# Scientific Notation

MCHS Honors Physics 2014-15

## Scientific Notation – Why?

- Exponents are widely used in science, especially because they are convenient for expressing large and small numbers.
- An exponent is a number that indicates how many times another number should be multiplied by itself.
- To illustrate exponents and how to work with them, many examples are presented on the following pages.

## What Is An Exponent?

Examples:

- If five is multiplied by itself 3 times, $5 \times 5 \times 5$, the result is 125.
- This may be written using exponents as $5^3 = 125$.
- Here, 3 is the exponent, and 5 is the base.
- Consider a fraction with an exponent:

$$\left(\frac{1}{4}\right)^3 = \frac{1}{4} \times \frac{1}{4} \times \frac{1}{4} = \frac{1}{64}$$

## What Is A Negative Exponent

Examples:

- Another way to express $\left(\frac{1}{4}\right)^3$ is to reverse the fraction and change the sign of the exponent:
- $\left(\frac{1}{4}\right)^3 = \frac{1}{4^3} = 4^{-3} = \frac{1}{64}$ as before.
- In the equation $5^{-1} = \frac{1}{5}$, $-1$ is the exponent.

## Powers of Ten

Examples:

- Ten is often used as a base with an exponent.
- Note the patterns in the following set of examples. Starting with the middle line, read up and down as well as across:

$$10^{-3} = \frac{1}{10} \times \frac{1}{10} \times \frac{1}{10} = \frac{1}{1000} = 0.001$$
$$10^{-2} = \frac{1}{10} \times \frac{1}{10} = \frac{1}{100} = 0.01$$
$$10^{-1} = \frac{1}{10} = 0.1$$
$$10^{0} = 1 = 1 = 1$$
$$10^{1} = 10 = 10 = 10$$
$$10^{2} = 10 \times 10 = 100 = 100$$
$$10^{3} = 10 \times 10 \times 10 = 1000 = 1000$$

## Math With Exponents

Examples:

- Numbers with exponents can be added, subtracted, multiplied, divided, raised to powers, their roots can be taken, etc.
- Consider a number multiplied by another number with an exponent:

  $3 \times 2^4 = 3 \times 2 \times 2 \times 2 \times 2 = 3 \times 16 = 48$
- $5.1 \times 10^3 = 5.1 \times 10 \times 10 \times 10 = 5.1 \times 1000 = 5100$
- The number in front of ten is called the coefficient; in this case, it is 5.1.

## Re-Writing Numbers - Powers of Ten

Examples:

- A number can be represented in many ways by correctly changing both the exponent of ten and the position of the decimal point. For example:

$54321 = 54.321 \times 10^3 = 543.21 \times 10^2 = 5432.1 \times 10^1 = 54321 \times 10^0 = 543210 \times 10^{-1} = 5432100 \times 10^{-2}$

- A number written in this manner is in exponential form.
- If this form has only one digit in front of the decimal, it is said to be in "SCIENTIFIC NOTATION."

## Adding and Subtracting Exponents

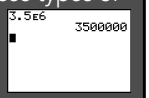
Examples:

- To add or subtract numbers in exponential form, the base and the exponents must be the same.
- In the example below, the base is 10 and the exponent is 2.
- $4 \times 10^2 + 2 \times 10^2 = 7 \times 10^2$
- Notice that $10^2$ is found in both numbers as well as in the answer ← It may be read as: $400 + 300 = 700$
- Subtraction is very similar:
- $4 \times 10^2 - 3 \times 10^2 = 1 \times 10^2 = 10^2 = 100$ ← This may be read as: $400 - 300 = 100$

## Adding and Subtracting Exponents

Examples:

- Below, the coefficients cannot be added or subtracted until the numbers have the same exponent:
- $5 \times 20^3 + 4 \times 10^2$ ← the exponents aren't equal.
- Since $5 \times 10^3 = 50 \times 10^2$, the problem becomes:
- $50 \times 10^2 + 4 \times 10^2 = 54 \times 10^2 = 5.4 \times 10^3$
- On your TI-84+, an easy way to enter these types of numbers is to type [2nd] + [ , ], which gives you the symbol "E":




- $5.4 \times 10^3 = 5.4\text{E}3 = 5400$

## Multiplying and Dividing Exponents

Examples:

- Multiplying and dividing with exponents is easier than addition or subtraction.
- $4 \times 10^2 \times 6 \times 10^5 = 24 \times 10^7 = 2.4 \times 10^8$
- Notice, to obtain 24, the coefficients of 4 and 6 were multiplied together (or divided for division).
- To obtain the exponent of 7, the exponents of 2 and 5 were added (or subtracted for division).
- $8 \times 10^{-4} \div 2 \times 10^3 = \frac{8 \times 10^{-4}}{2 \times 10^3} = 4 \times 10^{-7}$