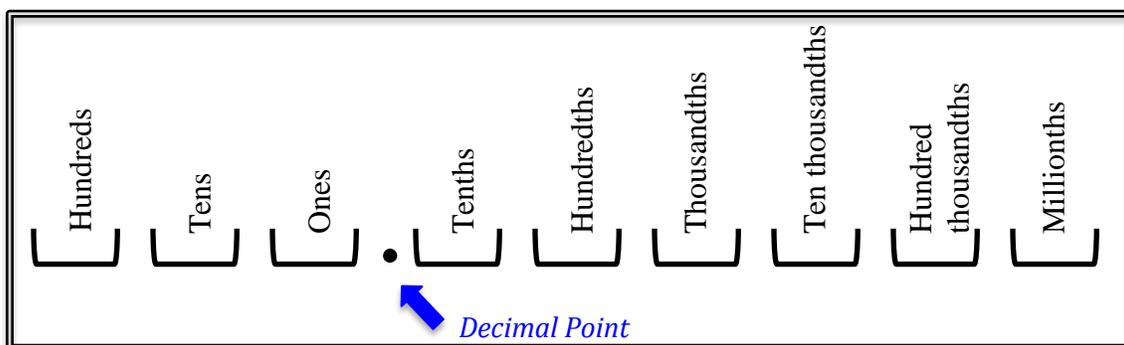
20.4 ends at the tenths place

- 1.3222

1.322 ends at the ten thousandths place

19.0778 » Final answer = **19.1**

⇒ Rounded to 19.1 since 20.4 only has one digit after the decimal point (the tenths place).



2.5 Multiplication/Division Rules

Multiplication and division: The number with the least number of significant figures limits your final answer. Round off your final answer to the same number of significant figures based on the number with the fewest significant figures in the calculation itself.

Example: $6.221 \text{ cm} \times 5.2 \text{ cm} = 32.3492 \text{ cm}^2$ » Final answer = **32 cm²**
(4 s.f.) (2 s.f.)

⇒ Rounded to two significant figures, 32 cm², since 5.2 only has 2 sig figs.

2.6 Scientific Notation

Convenient method for expressing very large or very small numbers.

(+) exponent means number is > 1

(-) exponent means number is < 1

Examples: $10^1 = 10$, $10^2 = 100$, $10^3 = 1000$, $10^{-1} = 0.1$, $10^{-2} = 0.01$, $10^{-3} = 0.001$

Two Parts to Writing Numbers in Scientific Notation:

- 1) One digit in front of the decimal - this is a number between 1 and 10
 - Obtain by expressing number with one digit followed by a decimal point.
 - Continue with remaining digits after the decimal up to the correct number of significant figures.
- 2) The exponential term that is 10 raised to a power
 - Value of exponent is obtained by counting the number of places that the decimal point must be moved to give one digit followed by the decimal point.
 - For big #'s > 1, move the decimal point to the left positive exponent
 - For small #'s < 1, move the decimal point to the right negative exponent.

Example: Convert the following to scientific notation

1) $100.03 = 1.0003 \times 10^2$

2) $0.000340 = 3.40 \times 10^{-4}$

In your calculator punch in 3.40×10^{-4} as



- Use the special (-) or +/- button *NOT* the subtraction button!
- The “EE” button literally means “times ten to the power of”. Some calculators call it the EXP button.
- Do not punch in $\times 10^{-4}$. This will result in an incorrect answer.

2.7 Percent

Percent: Ratio of parts per 100 parts. (e.g. 80% is $\frac{80}{100}$)

To calculate percent: $\% = \frac{\# \text{ of parts}}{\text{whole sample}} \times 100$

⇒ Note: Both the “part” and the “whole” must be expressed in the *same* unit.
The percentage may be used to solve problems as a conversion factor.



CHAPTER 2 PRACTICE PROBLEMS

1. Determine the number of significant figures in each of the following.
 - a. 0.00036 _____
 - b. 0.140150 _____
 - c. 39.00 _____
 - d. 670 _____

2. Round the following to the number of significant figures indicated:
 - a. Round 56,028 to 2 sig figs _____
 - b. Round 0.00062187 to 3 sig figs _____
 - c. Round 2.00039 to 4 sig figs _____
 - d. Round 67,893 to 3 sig figs _____

3. Perform the following operations, expressing each answer to the correct number of significant figures.
 - a. $862 + 14.71 + 1.1 =$ _____
 - b. $725.50 - 103 =$ _____
 - c. $\frac{5.60}{2.800} =$ _____
 - d. $(6.43 \times 10^{-7}) \times (4.5 \times 10^8) =$ _____
 - e. $(1.90 \times 10^{15}) \div (2.500 \times 10^8) =$ _____

4. Express these numbers in exponential notation.
 - a. 0.000823 _____
 - b. 135,200 _____
 - c. 8.714 _____
 - d. 0.00000002710 _____

5. What does each of the following measure?
 - a. Burette b. Ruler c. clock d. graduated cylinder e. balance

6. If 12.5 gallons of gasohol contains 1.50 gal of ethyl alcohol, what is the percent of alcohol in the gasoline?

Answers to Practice Problems

- a. 2 b. 6 c. 4 d. 2
- a. 56,000 b. 0.000622 c. 2.000 c. 67,900
- a. 878 b. 623 c. 2.00 d. 2.9×10^2 e. 7.60×10^6
- a. 8.23×10^{-4} b. 1.352×10^5 c. 8.714×10^0 d. 2.710×10^{-8}
- a. volume b. length c. time d. volume e. mass
- $\left(\frac{1.50 \text{ gal alcohol}}{12.5 \text{ gal gasohol}} \right) \times 100\% = 12.0\% \text{ alcohol}$