III.Measurement

- i.Units / Scientific Notation
  - I.Scientific Notation
    - i.Used when expressing very large or very small numbers.
    - ii.Eliminates ambiguous numbers of significant digits (more on this later)
    - iii.Is written in the form such that the first number is greater than or equal to 1 an multiplied by some factor of 10.
      - 1.04 x 10^6 would be equal to 1,040,000
      - 3.650 x 10^ -14 would be equal to 0.00000000000003650
      - you will see different forms for scientific notation but all of the following are
        - 2.4×10^{6} = 2.4 x 10^6 = 2.4 x 10+6 = 2.4 e+6
    - iv.Try this now on your calculator to see which form it uses to display scientific n see this by repeatedly multiplying or dividing some number by a very large num
  - II.Units
    - i.Prefixes are commonly used in expressing a unit of measurement.

Prefix	Symbol	Factor	Meaning	Prefix	Symbol	Factor
yotta	Y	10^{24}	?	yocto	y	10^{-24}
zetta	Z	10^{21}	?	zepto	z	10^{-21}
exa	E	10^{18}	?	atto	a	10^{-18}
peta	P	10^{15}	?	femto	f	10^{-15}
tera	T	10^{12}	trillion	pico	p	10^{-12}
giga	G	10^{9}	billion	**nano**	**N**	$\mathbf{10^{-9}}$
mega	**M**	$\mathbf{10^{6}}$	**million**	**micro**	**µ**	$\mathbf{10^{-6}}$
kilo	**k**	$\mathbf{10^{3}}$	**thousand**	**milli**	**m**	$\mathbf{10^{-3}}$

length will be measured in meters (m) or centimeters (cm)
volume in centimeters (cm^3), milliliters (mL), or liters (L)
mass in grams (g) or kilograms (kg) - Note: at no time will we be measuring t
weight of any substance in this class, only its mass.

ii. Accuracy vs. Precision

I. Accuracy is how close a measurement or estimate is to the correct value.

II. Precision is how exact and reproducible a measurement or estimate is.

III. Notice that I stressed the fact that we are talking about measured or estimated data. numbers like exact counts or numerically defined numbers have infinite precision a accuracy

i. If I count the number of people in this room to be 24 then that is perfectly accura (assuming I counted correctly) and infinitely precise.

ii. The equivalence 1 in = 2.54 cm is determined by definition. These numbers, wh used in doing conversions would be considered to be both perfectly accurate and precise.

IV. Below is a joke I found at http://www.mpce.mq.edu.au/~malcolmt/measrmnt/si

A group of Civil Engineers were at a conference being held in Central Australia. As part of the conference entertainment, they were taken on a tour of the famous rock, Uluru.

"This rock", announced the guide, "is 50,000,004 years old."

The engineers - always impressed by precision in measurement - were astounded.

"How do you know the age of the rock so precisely?" asked one of the group.

"Easy!", came the reply. "When I first came here, they told me it was 50 million years old. I've been working here for four years now."

V. Which below best describes the age of the rock given by the guide?

1. Correct accuracy

VI.Below is a data table produced by three groups of students who were measuring th
a paper clip which had a known mass of 1.0004g.

	Group 1	Group 2	Group 3	Group 4
	1.01 g	2.863287 g	10.13251 g	2.05 g
	1.03 g	2.754158 g	10.13258 g	0.23 g
	0.99 g	2.186357 g	10.13255 g	0.75 g
Average	**1.01 g**	**2.601267 g**	**10.13255 g**	**1.01 g**

VII.Which of the above measurement(s) is represents a properly accurate and precise
measurement of the mass of the paper clip

1.Group 1
2.Group 3
3.Group 4
4.Both Group 1 and Group 4

a.Notice that Group 1 had data that was precise (in terms of consistency) and the
average was very close to the correct answer (accurate).
b.Group 2 had data that look precise (many numerical digits of information). Hov
is not very accurate. Notice that whatever instrument they are using to measure
really only gives measurements that are consistent to the tenths place. It makes
sense for them to record all the other digits. This answer should really be only

iv. Demo: Using various rulers for measurement.
v. Lab: Measure various objects with different rulers, balances, and cylinders.
vi. Homework: Rulers and Cylinders Practice
vii. Significant Digits

I. All measurements have some limit to their precision. You can only be as precise as th instrument used to make the measurement. How many significant digits should yo the following instrument

II. The digits which are considered significant are all the measured digits plus one esti digit. How many significant digits were there in each of the measurements I made v various rulers during the demonstration?

III. Here are some rules to help determine how many significant digits are in a numbe

i. All non-zero digits should be counted. (ex. 432.181 has 5 significant digits)

ii. Zeros to the left of non-zero digits are never counted. (Ex. 0.000456 has 3 signific digits)

iii. Zeros to the right of non-zero digits definitely count if a decimal place is preser may or may not count if a decimal place is not present.

The number 11.5000 has 6 significant digits.

The number 11000 could have between 2 and 5 significant digits. This is ambiguous because you don't know how this measurement was made. Perhaps it is only an estimate good to the thousands place. Then there would be only 2 significant digits.

IV. In the last example, where the number 11000 has an ambiguous number of signific scientific notation will clear up this problem. 11000 can be written several ways in sc notation to indicate a certain amount of significant digits.

$1.10 \times 10^4 = 11000$ and has 3 significant digits.

$1.1 \times 10^4 = 11000$ and has 2 significant digits.

$1.1000 \times 10^4 = 11000$ and has 5 significant digits.

3.456	5.000	10003
0.666	5.001	0.00300
5	0.005	314.000
10000	12000	10000.0
100321	90210	314000

see answers below

VI. Significant digits in calculations - see the handout Calculations With Significant D
examples.

i. Addition/Subtraction - you examine the decimal places of each of the numbers determine the number of decimal places in the final answer. The final answer s be rounded to the same number of decimal places as the number with the least number of decimal places used in the calculation.

ii. Multiplication/Division - you examine all the significant digits of each of the n to determine the number of significant digits in the final answer. The final answ should be rounded to the same number of significant digits as the number with least significant digits used in the calculation.

Answers to the above practice problems.

The numbers which are in bold are definitely significant. The green numbers may or m significant depending on how the measurement was made.

3.456 -> 4	**5.000** -> 4	**10003** -> 5
0.**666** -> 3	**5.001** -> 4	0.00**300** -> 3
5 -> 1	0.00**5** -> 1	**314.000** ->6
10000 -> 1 to 5	**12**000 -> 2 to 5	**10000.0** -> 6
100321 -> 6	**9021**0 -> 4 to 5	**314**000 -> 3 to 6

referred to as labels or dimensions).

x. Homework: Label Factoring Practice Sheet; Read sections 2.6 and 2.8

xi. Density

I. Density is the relationship between the mass of an substance the the amount of space t
mass occupies.

II. D=m/Vor Density is the ratio of mass to volume.

III. Demo: Sample of Mercury

IV. Video: Raiders of the Lost Ark

V. Using the measured density of gold to be 19.32 g/cm3, estimate the mass of the solic
idol that Indiana Jones is tossing around in the first 10 minutes of this video.

xii. Handout: Putting Data in lab Format

xiii. Lab: Measuring the Thickness of Aluminum Foil: Given three different pieces of foil (generic standard foil, name brand standard foil, and name brand heavy duty foil) determine their thicknesses. You should find at least 2 ways to determine this thickness using only a ruler, a balance, and anything else in your lab drawers. One method for determining the thickness must take into consideration the density of aluminum 2.70g/cm3.

xiv. Homework: Write up the Foil calculations in correct lab format and give a numerical conclusion about the thickness of each piece of foil.

xv. Writing a Good Lab Report

a. Handout: ClarisWorks spreadsheet tutorial.

b. Handout: How to create proper graphs.

c. Handout: Graphical Analysis software tutorial.

d. Handout: Writing a Lab Report.

e. Handout: Shorthand remarks I use when correcting your labs.

xvi. Lab: Measuring the Density of Coke vs. Diet Coke

xvii. Homework: Type a full lab write up for the Coke vs. Diet Coke lab.