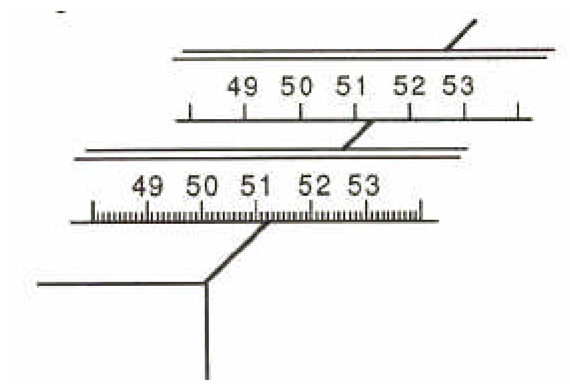
SIGNIFICANT FIGURES

Appendix III

MEASUREMENTS AND ERROR

All measurements consist of a number and a unit. Both are necessary to completely express that quantity. For example if you express a distance as 50 only, it is incomplete. The number 50 tells how many, but without a unit it is a meaningless measurement. However, if you express the distance as 50 km or 50 m, it gives a more meaningful quantity.

All measurements also contain uncertainty or error. This error could be due to limitation of instrumentation, human error in making the measurement or many other uncontrollable sources. For example, in the diagram shown on the right, the measurement with the lower scale can be read more accurately compared to the upper scale, due to better scaling in the lower ruler. Scientists express the amount of certainty in their measurements by use of ***significant figures***.



SIGNIFICANT FIGURES

Each measurement could contain many certain digits (those that are measured), but should only contain one uncertain digit (those that are estimated). The number of certain and uncertain digits in a measurement is called ***significant figures***. For example, the measurement shown in the diagram above should be represented as:

Upper ruler 51.<u>2</u> or 51.<u>3</u>
Lower ruler 51.2<u>5</u>

Note that the last digit in each measurement (underlined) is estimated and therefore uncertain. Standard rules have been developed for writing and using significant figures, both in measurements and in values calculated from measurements. These rules are summarized on the next several pages.

SIGNIFICANT FIGURE RULES

	Example	Sig. Digits	Scientific Notation
1. All non-zero digits are significant.			
	1.589	4	1.589×10^{0}
	0.897	3	8.97×10^{-1}
	36000	2	3.6×10^{4}
2. All ***sandwiched*** zeros are significant.			
	13.02	4	1.302×10^{1}
	1.0002	5	1.0002×10^{0}
	0.105	3	1.05×10^{-1}
3. All ***trailing*** zero's preceded by a non-zero digit are significant.			
	5.000	4	5.000×10^{0}
	20.000	5	2.0000×10^{1}
	0.00700	3	7.00×10^{-3}
4. All leading zero's are not significant.			
	0067	2	6.7×10^{1}
	0.0003	1	3×10^{-4}
	0.00506	3	5.06×10^{-3}
5. Zero's ending a number without a decimal point are not significant. These numbers are more properly written in scientific notation.			
	56000	2	5.6×10^{4}
	1360	3	1.36×10^{3}
	2000	1	2×10^{4}

ROUNDING OFF RULES

1. If the last digit to be retained in a number is followed by a number less than 5 (<5), **ROUND DOWN**.

Round to 3 significant figures

28.23	rounds to	28.2
578.1	rounds to	578

2. If the last digit to be retained in a number is followed by a number greater than 5 (>5), **ROUND UP**.

Round to 2 significant figures

5.998	rounds to	6.0
0.00258	rounds to	0.0026
3.6502	rounds to	3.7

3. If the last digit to be retained in a number is followed by 5 (00000…implied), ROUND to an **EVEN NUMBER**.

Round to 2 significant figures

1.75	rounds to	1.8
1.050	rounds to	1.0
1.45	rounds to	1.4

Round to 4 significant figures

67.835	rounds to	67.84
67.885	rounds to	67.88

CALCULATIONS WITH SIGNIFICANT FIGURES

? The **<u>Least Accurate Number (LAN)</u>** determines the number of digits to which the answer of a calculation is rounded.

<u>Addition and Subtraction</u>

1. The **LAN** is the number with the **least number of digits following the decimal point**.
2. The answer (sum or difference) can have **no more digits** following the decimal point than the **LAN**.

Example:

What is the mass of a mixture prepared from the following:

212 g	water	(LAN)
1.8 g	salt	
1.88 g	sugar	
215.98 g	(calculated answer)	
216 g	(correct rounded answer)	

<u>Multiplication and Division</u>

1. The LAN is the number with the least number of significant figures.
2. The answer (product or quotient) can have no more significant figures than the LAN.

Example:

Calculate the volume of a rectangular solid that has a length of 4.16 cm, a width of 2.2 cm and a height of 2.00 cm.

Volume = length x width x height

Volume = (4.16 cm) (2.2 cm) (2.00 cm)
LAN

Volume = 18.304 cm^3 (calculated answer)

Volume= 18 cm^3 (correct rounded answer)