Module 1 – Scientific Notation

INTRODUCTION

This experiment covers the following topics.

- Powers of 10[1]
- Scientific Notation[2]
- Significant Figures[3]

Each of these topics is considered basic to understanding all science courses and, in particular, physics.

In this lab, you will be visiting websites, performing conversions, and completing a self-graded lab report.

POWERS OF 10

In the next section, you will study how to convert a number in standard form, such as 165, to scientific notation, which is written as 1.65×10^2. But before you begin, it is important that you review the basic underlying principle behind both scientific notation and the Sl units of measurement. The underlying principle uses the powers of 10.

Numbers such as 10, 100, 1000, etc., can be written as products of 10, where each factor in the multiplication is 10. So, for example, you could write the following.

- $100 = 10 \times 10$
- $1000 = 10 \times 10 \times 10$
- $10{,}000 = 10 \times 10 \times 10 \times 10$

Notice that these multiplications all have the same factor. A shorthand way of writing products where the factors are all 10 is to write them as powers of 10. To do this, you write the numbers in the following ways.

- $100 = 10 \times 10 = 10^2$
- $1000 = 10 \times 10 \times 10 = 10^3$
- $10{,}000 = 10 \times 10 \times 10 \times 10 = 10^4$

Since 10 is multiplied by itself three times to get 1000, it is possible to write 1000 as 10^3, where the 3 is called the exponent. 10^3 is read as 10 to the third power, or 10 to the power of 3. Notice that the number of zeros in the examples above is equal to the power.

[1] manual.html#powers
[2] manual.html#scientific
[3] manual.html#significant

As stated above, the Sl system of measurement uses powers of 10. Below are some examples.

- 1 kilometer = 10^3 meters
- 1 centimeter = 10^{-2} meters

You may have noticed the negative exponent in the second example above. Let's take a look at another set of powers of 10.

- 1,000,000 = 10^6
- 100,000 = 10^5
- 10,000 = 10^4
- 1000 = 10^3
- 100 = 10^2
- 10 = 10^1
- 1 = 10^0
- 1/10 = 10^{-1}
- 1/100 = 10^{-2}

Observe how the exponent is the same as the number of zeros in the power of 10 through the number 1. Powers of 10 resulting in decimals, such as 0.01, 0.001, etc., can be expressed using negative exponents. Also observe that 10^0 is not zero; it is 1.

APPLICATION OF POWERS OF 10

Florida State University has a very interesting presentation on their website. It starts as a view of the Milky Way Galaxy seen from a distance of 10 million light years. It then zooms in towards the Earth in powers of 10 (i.e., from 10 million → 1 million, from 1 million → 100,000, from 10,000 → 1,000 light years, etc.) until it finally reaches a large oak tree leaf. *But that is not all!* It continues zooming into the leaf from 1 to 0.1 to 0.01, etc., light years until it reaches the level of the quarks viewed at 100 attometers.

> Select the Secret Worlds: The Universe Within[4] link to explore powers of 10 in the universe. (This activity may be helpful but is not required.)

View each change of the universe from a distance of 10 million light years down to 10^{-16} meters. (Note: You can slow down the sequence of pictures by the sliding tab near the bottom of the screen.) At the end of this experiment, you will complete an assignment in WebAssign. Think about who you would like to share it with as well.

SCIENTIFIC NOTATION

Now that you have reviewed powers of 10, turn your attention to scientific notation. Scientific notation is a method of writing very large and very small numbers in a convenient form. For example, a large number like 6,890,000,000 can be written using powers of 10 in the following way.

$$6,890,000,000 = 6.89 \times 10^9$$

A very small number such as 0.0000000789 can be written using powers of 10, too.

$$0.0000000789 = 7.89 \times 10^{-8}$$

Observe that a number is written in scientific notation when it is the product of a number less than 10 but greater than or equal to 1 and a power of 10. All numbers in scientific notation have the following form.

$$A \times 10^n \tag{1}$$

The number at the front, A, is called the mantissa, and n is the exponent, or power, of 10.

EXAMPLE:

1.00×10^4 — the mantissa is 1.00 and the exponent is 4.

9.999×10^{-4} — the mantissa is 9.999 and the exponent is –4.

LEARNING MORE ABOUT SCIENTIFIC NOTATION

Make sure that you read the information in your text concerning scientific notation. It is found in the appendix section.

SKILLS YOU NEED TO BE GOOD AT USING SCIENTIFIC NOTATION:

- Converting from standard numbers to numbers in scientific notation
- Multiplying and dividing numbers in scientific notation
- Adding and subtracting numbers in scientific notation
- Converting numbers in scientific notation to standard numbers

Optional activity: You can read the information found at New York University's Scientific Notation[5] website.
(NOTE: This site requires Java to operate. You may have to add the website URL as an exception to Java (Java control panel > Security > Exceptions) in order for it to function properly.)

SIGNIFICANT FIGURES

Numbers in science are values that represent measurements. Most people have noticed that when using a ruler, the object being measured does not always align with one of the markings, and so the measurement is taken as the value closest to a marking.

> **EXAMPLE:**
>
> You might report a length of 5.6 cm for any measurement between 5.55 and 5.65 cm. In short, you estimate your measurement to the nearest millimeter when using a ruler calibrated in millimeters. All measurements have this type of uncertainty.
>
> The question is, "Does it make sense to report the length of your measurement as, say, 5.56788 cm when you are using a ruler?"
>
> The answer is clearly no! The last 4 digits in 5.56788 cm are insignificant because we are only certain about the first digit or two. The remaining digits are a complete guess (if we are using a ruler marked in millimeters).

The subject that tells you how to handle the number of digits to report in a measurement is the subject of significant figures.

RULES OF SIGNIFICANT FIGURES

The number of significant figures in a number is equal to the sum of the number of digits known with certainty plus one digit that is uncertain. 2.1 has two significant figures since it lies between 2.15 and 2.05. The tenths place is uncertain, but the units place is very certain.

1 All nonzero digits are significant. For example, 124.56 has five significant figures.

2 All zeros between two nonzero digits are significant. For example, 1.001 has four significant figures.

3 Unless otherwise noted by context, all zeros to the left of an understood decimal point but to the right of a nonzero digit are not significant. 63,000 has only two significant figures.

4 If a decimal is placed into the above example, then all zeros are significant. 63,000. has five significant figures.

5 All zeros to the right of a decimal point but to the left of a nonzero digit are not significant. 0.00456 has three significant figures.

[5] http://www.nyu.edu/pages/mathmol/textbook/scinot.html

6 All zeros to the right of a decimal point and to the right of a nonzero digit are significant. For example, 0.06780 has four significant figures.