Chapter 1 : Introduction

It is doubtless fact that people always want to know about the mysteries of nature and the world around them since they are born. So they start thinking and formulating their views on nature. Lots of natural facts were collected by various experimental observations. This is Science!

The word “Science” originally based on the Latin verb “Scientia” that means “To Know”. So, Science means “to know nature (and its laws) by observations!

Science needs scientific methods to find its way. The Scientific method can be given as followings:

- - Systematic observations,
- - Formulation of reasons (called hypothesis –that means “not certain”),
- - Theoretical predictions,
- - Experimental verifications of theoretical predictions –that means “theory is invalid until it gives same experimental verification”-)

So, what is the relationship between Science and Physics? It is well known that the Physics is a branch of Science. But what is Physics?

Before answering, let me introduce some history: It was proposed by the thinkers of old time that air, water, fire and soil (not wood! ☺) are the elements from which the entire Universe is made. Later, it was released that Universe is composed of Matter and Radiation. After that point, the radiation is called by its universal name “Energy”. So then, the Matter and the Radiation are defined.

The Matter is defined as “any substance that occupies space and has mass in universe.”

and

The Energy is defined as “capacity to do WORK -any thing that occupies NO space and has NO mass-”.

That is the answer of what the Physics is:

Physics (in Latin alphabet: $\phi\bar{\nu}\sigma\iota\zeta$ which means “NATURE”) is the branch of Science that deals with different forms of Energy, its effect on Matter and its relations with Matter.

Measurement and Units

A large part of science is based upon the creation of mathematical models that describe physical phenomena. For example, the subject of Newtonian Mechanics describes how objects will behave when they are subject to forces. We can use Newtonian Mechanics to model our solar system allowing us to accurately predict the positions of the sun and the planets. However, to relate the mathematical description to the real world requires that there is a mutually agreed upon measurement system so that, for example, the distance between the earth and the sun is assigned the same numerical value by different scientists in different parts of the world. To accomplish this task we use a mutually agreed upon system of units.

Currently, there are actually two widely used systems of units. The first-British Engineering Units-is, strangely enough, used primarily in the USA and almost no place else (certainly not in Britain!). The second is the Metric System (or Systeme International [SI] –it is in French-) which is an internationally agreed upon standard. (In 1971, 14^{th} Conference of The International Bureau of Weights and Measures, IBWM, has agreed upon the standards and Units). <u>We will mostly use the metric system (SI) for problems in this class</u>.

The Standard Prefixes used in SI Units

One nice thing about the SI system is that there is a uniform prefix system that is used across all measured quantities. For example the prefix kilo means 1000. Thus a kilogram is 1000 grams or a kilometer is 1000 meters. All of the prefixes are some multiple of 10; thus, there is no remembering awkward quantities such as 12 inchs in one foot, three feet in a yard, 5280 feet in a mile etc. You should memorize the following prefixes (I actually hope that you pretty much know most of them already!). You should also be able to manipulate quantities in scientific notation. Try the problems at the bottom of this page to see if you are up on working with numbers in SCIENTIFIC NOTATION.

The Basic Units: Meter, Kilogram, and Second

<u>Prefix</u>	<u>Multiplier</u>
tera	10^{12}
giga	10^{9}
mega	10^{6}
kilo	10^{3}
deca	10
centi	10^{-2}
milli	10^{-3}
micro	10^{-6}
nano	10^{-9}
femto	10^{-15}

Most of the quantities that we will discuss this semester have units that are expressable as some combination of the three basic quantities Meter, Kilogram, Second which measure length, mass, and time respectively.

UNIT	SYMBOL	DESCRIPTION
Meter	m	Measures length
Kilogram	kg	Measures mass (different than weight!)
Second	s	Measures time

Significant Figures

It is important to be honest when reporting a measurement, so that it does not appear to be more accurate than the equipment used to make the measurement allows. We can achieve this by controlling the number of digits, or significant figures, used to report the measurement.

Determining the Number of Significant Figures

The number of significant figures in a measurement, such as 2.531, is equal to the number of digits that are known with some degree of confidence (2, 5, and 3) plus the last digit (1), which is an estimate or approximation. As we improve the sensitivity of the equipment used to make a measurement, the number of significant figures increases.

Postage Scale	<u>3</u> ±1 g	1 significant figure
Two-pan balance	<u>2.53</u> ±0.01 g	3 significant figures
Analytical balance	<u>2.531</u> ±0.001 g	4 significant figures

Rules for counting significant figures are summarized below.

Zeros *within* a number are always significant. Both 4308 and 40.05 contain four significant figures. (Because; 4308 is 4308 -or $4.308*10^3$- and 40.05 is 40.05 –or $4005*10^{-2}$-).

Zeros that do nothing but set the decimal point are not significant. Thus, 470,000 has two significant figures. (Because 470,000 is $47*10^4$).

Trailing zeros that aren't needed to hold the decimal point are significant. For example, 4.00 has three significant figures. (Because 4.00 is merely 4.00 –it includes .<u>00</u> accuracy)

If you are not sure whether a digit is significant, assume that it isn't. For example, if the directions for an experiment read: "Add the sample to 400 mL of water," assume the volume of water is known to one significant figure.

Count all the numbers when using Scientific Notation. For Example, 1.30×10^{-2} has three significant figures.

Addition and Subtraction with Significant Figures

When combining measurements with different degrees of accuracy and precision, *the accuracy of the final answer can be no greater than the least accurate measurement.* This principle can be translated into a simple rule for addition and subtraction: When measurements are added or subtracted, the answer can contain no more decimal places than the least accurate measurement.

	150.0	g H_2O
+	0.507	g salt
	150.5	g solution

Multiplication and Division with Significant Figures

The same principle governs the use of significant figures in multiplication and division: the final result can be no more accurate than the least accurate measurement. In this case, however, we count the significant figures in each measurement, not the number of decimal places: When measurements are multiplied or divided, the answer can contain no more significant figures than the least accurate measurement.

Example: To illustrate this rule, let's calculate the cost of the copper in an old penny that is pure copper. Let's assume that the penny has a mass of 2.531 grams, that it is essentially pure copper, and that the price of copper is 67 cents per pound. We can start by from grams to pounds.

2.531 g x 1 lb / 453.6 g = .005579 lbs

We then use the price of a pound of copper to calculate the cost of the copper metal.

.005579 lbs x 67 cents / lb = .37 cents

There are four significant figures in both the mass of the penny (2.531) and the number of grams in a pound (453.6). But there are only two significant figures in the price of copper, so the final answer can only have two significant figures.

Rounding

When the answer to a calculation contains too many significant figures, it must be rounded off.

There are 10 digits that can occur in the last decimal place in a calculation. One way of rounding off involves *underestimating* the answer for five of these digits (0, 1, 2, 3, and 4) and *overestimating* the answer for the other five (5, 6, 7, 8, and 9). This approach to rounding off is summarized as follows.

If the digit is smaller than 5, drop this digit and leave the remaining number unchanged. Thus, 1.684 becomes 1.68.

If the digit is 5 or larger, drop this digit and add 1 to the preceding digit. Thus, 1.247 becomes 1.25.

EXAMPLE:

Using a ruler that can measure in mm, the height of a pencil is measured by three different observer:

- 1st person measures the height by 14cm
- 2nd person measures the height by 14,2cm
- 3rd person measures the height by 14,23cm

As seen in results;

1st person could measure the height in mm but he did not! It is rough measurement!

2nd person does the measurement by using the mm division of the ruler. Since the measurement can be done by this ruler, it is acceptable.

3rd person does his experiment in mm including some assumption (14,23cm); but in this assumption, he did not take care of the uncertainty of the measurement done in mm dimension. This measurement includes some errors! Well; all numbers, including the error, are called Significant figures. So that, 14,23cm=142,3mm that means there are 4 significant figures.

142 exact value	,	3mm The value including error

Questions

1. Express the following numbers in scientific notation:

(a) 0.015 (b) 0.0000002 (c) 54800 (d) 76

2. A car travels at a constant speed of $33ms^{-1}$. How many kilometers does it travel in 10 minutes?

3. How many nanoseconds are there in a day?

4. You are 2 km away from a lightning strike. How long does it take the light of the lightning flash to reach you? How long does it take for the sound (the thunder) to reach you? The speed of light can be taken to be 3x108 m/s and the speed of sound to be 340 m/s (approximately).

5. What is the difference between mass and weight? Are the units pounds and kilograms both units of mass, or are they units or weight or ...?

Answers

1. (a) 1.5 x 10-2 (b) 2 x 10-7 (c) 5.48 x 104 (d) 7.6 x 101 = 7.6 x 10

2. 33 x 10 x 60 = 19800 m = 19.8 km

3. 24 hr/day x 60 min/hr x 60 s/min x 109 ns /s = 8.64 x 1013 ns/day.

4. Since $v = \frac{\Delta x}{t}$, then $t = \frac{\Delta x}{v}$. For sound the time is $t = \frac{2000}{340} = 5.88s$. For light the time is $t = \frac{2000}{3 \times 10^8} = 6.67 \times 10^{-6} s$.

5. We should have a discussion of this in class (hope you were there!). Briefly mass is a measure of a body's inertia, in other words, a body's resistance to a change in its state of motion. Mass is the same everywhere (even out in deep space where the body is "weightless"). Weight is the force a body experiences due to a gravitational attraction-thus the units of weight must be the unit of force. Kilogram is a measure of mass. Newton is a measure of weight. In the British Engineering system mass is measured in units of slugs.