Homework #1
NATS 101
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This homework begins with background information about converting between units, cancelling of units in equations, conversion to and from scientific notation, and interpreting graphs. If you feel comfortable with these areas, then you may skip to the assignment section.

I. Conversions: Units

Converting from one system of measurement to another is like translating from one language to another, except that we use equations to make the change. The examples below demonstrate the procedure.

Example 1: You have borrowed your friend's old 1971 Toyota Landcruiser for a scuba trip to San Carlos, Mexico. Deeper into Mexico the speed is only posted in kilometers per hour, but the Landcruiser speedometer is only marked in miles per hour. You want to get there as fast as possible, but you really don't want to get pulled over. The posted speed is 120 km (kilometers per hour). How fast can you travel in miles per hour without 'adverse consequences'?

$\frac{x\,km}{hr}\left(\frac{1\,mi}{1.609\,km}\right)=\frac{y\,mi}{hr}$ (Read this as “the number of kilometers per hour, times 1 mile per 1.609 kilometers, equals the number of miles per hour.”)

Solution: 120km/hr x 1mi/1.609km = 74.58 miles/hr, so you can drive at just under 75 miles per hour and not get pulled over (assuming the speedometer is accurate!)

Example 2: You are at a store buying a microwave oven for your apartment. It must fit on the kitchen counter under a cabinet in a space you measured to be 21in wide by 15in high by 19in deep. The measurements on the microwave you want, are in metric units. Oh No! Will a microwave oven 45cm wide by 39cm high by 43cm deep fit on your counter?

We know from the conversions table that 1 inch = 2.54 centimeters, and 1cm = 0.3937 inches, so we can solve this problem going either direction. Here are the ways to set up the equations:

(1) Solution for space: inches to centimeters (need space larger than microwave size)

$x\,in\left(\frac{2.54\,cm}{1\,in}\right)=y\,cm$ (Read this as “the number of inches, times 2.54 centimeters per inch, equals the number of centimeters”) Plug in the measurements you made.

(a) 21in(2.54cm/1in) = 53.3cm
(b) 15in (2.54cm/1in) = 38.1cm
(c) 19in(2.54cm/1in) = 48.3cm

53.3cm is greater than (>) 45cm wide
38.1cm is less than (<) 39cm high
48.3cm is greater than (>) 43cm deep

(2) Solution for microwave size: centimeters to inches (need microwave size smaller than space)

$x\,cm\left(\frac{0.3937\,in}{1\,cm}\right)=y\,in$ (Read this as “the number of centimeters, times 0.3937 inches per centimeter, equals the number of inches.)

(a) 45cm(0.3937in/1cm) = 17.7in
(b) 39cm(0.3937in/1cm) = 15.4in
(c) 43cm(0.3937in/1cm) = 16.9in

17.7in is less than (<) 21in wide
15.4in is greater than (>) 15in high
16.9in is less than 19in deep

The microwave oven is too high for the space.

II. Conversions: Cancelling Units

The units of measure must be accounted for in any conversion. The units are obvious in simple conversions:

$x\,km\left(\frac{1\,mi}{1.609\,km}\right)=y\,mi$ from Example 1 may also be written $\left(\frac{x\,\cancel{km}}{1}\right)\left(\frac{1\,mi}{1.609\,\cancel{km}}\right)=\left(\frac{y\,mi}{1}\right)$

Notice that the *km* units cancel out when they occur in both the numerator and the denominator, leaving *mi* as the final unit. Think of units in fractions as numbers, in a sense. Where 3/3=1, simplifying the threes to 1, km/km simplify and cancel out. But why bother? Well, cancelling out units also allows you to make certain that you have the conversion set up correctly. For example:

$x\,km\left(\frac{1.609\,km}{1\,mi}\right)\neq y\,mi$ (an incorrect conversion) expands to $\left(\frac{x\,km}{1}\right)\left(\frac{1.609\,km}{1\,mi}\right)\neq\left(\frac{y\,mi}{1}\right)$

leaving km times km per mi, or km^2/mi, obviously <u>NOT</u> what you wanted!

III. Conversions: Scientific Notation (see http://www.ieer.org/clssroom/scinote.html for more)

What is scientific notation? Scientific notation is a way of expressing very large or very small numbers in a form that's short and easy to use. Consider the number 5,681,805,550,528.27. This is the U.S. National Debt on Jan 7, 2001 4:49:39 PST (from the following URL: http://www.brillig.com/debt_clock/). If we round this number off to the second digit it still takes a lot of space: 5,700,000,000,000.00 dollars. However, if we remember that each place to the right or left means multiplying or dividing by ten, then we can shorten the way the number is written. 1000 is 10 times 10 times 10, or 10^3. Using this transformation, 5,700,000,000,000.00 dollars becomes 5.7×10^{12}dollars. Starting from the left, count the places **from the right** of the first number to the decimal point 5,**700,000,000,000**.00 (highlighted), then move the decimal point to the position immediately to the right of the first number, and use the number of places counted to give you the 'power of ten'.

Likewise, the size of a Hydrogen atom may be written 0.000000012 meters. If we wanted to determine how many Hydrogen atoms were present in $1m^3$ (cubic meter) at the center of our sun, then the size of the Hydrogen atom would need to be expressed in meters. Similarly, starting from the left, count the number of places between the decimal point and the first number (including the number) 0.**00000001**2 (highlighted), move the decimal point to the position immediately to the right of the first number, and use the number of places counted to give us the 'power of ten' (in this case a negative power because the number is less than 1). So, 0.000000012m becomes 1.2×10^{-8}m.

We simply reverse the process to convert to general format. For the first example, a positive exponent, we move the decimal point 12 places to the right. For the second example, a negative exponent, we move the decimal point 8 places to the left.

IV. Interpreting Graphs

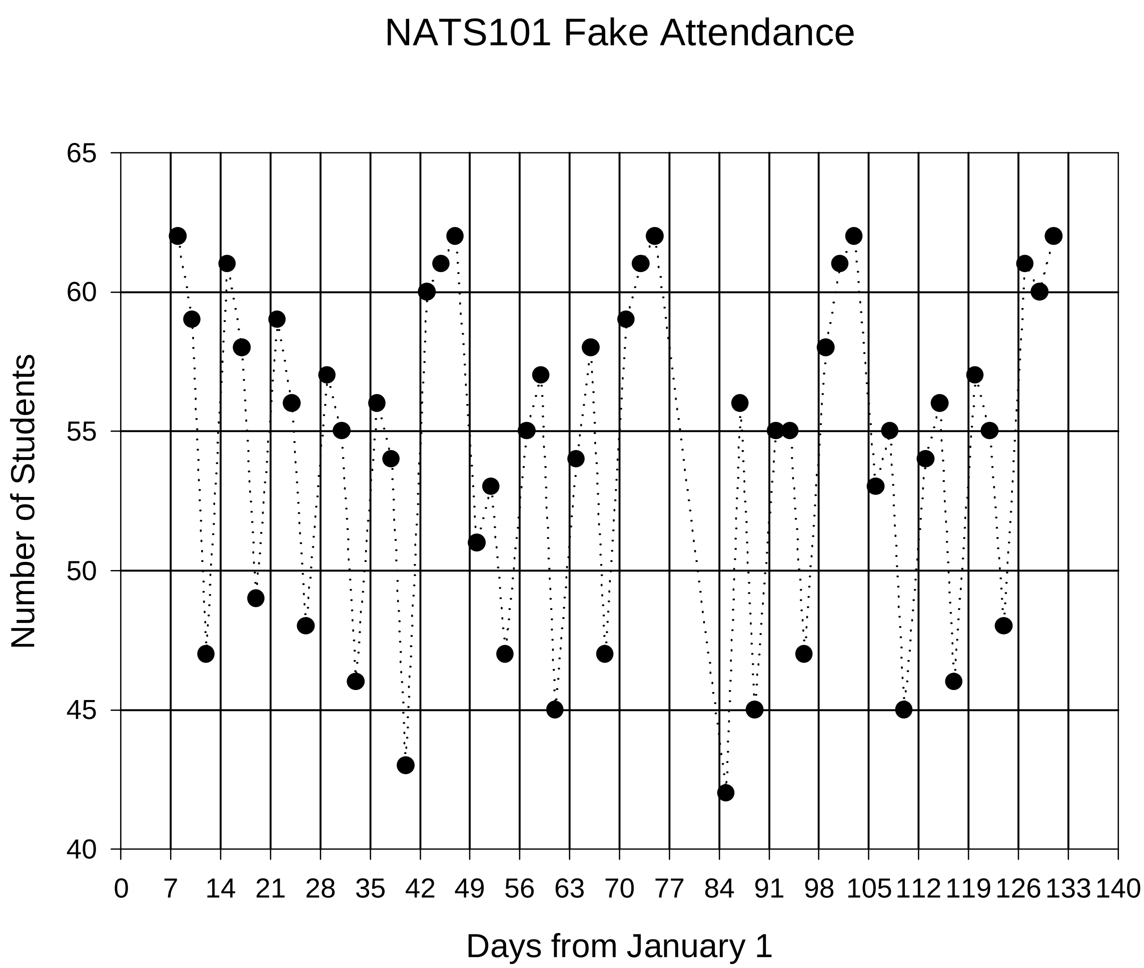
Graphs allow us to present a lot of information in a small space, and to make it more easily understandable. If we wanted to know how many days in a semester every student showed up for class and what day had the lowest student attendance, we might keep a running count for each class session. We could get the information we want by looking down the table of numbers, but we can instantly see the highs and lows if we make a plot of days against student attendance.

On the next page I have produced a fake graph of student attendance for a class of 62 students, and added other information in the text that might be used to interpret the graph. The scale across the bottom of the graph is time. The scale along the left side of the graph is the number of students attending. Now we find the place on the grid (lines) in between for each pair of numbers. For instance, on day 29 there were 57 students in class. So the place where day 29 (moving up from the bottom scale) and 57 students (moving over from the left scale)intersect becomes a unique dot on the graph telling us both values.

The time axis (the x-axis), says “Days from 1/1/2001”. The tick marks on this axis are at 7 day intervals allowing any weekly information to be easily seen. The axis for the number of students (the y-axis), says “Number of Students”(duh). The tick marks for this axis mark off the student attendance in fives.

From the fake class syllabus I know that the dates for the exams were Feb 16th, March 14th, April 13th, and May 11th. These are Julian Days 47,73,103, and 131, respectively. Also, Spring Break was from March 17th-March 25th. The lines between the datapoints are not real, of course. No students were attending class when there was no class. But these lines help us to see patterns in the data through time.

So what interpretations can we make? We can immediately see a pattern related to the time crossbars, placed at 7 day intervals. These students tended to come to class on Mondays and Wednesdays, and miss Fridays. Also, notice the gradual dropoff in attendance over the first five weeks of class, then a resurgence before the first exam. In fact, this pattern recurs before each exam. Also, note that the lowest attendance was on the Monday immediately after Spring Break. If we trace up from the x-axis on this day (Day 85), and over from the y-axis, we see that only 42 students showed up for class that day. The same procedure also tells us that all students showed up on 5 days, those days being the first day of class and each exam.



Assignments: <u>Solve these Problems</u> (Two tables of conversions are provided at the end of this document)
(1) Assignment 1: Conversion of Units
(1a) Problem 1: On the same trip mentioned in Example 1, you are well into Mexico and you realize your gas gauge is at the edge of the red mark. Your friend told you the Landcruiser gets 23 miles to the gallon on the highway. He also told you that there will be 1.5 gallons left when you reach the red. San Carlos is still 50 kilometers away. The 1.5 gallons left in your gas tank will take you about 34 miles. Will you be able to travel at least 50 kilometers?
(show the calculations)

(1b) Problem 2: The purpose of your trip to Mexico is to see the rare blue Mugglump in its native environment. Your UA oceanography professor told you the Mugglump has only been reported in the Gulf of California in water colder than 71°F. You don't own an underwater thermometer, but a local marine research facility reports a temperature close to your dive area of 21°C at 30m down, as deep as you can go. Can you reach the habitat of the Mugglump by diving this deep? In other words, what is this temperature in °F? (show your calculations)

(2) Assignment 2: Conversion to and from Scientific Notation (a page on scientific notation is available at the end of this document) Also, you can check you answers at http://www.quickmath.com/.

Use the information provided on the pages on conversions at the end of this homework to convert these numbers (fill in the blanks).

General Notation	Scientific Notation
13,500,000 Pascals (Pa)	
	4.5×10^{-9} liters (l)
0.000000071 kilometers (km)	
	1.23×10^{18} kilograms (kg)

(3) Assignment 3: Graph Interpretation

On the next page are two graphs. The first graph presents the carbon dioxide (CO_2) concentration as measured at Mauna Loa, Hawaii from 1958-1995. The second graph presents CO_2 concentration reconstructed, at irregular time intervals, from gas trapped in an ice core collected at Taylor Dome, Antarctica. Answer the following questions about these graphs.

(3a) Years are the unit plotted on the x-axis on these two graphs. The most recent data points on the first graph are on the right side. Is this true for the second graph?

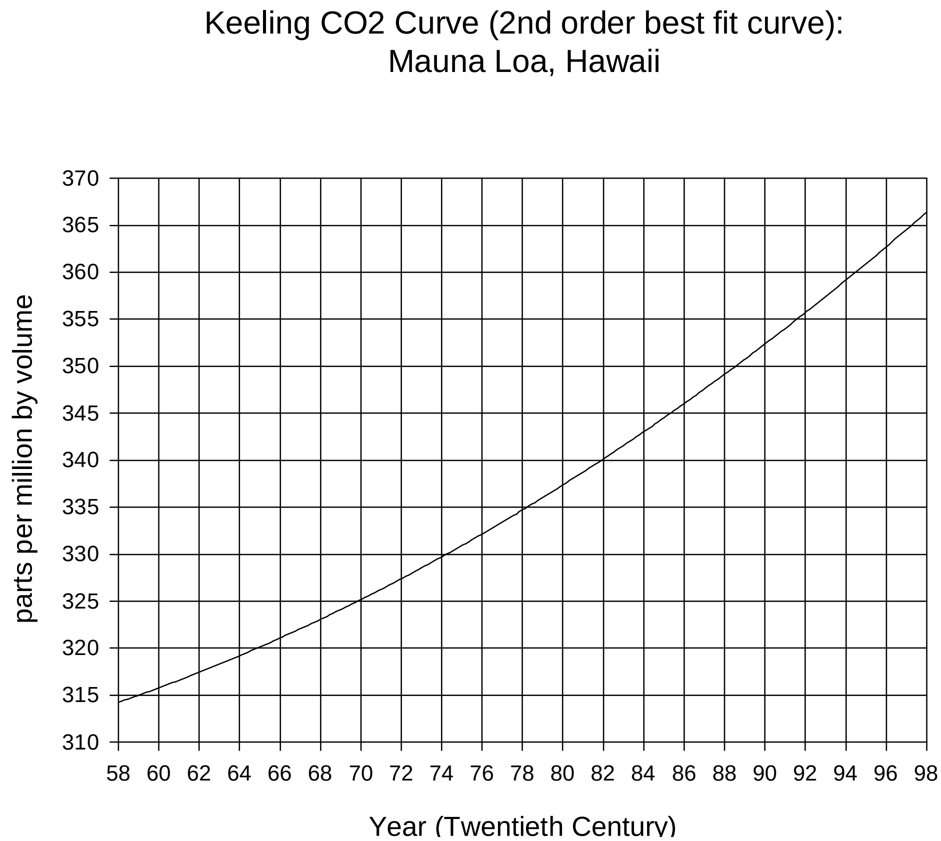
(3b) The y-axes on both graphs present CO_2 concentration in parts per million by volume. What is the range of concentrations presented on the first graph (to the closest 5ppmv)? What is the range on the second graph (to the closest 5ppmv)?

(3c) In what year do we see the highest CO_2 concentration in the first graph? What is the concentration (to the nearest 5 ppmv)?

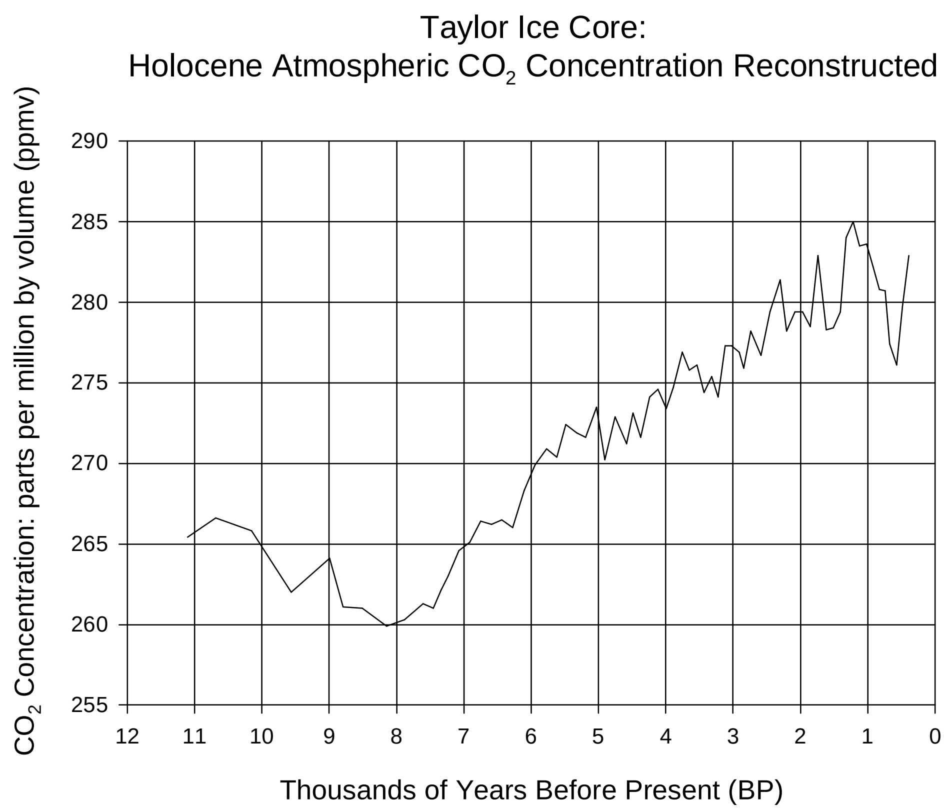
(3d) At what time do we see the lowest CO_2 concentration in the second graph (to the nearest thousand years)? What is the lowest concentration (in ppmv)? What is the difference (mathematically) between the highest concentration in the first graph and the lowest concentration in the second graph? (show your calculations)

(3e) What is the **change** in CO_2 concentration between 1958 to 1967 (10 years), early in the history of the measurements, and 1989 to 1998 (10 years), the latest years on the first graph? (show your calculations)

Graph 1



Graph 2



4. Assignment 4: Periodic Table of the Elements

Atoms are composed of neutrons (neutral charge), protons (positive charge) and electrons (negative charge). The neutrons and protons are located in the nucleus and the electrons revolve around the nucleus. When the number of electrons and protons in an atom are equal, the atom is "neutral"; if they are not equal, the atom is "ionized". The Periodic Table of the Elements ranks the chemical elements in order of increasing number of protons, known as the atomic number.

What chemical elements correspond to the following atomic numbers (put down the 2-letter chemical symbol and the full name):

1 = ______________________________	12 = ______________________________
16 = ______________________________	14 = ______________________________
11 = ______________________________	7 = ______________________________
6 = ______________________________	79 = ______________________________

A periodic table of the elements is provided on the next page.

5. Assignment 5: Images of Global Change

Select an image from the page of images on a later page. In one paragraph (at least 150 words), describe one image (or two in the cases of the Tucson images and the glacier images) and suggest how the subject of the image might be related to Global Change. Keep in mind that this is a Tier 1 course, and as such has a writing requirement. We expect your grammar to be correct, your sentences to be complete, and your thoughts to be organized **before** you begin writing, and we will grade accordingly. **Outline** your thoughts immediately below, then write from the outline. The paragraph must be typed (**double-spaced)** on a separate piece of paper and included with this homework.

6. Assignment 6: Computer Lab

Read through the "Earth and Space" computer based lab exercise. This lab exercise is available at the Harshbarger Rm 203 computer lab, and at [http://www.hwr.arizona.edu/Alpine/IGCL/home.html.](http://www.hwr.arizona.edu/Alpine/IGCL/home.html)

SI (Système Internationale) Units and Conversion Factors

SI Prefixes: Those commonly used (abbreviations in parentheses)

Greater Than 1			Less Than 1		
hecto-	100	10^3	centi-	0.01	10^{-2}
kilo-	1,000	10^3	milli-	0.001	10^{-3}
mega-	1,000,000	10^6	micro-	0.000001	10^{-6}
giga-	1,000,000,000	10^9	nano-	0.000000001	10^{-9}

Conversions

SI SYSTEM TO ENGLISH		ENGLISH SYSTEM TO SI	
Length/Area: Common conversions, base unit = meter (m)			
1 meter (m) =	**1.0936 yards** 39.37 inches (in or ”)	**1 yard =** [3 feet or 36 inches]	**0.914 meters**
1 centimeter (cm) =	**0.3937 inches** (in or “)	**1 inch =**	**2.54 centimeters**
1 kilometer (km) =	**0.62137 miles** (mi)	**1 mile =**	**1.609 kilometers**
1 hectare =	**2.471 acres** [107,600 ft^2]	**1 acre =** [43,560 ft^2]	**0.405 hectares**
Volume: Common conversions, base unit = liter (l)			
1 liter (l) =	**0.264 gallons** (gal) [1.057 quarts (qt)]	**1 gallon** = [4 quarts]	**3.785 liters**
1 milliliter (ml) =	**0.03381 fluid ounces** (oz)	**1 fluid ounce** =	**29.57 milliliters**
Mass: Common conversions, base unit = gram (gm)			
1 gram (gm) =	**0.03527 ounces** (oz)	**1 ounce** =	**28.35 grams**
1 kilogram (kg) =	**2.205 pounds** (lb)	**1 pound** =	**0.454 kilograms**
Other Common conversions			
Energy: **1 joule** (J) =	**0.239 calories**, (cal) [0.000948 British Thermal Units, btu]	**1 calorie** = [0.0397 btu]	**4.19 joules**
Pressure: **1 pascal** (Pa) = [0.01 millibars]	**0.000009869** atmospheres (atm)	**1 atmosphere** = [14.7 pounds per square inch (psi)]	**101300 Pascals** [1013 millibars]
Temperature: **0 Kelvin** (K) =	**-273.15° Celsius**, (°C) **-459.7° Fahrenheit**, (°F)	**0°C** = [°C = 5/9(°F-32)] **32°F =** [°F = (9/5°C)+32]	**273.1K** [K = °C +273.15] [°C = K − 273.15]
Astronomical Unit (AU) **1 AU=149,597,870km =**	**92,955,807 miles**	**1 AU is the average distance between the Earth and the Sun**	

For more SI notation, units and conversions: http://www.chemie.fu-berlin.de/chemistry/general/si_en.html
For more conversions, including unusual and obsolete ones, look here: http://www.convert-me.com/en/

Scientific Notation

The notation is based on powers of base number 10. The general format looks something like this:

$N \; X \; 10^x$ where N= number greater than 1 but less than 10 and
x=exponent of 10.

Placing numbers in exponential notation has several advantages.

1.For very large numbers and extrememly small ones, these numbers can be placed in scientific notation in order to express them in a more concise form.

2.In addition, numbers placed in this notation can be used in a computation with far greater ease. This last advantage was more practical before the advent of calculators and their abundance.

In scientific fields, scientific notation is still used. Let's first discuss how we will express a number greater than 10 in such
notational form.

Numbers Greater Than 10

1.We first want to locate the decimal and move it either right or left so that there are only one non-zero digit to its left.

2.The resulting placement of the decimal will produce the N part of the standard scientific notational expression.

3.Count the number of places that you had to move the decimal to satisfy step 1 above.

4.If it is to the left as it will be for numbers greater than 10, that number of positions will equal x in the general expression.

As an example, how do we place the number

23419

in standard scientific notation?

1.Position the decimal so that there is only one non-zero digit to its left. In this case we end up with

2.3419

2.Count the number of positions we had to move the decimal to the left and that will be x.

3.Multiply the results of step 1 and 2 above for the standard form:

So we have: $2.3419 \text{ X } 10^4$

How about numbers less than one?

We generally follow the same steps except in order to position the decimal with only one non-zero decimal to its left, we will have to move it to the RIGHT. The number of positions that we had to move it to the right will be equal to -x. In other words we will end up with a negative exponent.

Negative exponents can be rewritten as values with positive exponents by taking the inversion of the number.

For example: 10^{-5} can be rewritten as $1/ 10^5$.

Here is an example to consider:

Express the following number in scientific notation:

0.000436

1. First, we will have to move the decimal to the right in order to satisfy the condition of having one non-zero digit to the left of the decimal. That will give us:

   4.36

2. Then we count the number of positions that we had to move it which was 4. That will equal -X or x = -4

   And the expression will be $4.36 \text{ X } 10^{-4}$

What about numbers that are between 1 and 10?

In those numbers we do not need to move the decimal so the exponent will be zero. For example:

7.92 can be rewritten in notational form as:

$7.92 \text{ X } 10^0$