ASTRO 1050 - Fall 2012
LAB #1: Scientific Notation, Scale Models, and Calculations

ABSTRACT

We will be doing some review of Math concepts in this lab. Scientific notation, unit conversions, scale modeling, time to location calculations, algebra, angles and graphing are covered.

Materials

Ping pong balls, meter sticks, protractors

1. Scientific Notation

Describing the universe requires both exceptionally large numbers and exceptionally small ones. For example, the mass of the Earth is approximately 6,000,000,000,000,000,000,000,000 kilograms. And that is only the mass of the Earth, imagine the mass of the Sun! Needles to say, such numbers are tough to write in long decimal notation, so we'll be using *scientific notation.*

Scientific notation allows us to write these numbers more compactly (and makes it much easier to do math with them) by keeping track of how many places you have to move the decimal point to get it behind the leading digit of the number. In the case of the Earths mass, the decimal place moves 24 spots to go from the end of the number to behind the six. Thus in scientific notation the Earth's mass is 6.0 x 10^{24} kilograms. On your calculator, this may be written as 6.0E24

Another example is the wavelength of green light, approximately 0.0000005 meters. (The meaning of wavelength of green light will be explained later in the semester, were just interested in the number right now.) To write this in scientific notation we again count the number of places the decimal has to move, but this time it is moving to the right to get behind the five. Since it is moving right, the exponent in the scientific notation will be negative. It moves seven places, so the final answer is 5.0x10-7 meters. This may be 5.0E-7 on your calculator.

A few more examples are:

$$314.15 = 3.1415 \times 10^2 \quad (1)$$

$$0.00042 = 4.2 \times 10^{-4} \quad (2)$$

$$234.5 \times 10^2 = 2.345 \times 10^4 \quad (3)$$

You get the idea. Now try it. Convert the following to scientific notation:

Decimal	Scientific	Decimal	Scientific
2345.4578	__________	0.000005	__________
356,000,000,000	_____________	0.0345	__________

Great!

2. Significant Figures

Calculators tend to spit out infinitely long numbers. Including a huge number of decimal places in an answer actually makes the answer wrong because yo u're claiming that you're more accurate than you actually are. For example, consider the difference between telling someone to drive a couple dozen miles and 24.5 miles. A couple dozen really means something between 12 and 36 so technically, the two statements agree. The second distance though is much more accurate.

For instance:

240.01 has 5 significant figures

0.0052 has two significant figures (the zeros to the left of a decimal less than 1 don't count)

1.000 has four significant figures.

There are plenty of rules in terms of determining how many significant figures are necessary for the answer of a calculation. But let's make our lives easier and focus on just one rule, the cheating rule: limit yourself to two decimal places. Do this throughout the rest of the semester!

3. The Metric System

I cannot stress the importance of this section enough; this is a skill you will be using throughout the course and will come in handy in everyday life. Often we make a measurement in one unit (such as meters) but some other unit is desired for a computation or answer (such as kilometers). There are prefixes that define larger or smaller units.

At this point its also very important to note that numbers need units. 832 m is a distance, but 832 alone could mean just about anything. The only time, in general, that you dont need a unit is when the number you compute is a ratio between two things with the same unit.

Selected Metric Prefixes

Name	Abbreviation	Multiplier
giga	G	10^9
mega	M	10^6
kilo	K	10^3
deca	D	10^1
deci	d	10^{-1}
centi	c	10^{-2}
milli	m	10^{-3}
micro	μ	10^{-6}
nano	n	10^{-9}

Example: You have 2,340,000,000,000 meters. How many kilometers is this? How many astronomical units?

There are 1000 m per km, (1000 m/km). Because kilometers are larger than meters, we need fewer of them to specify the same distance, so divide the number of meters by the number of meters per kilometers and notice how the units cancel out and leave you with the desired result.

$$\frac{2.34 \times 10^{12}\ m}{1000\frac{m}{km}} = 2.34 \times 10^{9}\ km. \tag{4}$$

Remember that dividing by a fraction is the same as multiplying by the reciprocal, so another way to visualize this is:

$$\frac{2.34 \times 10^{12}\ m}{1} \times \frac{1\ km}{1000\ m} = 2.34 \times 10^{9}\ km. \tag{5}$$

Similarly, to convert this number of meters to astronomical units, you would look up (in your textbook, for example) how many meters are in one astronomical unit (1.49×10^{11}) and do the following:

$$\frac{2.34 \times 10^{12}\ m}{1} \times \frac{1\ AU}{1.49 \times 10^{11}\ m} = 1.57 \times 10^{1}\ AU = 15.7\ AU \tag{6}$$

A third way to think about this operation, is that you want fewer km than m, so just move the decimal place three to the left since there are 10^3 m per kilometer. Or, if the new desired unit is smaller, and you expect more of them, then multiply. For example, how many cm are there in 42 km?

$$42\ km \times 10^{5}\frac{cm}{km} = 42 \times 10^{5}\ cm. \tag{7}$$

Use the information in the appendix of your text (or the internet, or your instructor's materials) the convert the following:

50 km	=	____________m	3×10^6 m	=	____________cm
52,600,000,000 km	=	____________m	300,000,000,000 km	=	____________AU
6.0×10^{18} m	=	____________ly	4500 parsecs	=	____________cm
5.2×10^{12} kg	=	____________g	4.0×10^{-5} sun masses	=	____________kg
3450 seconds	=	____________min	99 min	=	____________hr

4. Time to Travel

Suppose you could travel at the speed of light, 3×10^5 km/s. The distance, D, traveled in time, t, and speed, v, is:

$$
\begin{array}{ccccc}
\mathrm{D} & = & \mathrm{v} & \times & \mathrm{t} \\
(\mathrm{km}) & = & (\mathrm{km/hr}) & \times & (\mathrm{hr}) \\
(\mathrm{km}) & = & (\mathrm{km/s}) & \times & (\mathrm{s}) \\
(\mathrm{m}) & = & (\mathrm{m/s}) & \times & (\mathrm{s})
\end{array}
$$

Notice that the units of time in v and in t must be the same, as must the units of distance in v and D, otherwise, we get nonsensical answers!

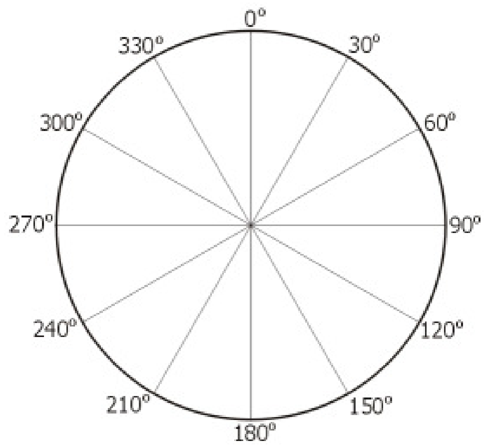
Traveling at the speed of light, how long would it take to get from Earth to:

	Distance (km)	Time (s, hr, or days)
The Moon	______________	______________
The Sun	______________	______________
Mars (when closest to Earth)	______________	______________
The nearest star (to the Sun)	______________	______________

Table 1: Use the space below for calculations.

5. Angles

Often in astronomy we measure the size of things in the sky, or the motion of things across the sky, in terms of angles. In one circle there are 360 degrees. In one-half of a circle there are 180 degrees, etc.



Degrees are subdivided into "minutes of arc" or *arcminutes*. This is necessary because the moon itself is half a degree across. Astronomers look at much much smaller objects and therefore need to divide degrees into another unit of measurement. There are 60 arcminutes in one degree. As an analogy, think of degrees as being like hours, and arcminutes like minutes. There are 60 minutes in an hour, and 60 arcminutes in a degree.

Arcminutes are further subdivided into "second of arc" or *arcseconds*. As you might guess, there are 60 arcseconds in one arcminute. Continuing the analogy with time, there are 60 seconds in a minute, and 60 arcseconds in an arcminute. Convert the following:

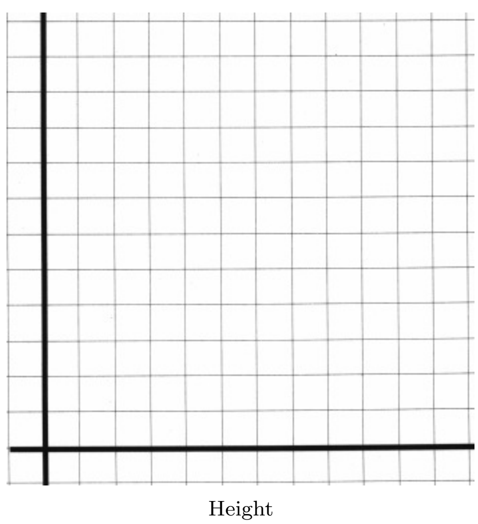
12 arcminutes	=	______________degrees	6 arcseconds	=	______________degrees
12 degrees	=	______________arcminutes	55 arcmin	=	______________arcsec
360 degrees	=	______________arcmin	360 degrees	=	______________arcsec

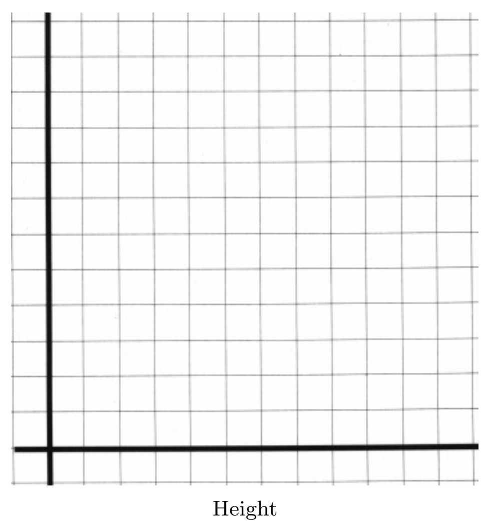
6. Measurements and Graphing

Measure the height and shoe length (we really mean foot length, but we don't want everyone taking off their shoes in lab...) and the length of the index fingernail of your lab mates, then record data in the table on the last page for everyone else in the lab.

Do you expect to see a correlation between height and shoe length? Between height and nail length? Why or why not?

Now plot these data on the graphs provided. Title the axes, axis numbers (scale) and make sure to plot the correct units.





Which variables show correlations?

What is the explanation for this correlation?

Table 2.

	Height (cm)	Shoe Length (cm)	Nail Length (mm)		Height (cm)	Shoe Length (cm)	Nail Length (mm)
1				11			
2				12			
3				13			
4				14			
5				15			
6				16			
7				17			
8				18			
9				19			
10				20			