SIGNIFICANT FIGURES

When making a measurement, it is obvious that the accuracy of your number is always limited by the equipment used or by the sheer size of the number involved. For example, we are taught that the distance to the sun is 93 million miles. That's good enough for our purposes, but we do know that the distances changes throughout the year and that, if we had a long enough ruler, we could measure the distance down to feet and inches. But why? 93 million miles is as good as we need, and is said to be expressed to **two significant figures.**

Significant figures are those figures in a number or a measurement that are known with certainty *plus*, the first digit that is uncertain.

- As an example, if you were to make a measurement with a standard meter stick, you would observe that the object was 1 meter long plus 35 centimeters plus another 5 millimeters and somewhere between the 5 and 6 millimeter mark. To write this number, we would write 1.3556, estimating that the measure was approximately 6/10 of the way between 5 and 6 millimeters. The 1, 3, 5 and 5 are known with certainty as we can read those marks on the stick, the 6 was our best guess and is referred to as the figure of uncertainty (or estimated digit). In this example, we know the measurement to 5 significant figures (S/F).

Rules for significant figures:

1. All non-zero numbers are significant.
   - 112.6 km has 4 S/F

2. All zeros between non-zero numbers are significant.
   - 108.005 km has 6 S/F

3. Zeros to the right of a non-zero figure, but to the left of a <u>understood</u> decimal point are **not significant** unless specifically indicated to be so.
   - 109000 km has 3 S/F.

4. All zeros to the right of a decimal point and to the left of a non-zero digit are **not significant**.
   - 0.000647 kg has 3 S/F. (The zero to the left of a decimal in such an expression only serves to call attention to the decimal point.)

5. All zeros to the right of a decimal and following a non-zero digit **are significant**.
   - 0.07080 m and 20.00 kg both have 4 S/F.

Practice: Determine the number of significant figures in the following.

1.	967	_______	6.	2,700	_______	11.	670,004	_______
2.	967,000	_______	7.	0.00881	_______	12.	500,000,000	_______
3.	96.7	_______	8.	780.000	_______	13.	30.4	_______
4.	9.67	_______	9.	0.04010	_______	14.	0.1110	_______
5.	0.00967	_______	10.	4.530	_______	15.	24,091,800	_______

Rules for addition and subtraction.

1. Remember that the 'rightmost'figure in a measurement is uncertain. The 'rightmost' figure in a sum or difference will be determined by the 'leftmost' uncertain digit. It maybe helpful to place the numbers in a column so that you can visualize the 'leftmost' uncertain digit.

   Ex. 13.05 (4 S/F, 5 uncertain)
   309.2 (4 S/F, 2 uncertain)
   <u>3.785</u> (4 S/F, 5 uncertain)
   326.035 (since the 'leftmost' uncertain figure was the 2, in the tenths place, that is the last place that can be known with certainty.)

   The proper answer is 326.0

Practice: Calculate the following, keeping significant digits in mind.

1. 12.01ml + 35.2ml + 6ml=____________________
2. 0.15cm + 1.15cm + 2.051cm=____________________
3. 505kg – 450.25kg=__________________
4. 123.25ml + 46.0ml + 86.257ml=___________________

Rules for multiplication and division.

1. Remember that when an uncertain figure is multiplied (or divided) by any figure, the answer must also be uncertain. Therefore a product or a quotient should not have more significant figures than the least precise factor.
   Ex. 3.54cm X 4.8cm X 0.541cm = 9.192672 cm^3
   While this is the answer that your calculator would give you, remember that 4.8cm is the least precise number and you will have to change your answer to **9.2 cm^3**. (Rules for rounding off: 1. if the figure to be dropped is 5 or more round up. 2. if the figure to be dropped is less than 5, drop it.)

Pratice: Calculate the following, keeping significant digits in mind.

1. 1.35m X 2.467m = ________________
2. 1,035m^2 ÷ 42m = ________________
3. 0.021cm X 3.2cm X 100.1cm = _________________
4. 150 L^3 ÷ 4 L = _________________
5. 23.0cm X 432cm X 19cm = _______________

SCIENTIFIC NOTATION

Scientists often deal with very small and very large numbers, which can lead to a lot of confusion when counting zeros! We have learned to express these numbers as powers of 10. Scientific notation takes the form of **$M \times 10^n$** where 10>M≥1 and "n" represents the number of decimal places to be moved. Positive n indicates the standard form is a large number. Negative n indicates a number between zero and one.

- As an example, convert 1,500,000 to scientific notation.
  We move the decimal point so there is only one digit to its left, a total of 6 places. 1,500,000 = 1.5×10^6
- Another example would be, convert 0.000025 to scientific notation.
  We move the decimal point five places to the right. (Creating a negative exponent)0.000025 = 2.5×10^{-5}

Practice: Covert the following to scientific notation.

1.	0.005 =	________________	2.	0.25 =	________________
3.	5,050 =	________________	4.	0.025 =	________________
5.	1,000,000=	________________	6.	5,000 =	________________

Convert the following to standard notation.

1.	1.5×10^3 =	______________	2.	3.35×10^{-1} =	______________
3.	3.75×10^{-2} =	______________	4.	1×10^4 =	______________
5.	2.2×10^5 =	______________	6.	4×10^0 =	______________

Rules for Adding and Subtracting with Scientific Notation

When adding or subtracting in scientific notation, you must express the numbers as the same power of 10. This will often involve changing the decimal place of the coefficient.

- As an example, $(3.2 \times 10^4) + (1.35 \times 10^6) = 1.38 \times 10^6$
  To complete the calculation you must change one of the exponents to match the other. Let's express 3.2×10^4 as 0.032×10^6. Now we can add,
  0.032×10^6
  $+1.35 \times 10^6$ (remember your significant digits!!)
  1.382×10^6 would be written as 1.38×10^6
- Another example, $(5.34 \times 10^{-3}) – (2.167 \times 10^{-4}) = 5.12 \times 10^{-3}$
  To complete the calculation remember to change one of the exponents to match the other. Let's express 5.34×10^{-3} as 53.4×10^{-4}. Now we can subtract,
  53.4×10^{-4}
  $- 2.167 \times 10^{-4}$
  51.233×10^{-4}, remember to express as sig. Figs, 51.2×10^{-4}

**** we also need to remember to keep our digit to the left of the decimal less than 10 but more than 1.**

Practice: Calculate the following.

1. $(3.95 \times 10^5) + (7.8 \times 10^3) =$ ____________________________
2. $(2 \times 10^{-3}) + (8 \times 10^{-4}) =$ ____________________________
3. $(4.54 \times 10^7) – (1.01 \times 10^8) =$ ____________________________
4. $(7.83 \times 10^{-2}) – (2.20 \times 10^{-3}) =$ ______________________________

Rules for Multipling and Dividing with Scientific Notation

When you multiply numbers with scientific notation, multiply the coefficients together and add the exponents. The base will remain 10.

- For example, $(1.2 \times 10^2) \times (6.43 \times 10^6) = 7.7 \times 10^8$
  Multiply (1.2) and (6.43) = 7.716, and add 10^2 and $10^6 = 10^8$, you will write the answer as 7.7×10^8 (remembering sig. Figs.)

Practice: Calculate the following.

1. $(6.8 \times 10^3) \times (4.54 \times 10^6) =$ __________________________
2. $(2.0 \times 10^{-1}) \times (8.5 \times 10^5) =$ _________________________
3. $(4.42 \times 10^{-3}) \times (4 \times 10^{-2}) =$ _________________________

When you divide numbers with scientific notation, divide the coefficients and subtract the exponents. The base will remain 10.

- For example, $(3.66 \times 10^{-2}) \div (7.3 \times 10^{-4}) = 5.0 \times 10^1$
  Divide (3.66) by (7.3) = 0.5014, and subtract 10^{-4} from $10^{-2} = 10^2$, you will write the answer as 5.0×10^1 (keeping in mind the rules you have learned!)

Practice: Calculate the following.

1. $(3 \times 10^6) \div (7 \times 10^3) =$ _____________________
2. $(9.2 \times 10^{-3}) \div (6.3 \times 10^6) =$ _____________________
3. $(2.4 \times 10^6) \div (5.49 \times 10^{-9}) =$ _______________________

Name: ____ **Block:** ___ **Date:** _______________________

Homework – Significant Figures and Scientific Notation

Determine the number of significant figures for each of the following.

1. 5.432 ____	6. 40.319 ____	11. 146 _____	16. 3.285 _____
2. 0.189 ____	7. 429.3 ____	12. 2873.0 _____	17. 99.9 _____
3. 0.0023 ____	8. 144 ____	13. 2500 _____	18. 2500.0 _____
4. 1.04 ____	9. 35.08 ____	14. 8365.6 _____	19. 48.57193 _____
5. 7.500 ____	10. 7,500 ____	15. 0.920 _____	20. 0.002300 _____

Using significant figures, calculate the following addition and subtraction problems.

1. 12 cm + 0.031 cm + 7.969 cm = ______________________
2. 0.085 cm + 0.062 cm + 0.14 cm = ______________________
3. 3.419 g + 3.912 g + 7.0518 g + 0.00013 g = ______________________
4. 8.7 g + 15.43 g + 19 g = ____________________
5. 143.0 ml + 289.25 ml + 107.85 ml = ____________________
6. 41.025 cm – 23.28 cm = ___________________
7. 289 g – 43.7 g = ___________________
8. 145.63 ml – 28.9 ml = ___________________
9. 62.47 g – 39.9 g = ___________________
10. 40.08 ml – 29.0941 ml = ___________________

Using significant figures, calculate the following multiplication and division problems.

1. 2.89 cm x 4.01 cm = __________________
2. 17.3 cm x 6.2 cm = __________________
3. 3.08 m x 1.2 m = _________________
4. 5.00 mm x 7.3216 mm = ___________________
5. 20.8 dm x 123.1 dm = __________________
6. 8.071 cm^2 ÷ 4.216 cm = __________________
7. 24,789.4 km^2 ÷ 43.5 km = __________________
8. 109.3758 m^2 ÷ 5.813 m = __________________
9. 6.058 mm^2 ÷ 0.85 mm = __________________
10. 4.23 m^2 ÷ 18.491 m = _________________

Convert the following standard notations to scientific notation.

1. 28,000,000 ________________	6. 62,500 _______________
2. 305,000 ________________	7. 0.002403 _______________
3. 0.000024863 ________________	8. 8,809,000 _______________
4. 345.23 ________________	9. 0.251 _______________
5. 0.00025 ________________	10. 3,010,000 _______________

Convert the following scientific notations to standard notation.

1. 8.54×10^{12} ____________
2. 2.101×10^{-5} ____________
3. 3.051×10^{7} ____________
4. 5.94×10^{-4} ____________
5. 8.27×10^{3} ____________
6. 3.86×10^{9} ____________
7. 2.511×10^{-7} ____________
8. 4.820×10^{6} ____________
9. 2.88×10^{5} ____________
10. 4.05×10^{-2} ____________

Calculate the following addition and subtraction problems. (Remember Sig. Figs.)

1. $(1.20 \times 10^{2}) + (3.600 \times 10^{3}) + (4.5000 \times 10^{4}) =$ ____________
2. $(7 \times 10^{1}) + (6.5 \times 10^{-1}) + (4.9 \times 10^{-2}) =$ ____________
3. $(5.3 \times 10^{19}) + (1.32 \times 10^{18}) =$ ____________
4. $(1.2 \times 10^{1}) + (3.1 \times 10^{-2}) + (7.969 \times 10^{2}) =$ ____________
5. $(8.5 \times 10^{3}) + (6.2 \times 10^{4}) + (3.412 \times 10^{2}) =$ ____________
6. $(8.523 \times 10^{2}) - (6.27 \times 10^{1}) =$ ____________
7. $(3.25 \times 10^{-2}) - (4.679 \times 10^{-5}) =$ ____________
8. $(6.452 \times 10^{6}) - (5.352 \times 10^{5}) =$ ____________
9. $(6.2 \times 10^{-2}) - (6.18 \times 10^{-3}) =$ ____________
10. $(2.89 \times 10^{7}) - (4.37 \times 10^{2}) =$ ____________

Calculate the following multiplication and division problems. (Remember Sig. Figs.)

1. $(6 \times 10^{5}) \times (4 \times 10^{-3}) =$ ____________
2. $(3.2 \times 10^{3}) \times (3.332 \times 10^{-5}) =$ ____________
3. $(5.432 \times 10^{4}) \times (3.67953 \times 10^{6}) =$ ____________
4. $(9.8670 \times 10^{-3}) \times (2.1 \times 10^{-4}) =$ ____________
5. $(7.26 \times 10^{7}) \times (5.0030 \times 10^{5}) =$ ____________
6. $(7.7 \times 10^{6}) \div (1.1 \times 10^{2}) =$ ____________
7. $(8.53 \times 10^{5}) \div (5.0 \times 10^{3}) =$ ____________
8. $(9.32 \times 10^{-3}) \div (3.1 \times 10^{-5}) =$ ____________
9. $\dfrac{(2.1 \times 10^{-2})(4.56 \times 10^{5})}{(6.4 \times 10^{-7})} =$ ____________
10. $\dfrac{(8.4 \times 10^{-5})(1.4 \times 10^{3})}{(4.367 \times 10^{-2})} =$ ____________