Part I: Scientific Notation

Scientists often deal with really large numbers such as the distance light travels in 1 year (9,540,000,000,000,000 m) and really small numbers such as the mass of a proton (0.000000000000000000000000000167 kg.

Numbers that are really large and really small can be a hassle to work with (and take up a lot of space). To help deal with this, **scientific notation** abbreviates numbers like these to make them more manageable.

1. The diameter of the sun is equal to 1,390,000 km. This number is written as 1.39×10^{6} km in scientific notation. Type both numbers into your calculator to prove to yourself that they are equivalent.

2. Working in your PAL team, use the example in the previous question to come up with a generalized statement that describes how numbers greater than "1" are turned into scientific notation.

3. The mean diameter of a carbon atom is equal to 0.00000013 mm. In scientific notation, this same number is written as 1.3×10^{-7} mm. Type both numbers into your calculator to prove to yourself that they are equivalent.

4. Working in your PAL team, use the example in the previous question to come up with a generalized statement that describes how numbers less than "1" are turned into scientific notation.

5. Write the following measurements in scientific notation:

a. 0.000000000000000000000000000167 kg =

b. 9,540,000,000,000,000 m =

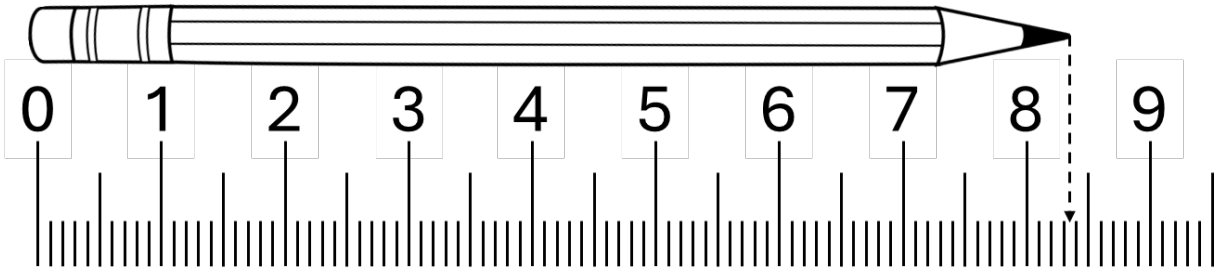
6. Change the following measurements from scientific notation back to their original long form.

a. 5.70×10^{-8} =

b. 8.4×10^{11} =

Part II: Measuring & Significant Figures

7. All measurements have a limited number of significant figures associated with them. Use the image of the pencil and ruler to estimate the length of the ruler (in cm).



Length of pencil = _____ cm

8. Go around your PAL team and compare your answers. What digits does everyone agree on? [These are our "certain digits"] What digit is there some disagreement on?
[This is our "estimated digit"]

9. Since we are only allowed one "estimated digit", what is wrong with reporting the length of the pencil as 8.361 cm?

10. Imagine the ruler only had been marked with "8" and "9" and did not have the tenths placed marked. How would that have changed your answer?
[*Hint*: think about how many digits we are allowed to use]

Part III: Determining Significant Figures

When using someone else's measurement, it is important to understand how many significant figures it has. **Table 1** shows a series of measurements and identifies how many significant figures each measurement has.

Table 1:

Measurement	Significant Figures
1.8335 mL	5
97531.82 gal	7
1.003 L	4
80.102 g	6

11. Based on the first 2 examples in **Table 1**, what is the general rule for whether to count "non-zero digits" (digits that are *not* zero) as significant? How many "non-zero digits" are there in the second 2 examples?

12. Based on the last two examples in table 1, what is the general rule for whether to count "zeroes sandwiched between other numbers" as significant?

Now let's look at "zeros" that are at the start or end of a measurement, not sandwiched between two non-zero numbers. **Table 2** shows when zero is used as a place holder. **Table 3** shows zeros that are *actual* significant figures.

Table 2: Zeros used as a place holder.

Measurement	Significant Figures
2400 mL	2
3,000,000 gal	1
0.00065 km	4

Is there another way to write these measurements which do not use the additional place holders? [Hint]: Think about scientific notation

Table 3: Zeros included as significant figures.

Measurement	Significant Figures
25.0 mL	3
3.000 gal	4
0.079000 km	5

13. How can you tell the difference between the "zeros" in Table 2 (place holders) and Table 3 (non-place holders)?

14. Based on Table 2, what is the general rule for whether to count, "zeros that are place holders" as significant?

15. Based on Table 3, what is the general rule for whether to count, "zeros that are non-place holders" as significant?

16. In summarizing your rules from questions 11-15 above, what are the only digits that are not considered to be significant?

17. How many significant figures are in each of the following measurements?

Measurement	Significant Figures
4530 kg	
0.00070 sec	
8.01000 miles	
501.040 cm	
56,004,000 lb	

Part IV: Significant Figure Rules

A. Multiplication and Division

When performing calculations we need to keep significant figures in mind. Our final answer must obey the rules of significant figures. The rules of multiplication and division follow rules than the rules for addition and subtraction.

18. Type the following calculation into your calculator. Write down the entire answer give to you by your calculator.

$$\frac{(1.070)(3.105)}{0.0209} =$$

How many digits did your calculator produce? _____

Our answer can only have as many significant figures as the measurement we used with the **least number of significant figures**.

In the above calculation, label the number of significant figures in each of the 3 measurements. Based on the smallest number of significant figures, go back to the answer your calculator gave you and round off your calculation to the correct number of significant figures.

19. Answer the following problems and report your answer using the correct number of significant figures.

a. $(12.08)(9.80) =$

b. $(1.79 \times 10^5)(0.570) =$

c. $\dfrac{7200}{122} =$

d. $\dfrac{151.040}{0.00493} =$

e. $806.08 + 14.9 =$

f. $1200.00 + 9.1 =$

g. $2.006 - 0.04 =$

h. $0.9122 - 0.04050 =$

20. Complete the following multistep calculations which may use a combination of multiplication/division and addition/subtraction. Remember to keep track of your significant figures throughout the calculation and don't round until the very end.

Parts a and b will help walk you through the steps on how to solve problems with multiple steps and a mix of addition/subtraction and multiplication/division.

a. $\dfrac{7.84 - 4.8}{6 + 4.27} =$

Step	Mathematics	Explanation
Solve the operations in the parentheses first. – Keep 1 extra significant figure until the very end. – Highlight or underline the significant figures in each step.	Numerator: $7.84 - 4.8 = \underline{3.0}4$ Denominator: $6 + 4.27 = \underline{10}.27 = \underline{10}.3$	We are subtracting and adding numbers, so we need to watch decimal places. – Numerator: the "4.8" only has only 1 decimal place, so our answer for that step is the underlined 3.0 (keep the extra digit, the "4" until the end). – Denominator: the "6" has no digits after the decimal, so our answer for that step is the underlined 10. (keep the extra digit, the "3" until the end).
Solve the division portion of the problem. – Pay special attention to underlined portions of each number from the previous step.	$\dfrac{\underline{3.0}4}{\underline{10}.3} = 0.\underline{29}5145631$	Now we are dividing, so we need to switch over to watching significant figures. – The numerator has 3.0 underlined which means it has **2 sig figs**. – The denominator has 10. underlined which means it has **2 sig figs**.
– Round off the answer to the correct number of significant figures.	Answer: $0.\underline{29}5145631 = 0.\underline{30}$	– Based on the underlined numbers, our answer should have 2 sig figs. – The "0.29" is rounded up to "0.30"

b. $\dfrac{793.104}{4.80} + \dfrac{2.1651}{0.35} =$

Step	Mathematics
Solve the quotients first. – Keep 1 extra significant figure until the very end. – Highlight or underline the significant figures in each step.	1st Quotient : $\dfrac{793.104}{4.80} =$ _____ 2nd Quotient: $\dfrac{2.1651}{0.35} =$ _____
Continue with the addition step. – Pay special attention to underlined portions of each number.	Addition: $\dfrac{\text{1st Quotient}}{} + \dfrac{\text{2nd Quotient}}{} = \dfrac{\text{Don't round yet}}{}$
Round off the answer to the correct number of decimal places.	_____ Final Answer

c. $\dfrac{108.298}{17.09 - 12.1} =$

d. $\dfrac{1.070 \times (3.105 + 0.0026)}{0.02090} =$

e. $2.19 \times (19.09 + 0.08) =$

f. $(6745 + 4.78) \times 3.56 =$

g. $\dfrac{(9.08.4\text{-}3.4)}{(2.52 \times 10^{4})} =$