Name_____

Lab #1 – Math Review Introduction

Purpose: Throughout the semester we will be using mathematics in both the lab and lecture. This lab is an introduction (or for some a review) of general calculations that will be performed. It is not all inclusive, but will cover the basic concepts and serve as a reference guide for future assignments. Additional information and tables can be found in your textbook (Fetter) in Sections 1.11 & 1.12 (p. 18-21) and the Appendices (p. 534-551).

USEFUL TABLES & SCIENTIFIC NOTATION

Standard (metric) units of measure

Physical Quantity	Base unit	Symbol
Length	Meter	m
Mass	gram	g
Time	Second	s
Temperature	Kelvin	K
Quantity	mole	Mol

Common prefixes in scientific notation

Prefix	Definition	Power	Symbol
Mega	1,000,000	10^{6}	M
Kilo	1,000	10^{3}	k
Centi-	0.01	10^{-2}	c
Milli-	0.001	10^{-3}	m
Micro	0.000001	10^{-6}	μ

When adding and subtracting numbers written in scientific notation, it is necessary for the two numbers to be the same power (same exponent). To do this move the decimal point (count the spaces to make the exponent the same as your other number) and change the exponent that amount. When multiplying or dividing numbers written in scientific notation, add or subtract the exponents, respectively.

UNIT CONVERSIONS/DIMENSIONAL ANALYSIS

Probably the most common type of problem you will encounter in this class. Paying attention to the units of a problem can aide you in reaching the correct answer. Additionally, it is common to need to convert one or more values because measurements may be performed with two different units or an uncommon unit may be measured. For example, your ruler may only measure in inches, but you are required to measure the length of an item in cm. Using a conversion factor of 1in = 2.54cm, the length in cm can be determined without finding a new ruler. An example will be given on the board for converting ft to cm. Write the example down for future reference:

Note that in this example the answer is a very large number, which is difficult to visualize and understand what this length is. This is another common reason to convert to another unit. The example will be continued, this time converting the final cm answer into both m and km. Write the example down:

We will often times be calculating areas or volumes…..it is important to note that both the value and the units need to be raised to the appropriate power if converting an area or volume. An example of this will be shown on the board, write it below:

SIGNIFICANT FIGURES (adapted from USCA Chemistry Department website)

Significant figures are critical when reporting scientific data because they give the reader an idea of how well you could actually measure/report your data. Below are the rules for significant figures:

1) All non-zero numbers (1,2,3,4,5,6,7,8,9) are ALWAYS significant.
2) All zeroes between non-zero numbers are ALWAYS significant.
3) All zeroes which are simultaneously to the right of the decimal point AND at the end of the number are ALWAYS significant.
4) All zeroes which are to the left of a written decimal point and are in a number >= 10 are ALWAYS significant.

*A helpful way to check rules 3 and 4 is to write the number in scientific notation. If you can/must get rid of the zeroes, then they are NOT significant.

Examples: Fill in the table below with the number of significant figures that are present in each of the numbers, and also the rule or rules you used to determine this.

Number	# Significant Figures	Rule(s)
48,923		
3.967		
900.06		
0.0004		
8.1000		
501.040		
3,000,000		
10.0		

Significant figures need to be taken into account when performing mathematical operations:
Addition & Subtraction-when adding or subtracting numbers, count the number of decimal places to determine the number of significant figures for each number in the operation. The answer cannot contain more places after the decimal point than the smallest number of decimal places in the numbers being added or subtracted.
Example:

23.112233	(6 places after the decimal point)
1.3324	(4 places after the decimal point)
+ 0.25	(2 places after the decimal point)
24.694633	(on calculator)
24.69	(rounded to 2 places in the answer)

Multiplication & Division **-** when multiplying or dividing numbers, count the number of significant figures for each number in the operation. The answer cannot contain more significant figures than the number being multiplied or divided with the least number of significant figures.
Example:

23.123123	(8 significant figures)
x 1.3344	(5 significant figures)
30.855495	(on calculator)
30.855	(rounded to 5 significant figures)

Note that when performing calculations, do not follow these guidelines for intermediate results; keep as many digits as is practical to avoid rounding errors.

FRACTIONAL EXPONENTS
Although your calculator may allow you to directly enter a fractional exponent, it is important to understand the process.
A fractional exponent like m/n means:
Do the m-th power, then take the n-th root
OR Take the n-th root, then do the m-th power $a^{\frac{m}{n}} = \sqrt[n]{a^m} = \left(\sqrt[n]{a}\right)^m$

AVERAGE
Generally, if the word "average" is used, it is the arithmetic mean that is being referred to. Other common types of averages include geometric mean, median, and mode, all of which are described below:
Arithmetic Mean = Sum of Values/Total Number of Values
Geometric Mean = e^ (Sum of natural log Values/Total Number of Values)
Median- the middle value in a list of values, the middle value can be determined by:
(Total number of values + 1)/2
Mode- the value that occurs most often

PROPORTIONS

Relative proportions of things= "parts per. . .something", which means the proportion of one thing in something else. There are a number of different ways to express this, as described below, but no matter which is used, the units must be dimensionless.

Percent (%)—one part per 100 parts. This is calculated by dividing the part by the whole, then multiplying by 100 to convert to a percentage. For example, the volume of pore space divided by the total volume as shown in the example on the board:

Per mille (‰) –"One part per thousand" denotes one part per 1000 parts. This is calculated by dividing the part by the whole, then multiplying by 1000 to convert to a permille. An example of this is:

ppm—one part per 1,000,000 parts
ppb- parts per billion
ppt—parts per trillion

Note that you can convert between these various proportions quite easily. For example, to convert from percent to per mille simply requires dividing by 100, then multiplying by 1000. Or, if you start with per mille, divide by 1000, then multiply your number by 100 to get a percent. Most commonly we will use percent; however, some chemical solutes still use ppm or ppb to report the amount of solute.

CROSS-SECTIONAL AREA

This is a common term used in both surface and groundwater measurements as will be explained in class. In the space below explain/draw what cross-sectional area is:

SEMI-LOG AND LOG GRAPHS

Most of the graphing we will do this semester will be on either semi-log or log-log paper. Semi-log graphs have one axis with a logarithmic scale and the other axis with a linear scale. Log-log graphs have logarithmic scales on both axes.

The most important thing to remember is that on a logarithmic scale each cycle increases by a factor of ten. For example, if a logarithmic scale had two cycles and the first scale marking was 1, the next marking would be 2, 3, …, up to 9. Then the next cycle would begin with 10, then 20, 30, …, up to 90.

Name_____

Lab #1 – Math Review Assignment
Due at the end of lab

Convert the following numbers into scientific notation:
Earth's average distance to the sun: 92,600,000 miles _____
Earth's diameter: 8,000 miles _____
Volume of one gram: 0.035 ounces _____
Wavelength of gamma rays: 0.00000000003 meters _____

Convert the following from scientific notation into a regular number:
Volume of water in the ocean: 1.4×10^{9} km^3 _____
Size of clay particles: 1×10^{-4} mm _____

Unit Conversions- (show your work and always use units, express your answers in scientific notation where appropriate)
1) How many meters are there in a mile?

2) A swimming pool has a volume of 2,000 ft^3, what is this in cm^3?

3) A river has a discharge of 25 cfs (cubic feet per second), what is this in km^3/d?

Various Additional Problems- (show your work including units, and report to the appropriate number of significant figures, expressing in scientific notation if necessary)
1) The simplest hydrogen atom consists of only one proton and one electron. If the mass of this simple hydrogen atom is 1.66035×10^{-24} grams and the mass of an electron is 9.1066×10^{-28} grams, what is the mass of the proton?

2) What is $23^{4/3}$?

3) The following low temperatures (in °F) are predicted for December 2012 in Clarksville: 50, 43, 33, 25, 32, 35, 29, 33, 32, 10, 17, 33, 34, 33, 20, 14, 28, 31, 30, 27, 26, 30, 31, 36, 40, 23, 23, 28, 18, 29, 30. Do you expect the arithmetic and geometric means to be similar? Why or why not?

4) An unfortunate accident spilled salt into the Cumberland River, causing it to have a salt concentration of 41.2 ppm. What is this in percent?

5) What is the cross-sectional area of a 24 km long river that averages 3.5 ft deep & 10.1 ft wide?

6) A student received the following grades on their labs: 75.2, 88.0, 71.05, 92.3, & 88.00. What is the student's median and mode lab grade?

7) A lake 1.1 km wide and 2.8 km in length holds 575 million gallons of water. What is the average depth of the lake in ft?

8) Graph the following data points on the semi-log paper below:

Drawdown (ft)	Time (min)
5	3
10	5
25	30
40	150
50	500