National Emergency Training Center
16825 S. Seton Avenue
Emmitsburg, MD 21727-8998

FEMA

R203

Dear National Fire Academy Student:

Congratulations on your acceptance into the U.S. Fire Administration's National Fire Academy's *Fire Dynamics – Fire Modeling* (R203) course. Your assistance is requested to prepare for this educational opportunity.

This course is dependant upon mathematical calculations. You will not experience a great deal of lecture-based instruction, rather a more instructor led/monitoring approach. This course will be very challenging, yet rewarding. We ask for your commitment to prepare yourself for this opportunity through completion of the precourse work assignments that follow.

You will have access to Unit 3: *Mathematical Review*. In addition, you will have access to the *Pre-Course Math Skills Review*. You should complete all questions and bring them with you for the first day of class.

The following reference materials are highly recommended reading/downloaded prior to your attendance.

- Quintiere, James G. *Principles of Fire Behavior*. Delmar Publishers, 1998.
- Lentini, John J. *Scientific Protocols for Fire Investigation.* Taylor and Francis, 2006.
- DeHaan, John, Ph.D. *Kirk's Fire Investigation.* 6th Ed. Pearson/Prentice Hall, 2007.
- Babrauskas, Vytenis, Ph.D. *Ignition Handbook*. Fire Science Publisher, 2003.
- Shackelford, Raymond. *Fire Behavior and Combustion Processes*, Delmar Publishers, 2009.
- Chandler, Russell K. *Fire Investigation*, Delmar Publishers, 2009.

You must bring with you a laptop computer that has a minimum of 512 MB RAM, with a Pentium 4 processor. Your computer also should have the Windows 2000® operating system or newer, Windows XP or Vista. If you have an Apple® computer, it must be able to run Windows XP or Vista.

You will also need to bring with you a scientific calculator for in-course work.

Prior to your departure, please ensure with your employing agency that your computer will allow you to run everything, as previous experience has shown that some are limited to administrator rights. Have your IT folks enable the programs, which allows you access.

You alone are responsible for security and maintenance of your equipment. The Academy cannot provide you with computer software, beyond that required in this course; hardware; or technical support: disks, printers, scanners, etc. In order to cover the amount of material required for this course, completion of individual and/or group assignments and studying after classroom hours will be necessary. Also, evening classes may be conducted to complete all course requirements or to provide instructor-led tutorials. A key preparatory component to this course is completion of the precourse information listed above.

End-of-class graduation ceremonies are an important part of the course and you are expected to attend. Please do not make any travel arrangements to leave campus until after you and your classmates graduate.

Should you need additional information related to course content or requirements, please feel free to contact Mr. Douglas R. Williams, Arson Curriculum Training Specialist at 301-447-1158 or email at doug.williams@dhs.gov

Sincerely,

Dr. Denis Onieal, Superintendent
National Fire Academy
U.S. Fire Administration

Enclosure

Precourse Math Skills Review

Introduction

Fire Dynamics and Fire Modeling requires some basic math skills in order to understand the ideas presented in the rest of the course. Because students come to the course with varying levels of these skills, and varying amounts of time that has passed since they were last exposed to them, some precourse review will be helpful for most students. This review contains examples that use most of the needed skills. We also will be spending time discussing them in class, and instructors will be available on some evenings if additional help is needed.

1. Multiplying and dividing signed numbers--numbers only	
a. Simplify: $(-3)(-2)(4)(-5)(1)$	b. Simplify: $\frac{(5)(-2)(3)}{(-6)(4)}$
2 Multiplying and dividing signed numbers--numbers and symbols	
a. Simplify: $(5)(-x)(2y)$	b. Simplify: $\frac{(-2)(x)}{(1-3)}$
3. Order for evaluating expressions--numbers only	
a. Simplify: $4[3(6-8)+2(5+9)]-11$	b. Simplify: $\frac{16}{30-2(3+4)}$
4. Order for evaluating expressions--numbers and symbols	
a. Simplify: $3x+4x-(x-2)$	b. Simplify: $3(x+2y)-(3y+1)$
5. Simplifying expressions with fractions	
a. Simplify: $\frac{1}{x}+\frac{2}{y}$	b. Simplify: $\frac{(x-1)}{3}+\frac{(x+1)}{2}$

6. Adding and subtracting fractions--numbers only	
a. Simplify: $\frac{4}{5}+\frac{7}{30}$	b. Simplify: $4\,{}^{1}\!/_{3}-2\,{}^{4}\!/_{5}$
7. Adding and subtracting fractions--numbers and symbols	
a. Simplify: $\frac{3x}{2}+\frac{5}{6}$	b. Simplify: $\frac{5}{3}+\frac{x}{6}-\frac{2x}{2}$
8. Multiplying and dividing fractions--numbers only	
a. Simplify: $\left(\frac{4}{11}\right)\left(\frac{3}{16}\right)$	b. Simplify: $\frac{2}{7}\div\frac{5}{9}$
9. Multiplying and dividing fractions--numbers and symbols	
a. Simplify: $\left(\frac{x^2}{3}\right)\left(\frac{x}{4}\right)$	b. Simplify: $\frac{x^4}{5}\div\frac{2}{x}$
10. Fractional exponents	
a. Write in radical form: $x^{\frac{5}{2}}$	b. Write in fractional exponent form: $\sqrt[7]{x^3}$
11. Raising quantities to positive powers	
a. Simplify: $\left(xy^2\right)^2$	b. Simplify: $\left(x^2y^3\right)^{\frac{1}{3}}$
12. Raising quantities to negative powers	
a. Simplify: $\left(x^{-3}\right)\left(y\right)^2$	b. Simplify: $x^3\div y^{-1}$

13. Raising quantities to fractional powers--numbers only	
a. Simplify: $\left(x^{\frac{1}{3}}\right)\left(x^{\frac{2}{3}}\right)$	b. Simplify: $\frac{x^{\frac{5}{2}}}{x^2}$
14. Raising quantities to fractional powers--numbers and symbol	
a. Simplify: $\frac{(3ax)^2}{8(y)^{-2}}$	b. Simplify: $(x^4 y^3 z^2)^2$
15. Using calculator to simplify raising to powers	
a. Simplify: $5(0.5)^{0.4}$	b. Simplify: $\frac{1}{3}(4)^{2.5}$
16. Solving equations with one unknown--numbers only	
a. Solve for x: $5x - 3 = 7$	b. Solve for x: $3x + 2 = -16$
17. Solving equations with one unknown--numbers and symbols	
a. Solve for x: $\frac{3x}{2} = \frac{7}{4} + x$	b. Solve for x: $3x - 2 = 6 - x$
18. English system conversions	
a. How many inches are in 2.0 miles?	b. How many yards are in 6.5 feet?
19. Metric system conversions	
a. How many millimeters are in 0.50 km?	b. How many decimeters are in 275 mm?

20.	Converting between English and metric systems		
a.	How many miles are in 7.5 km?	b.	How many millimeters are in 8.7 yards?
21.	Writing numbers in scientific notation		
a.	Convert to scientific notation: 83500	b.	Convert to decimal form: -2.87×10^{-3}
22.	Multiplying and dividing numbers written in scientific notation--numbers only		
a.	Solve/Write answer in scientific notation: $\frac{(-4.13\times10^{3})(5.69\times10^{-1})}{(2.4\times10^{-3})(1.99\times10^{-4})}$	b.	Solve/Write answer in scientific notation: $\frac{6.24\times108}{(-9.1\times10^{2})(-3.7\times10^{4})}$
23.	Multiplying and dividing numbers written in scientific notation--numbers and symbols		
a.	Solve/Write answer in scientific notation: Solve for V, using the formula, V=$\frac{d}{t}$, if d=100 meters and t=1.5x10^{-3}sec.	b.	Solve/Write answer in scientific notation Solve for a, using the formula, a=$\frac{\Delta\upsilon}{t}$, if $\Delta\upsilon = 10\frac{m}{s}$ and t=10s.
24.	Solving fire dynamics equations--no exponents		
a.	Solve for unknown: Solve for $\dot{q}''$, using the formula, $\dot{q}'' = \dot{m}''L,$ if $L = 0.33\frac{KJ}{g}$ and $\dot{m}'' = \frac{50g}{m^2 s}$	b.	Solve for unknown: Solve for $\dot{m}''$, using the formula, $\dot{q}'' = \dot{m}''L,$ if $L = 2.2\frac{KJ}{g}$ and $\dot{q}'' = 30.8\frac{kw}{m^2}$ $(1kw = 1\frac{KJ}{s})$

25.	Solving fire dynamics equations--with exponents		
a.	Solve for unknown: Solve for h_f , using the formula, $h_f = 0.174(KQ)^{0.4}$ if $K = 1$ and $Q = 1000 KW$	b.	Solve for unknown: Solve for h_f , using the formula, $h_f = 0.174(KQ)^{0.4}$ if $K = 2$ and $Q = 150 KW$
26.	Counting significant figures		
a.	How many significant figures? 256,000	b.	How many significant figures? 0.4730
27.	Multiplication and division using significant figures		
a.	Simplify and write answer in correct significant figures: (587)(0.022)	b.	Simplify and write answer in correct significant figures: $\frac{(0.391)}{1700}$

UNIT 3:
MATH REVIEW

TERMINAL OBJECTIVE

Given an explanation of the process, the precourse preparation, and practice problems, the students will be able to solve algebraic and geometric problems correctly.

ENABLING OBJECTIVES

The students will:

1. *Review the proper use of various signs and symbols involved in fire dynamics.*

2. *Use established mathematical practices to solve algebraic equations correctly.*

3. *Understand how graphs are created and what data are derived from interpretation of the graphs.*

4. *Use and practice conversion of English-based units of measure to the metric system.*

5. *Correctly calculate aspects of geometric shapes.*

INTRODUCTION

You will review some basic concepts of algebra and geometry in this unit. Knowledge of these concepts is required in order to understand the ideas presented in the rest of the course. Although you did not come to the course to review math, physics, and chemistry, you will have to commit whatever time it takes to master these ideas.

Feelings of anxiety about math are common, and they definitely do not indicate that you are unable to learn math. It may simply mean that you did not learn some of the basic skills. If you feel uncomfortable with this material, seek help from your instructor or a member of your group. Everyone in the class can be successful.

If you are comfortable with the material help others in your group.

Learning math is like learning a foreign language. You have to practice it and apply it to your real world.

What is Mathematics?

Mathematics is a process of thinking that involves building and applying a system of rules and logic to solve problems. During this unit we will be emphasizing the rules and processes that are needed to answer questions about fire dynamics. Numbers and relationships are represented in symbolic statements that provide a way to model, investigate, and display real-world situations.

Look for the rules and understand the process.

Internet Sources for Review

- Purplemath--Purplemath contains practical **algebra** lessons, demonstrating useful techniques and pointing out common errors.

  http://www.purplemath.com

- Understanding Algebra, An online algebra text by James W. Brennan--The complete contents of this algebra textbook are available here online. This text is suitable for high-school Algebra I, preparing for the GED, a refresher for college students who need help preparing for college-level mathematics, or for anyone who wants to learn introductory algebra.

  http://www.jamesbrennan.org/algebra

- Chemtutor--Parts of the following sections listed on the page link given below will be helpful for reviewing the topics of this unit: measured numbers or exact numbers, scientific notation, significance and rounding, problem solving, percent, basic algebra, proportionality, conversions using DA, and practice with W5P.

  http://www.chemtutor.com/numbr.htm

THE BASICS

Decimals, Fractions, and Percentages

Fractions are numbers we use to talk about part of something (part/whole). Two kinds of symbols are used for fractions.

The **ordinary fraction** is written as one number over another; the part over the whole.

Example: $\frac{3}{4}$

The top value (3) is the **numerator**; the bottom value (4) is the **denominator**.

The **decimal fraction** for $\frac{3}{4}$ is simply written in decimal form,

Example: .075

but it is numerically equivalent to the ordinary fraction. Decimal form simply means the denominator is some multiple of 10.

Percentages are another way to describe a part of something. Percentages are found by multiplying the decimal fraction by 100, and the decimal fraction is found by dividing the percentage by 100 and removing the percent sign (%).

Variables and Constants

Constants are quantities whose value does not change during the time you are working with it. It may change if you vary conditions in the situation you are studying.

Variables are quantities whose numerical value changes during the period of study. They are often represented by letters. Relationships among variables often are represented by equations.

Common Geometric Shapes

In our world, we often characterize the shapes of objects in terms of a relatively small number of geometric shapes. Although real objects seldom perfectly match these geometric figures, they approximate them so we can use what we know about the geometric shapes to help us describe the objects.

In our study of fire dynamics, the most common two-dimensional geometric shapes are the **circle**, **square**, and **rectangle,** and their three-dimensional counterparts, the **sphere**, **cube**, and

rectangular solid. In two dimensions, we are interested in calculating circumference and area, and in three dimensions, surface area and volume.

SIMPLIFYING EXPRESSIONS

Order of Operations

When we simplify expressions, we need a set of rules so that anyone carrying out the process will get the same answer. Some of the rules are based on convention (everyone agrees to do something the same way), and others are based on mathematical logic.

The universally agreed-upon order to be used when evaluating expressions is

- **Parentheses** (any grouping symbol) from inside out.

  - Anything inside parentheses $(\ )$, brackets $[\ ]$, braces $\{\ \}$, and radical signs $\sqrt{\ }$.

  - Any expression in numerator or denominator of fraction or in an exponent is considered grouped.

  - If there are parentheses inside parentheses, you work from the inside out.

- **Exponents.**

  - Multiplication and division, left to right.

    -- If only multiplication is involved, the left to right order does not matter, but it matters for division.

  - Addition and subtraction, left to right.

    -- If only addition is involved, the left to right order does not matter, but it matters for subtraction.

Until you get comfortable with the simplification process, you should write the steps clearly and completely. As your experience increases, you will be able to do some steps in your head and combine steps. If you try to solve problems in your head and make mistakes, go back to writing all of the steps.

Multiplying or Dividing Signed Numbers

Multiplying or dividing an even number of positive numbers gives a positive result, as does multiplying or dividing an even number of negative numbers. Multiplying or dividing an odd number of positive and negative numbers together gives a negative result.

Expressions with Numbers or Numbers and Letters

Letters follow the same rules as numbers when simplifying expressions, but must be treated independently of the numbers.

Multiplying by One

Any number multiplied by one is equal to that number.

Example: $7 \times 1 = 7$

You can multiply a fraction by one, or by a fraction equal to one, and change how the fraction looks without changing its value. You can also divide a fraction by one, or by a fraction equal to one, and change how the fraction looks without changing its value.

Simplifying Expressions with Fractions

In a **proper fraction**, the numerator is always smaller than the denominator and the value is always less than one.

Example: $\frac{3}{4}$

In an **improper fraction**, the numerator is larger than the denominator.

Example: $\frac{7}{5}$

A mixed fraction has both a whole number and a fraction.

Example: $5\frac{3}{4}$

Sometime it is convenient to change a mixed fraction to an improper fraction when simplifying expressions or equations.

Example: $1\frac{5}{8} = \frac{8}{8} + \frac{5}{8}$ or $\frac{13}{8}$

It is easier to deal with smaller fractions, so a fraction can be reduced by dividing the numerator and denominator by the same number.

Adding and Subtracting Fractions

When adding and subtracting fractions, you first convert the fractions so they have the same number in the denominator (lowest common denominator, or LCD). Add or subtract the numerators and leave the denominator the same (the LCD). Finally, reduce the answer if possible.

Multiplying Fractions

When multiplying fractions, you first change all mixed numbers to improper fractions. Then, multiply the numerators together and the denominators together and place the product of the numerators over the product of the denominators. Reduce the answer, if necessary. Multiplying by one is a useful tool to use when reducing the answer.

Multiplying by one is a useful tool to use when simplifying expressions. Any number multiplied by one is equal to that number. You can multiply a fraction by one, or by a fraction equal to one, and change how the fraction looks without changing its value. You can also divide a fraction by one, or by a fraction equal to one, and change how the fraction looks without changing its value.

Dividing Fractions

When dividing fractions, you first change all mixed numbers to improper fractions. Then you invert (flip) the fraction in the denominator, placing the bottom number on top and the top number on the bottom. After doing this, you continue as with multiplication of fractions.

Laws of Exponents

An exponent is the number of times a number or variable is multiplied by itself. As is the case in many parts of algebra, there are rules that define how we deal with exponents. They must either be committed to memory or be available to you while you are working with exponents. These are the rules:

- $x^1 = x$
- $x^0 = 1$
- $x^n x^m = x^{n+m}$
- $x^m / x^n = x^{m-n}$
- $(x^n)^m = x^{nm}$
- $x^{-n} = 1/x^n$

- $(xy)^n = x^n y^n$
- $(x/y)^n = x^n / y^n$

x and ***y*** are variables and *m* and *n* are exponents that can be positive, negative, or fractional numbers.

SOLVING ALGEBRAIC EQUATIONS

Some Basic Ideas

Simplifying and solving are two terms that are often used interchangeably when, in fact, they have different meanings. Simplifying usually refers to operations performed on expressions. Solving implies that you want to find an answer or figure out the value of a variable in an equation.

Algebraic operations can be performed on equations with symbols, numbers, or measurements. An equal sign (=) indicates that the right side of the equation is equal to the left side.

- The numbers on each side of the equal signs are equivalent.
- The sign of each side of the equal sign is equivalent.
- The units on each side of the equal sign are equivalent.

Rules for Working with Equations

- You can multiply or divide both sides by the same thing.
- You can add or subtract the same thing from both sides.
- You can raise both sides to the same power.
- You can substitute anything in an equation for something of equal value.

Procedure for Solving Equations

Combine all terms that can be combined on each side of the equation. Get all of the terms with the **variable for which you are solving** on the left side of the equal sign and all numbers on the right side. The key idea here is that, if you do something to one side of an equation (i.e., add or subtract a quantity, multiply or divide a quantity, raise to a power, or take a root), you must do the same thing to the other side of the equation.

Multiply or divide both sides of the equation by the coefficient of the variable representing the unknown quantity so you are left with the unknown quantity with a coefficient of one on the left and the numerical answer on the right.

If you are dealing with real-world quantities, your final question should always be, "Does my answer make sense physically?"

SOLVING REAL-WORLD EQUATIONS

One of the greatest difficulties in trying to apply the rules and logic of mathematics to real-world situations is that, while we were learning math, we frequently used "pure" numbers that were not associated with anything we could relate to physical situations. We were expected to apply pure math to real situations with very little practice except for the much feared and little understood "verbal" or "story" problems.

We use a problem-solving strategy to overcome this difficulty.

Problem-Solving Approach

- **Step 1**--Read the problem carefully so you understand the situation. Some people find it useful to write down the information that you are given and that you are asked to find. Writing it down forces you to read the problem more carefully.

- **Step 2**--Look at what you are asked to find and see what information you need to know to arrive at the answer. If you do not see a clear path to the answer, try something. Ask what you can find with the information given that will help you to find the answer.

- **Step 3**--Express mathematically the connection between what you are given and what you have to find. Assign variable names to unknown quantities. Translate the English of the problem into mathematical relationships.

- **Step 4**--Solve the equation(s) for the unknown(s). Check to see you solved for what the problem asked.

- **Step 5**--Check your answer to see if it has correct units and whether or not the answer is reasonable.

SYSTEMS OF MEASUREMENT

There are two primary systems of units in use in the world today, the English system and the metric system. Almost all countries, with the exception of the United States, use the metric system, as does the scientific community all over the world.

All measurement systems have fundamental or basic quantities called defined units from which all other units are derived. The defined units are units of length, mass or weight, time, temperature, electric current, and luminance.

In 1875, the **Systeme International d'Unites** (SI) adopted the following "base units" of measurement, which serve as the foundation of the metric system:

- **Distance: meter** (m): The meter is the length of the path traveled by light in vacuum during a time interval of $^{1}/_{299\,792\,458}$ of a second.

- **Mass: kilogram** (kg): The kilogram is the unit of mass; it is equal to the mass of the international prototype of the kilogram.

- **Time: second** (s): The second is the duration of 9 192 631 770 periods of radiation corresponding to the transition between the two hyperfine levels of the ground state of the cesium 133 atom.

- **Electric current: ampere** (A): The ampere is the constant current, which, if maintained in two straight, parallel conductors of infinite length and of negligible circular cross-section, and placed 1 meter apart in vacuum, would produce between these conductors a force equal to 2×10^{-7} Newton per meter of length.

- **Temperature: Kelvin** (K): The Kelvin, a unit of thermodynamic temperature, is the fraction $^{1}/_{273.16}$ of the thermodynamic temperature of the triple point of water.

- **Quantity of substance: mole** (**mol**): The mole is the amount of substance of a system that contains as many elementary entities as there are atoms in 0.012 kilogram of carbon 12; its symbol is "mol." When the mole is used, the elementary entities must be specified and may be atoms, molecules, ions, electrons, other particles, or specified groups of such particles.

- **Intensity of light: candela (cd)**: The candela is the luminous intensity, in a given direction, of a source that emits monochromatic radiation of frequency 540×10^{12} hertz and that has a radiant intensity in that direction of $^{1}/_{683}$ watt per steradian

The metric system has many other units that are derived from the above "base units" and are referred to as **SI-derived units**. Some examples of derived units:

- **Newton** (**N**): A force that will produce an acceleration of 1 meter per second per second (1 m/s^2) when applied against a mass of 1 kilogram.

- **Volt (V)**: The pressure that is the difference of electric potential existing across the ends of a conductor carrying a constant current of 1 ampere when the power dissipated is 1 watt.

- **Ohm (Ω)**: Defined as a unit of resistance in a circuit in which a potential difference of one volt creates a current of one ampere; hence, 1 ohm equals 1 volt/ampere.

- Degree **Celsius (°C)**: Celsius is the temperature scale where 0 °C is the freezing point of water, and 100 °C the boiling point. The scale is often referred to as the **Centigrade Scale** since it is divided into 100 units.

- **Joule (J)**: The joule is a unit of energy or work named for James P. Joule. The energy expended by a force of 1 Newton acting through a distance of 1 meter.

- **Watt (W)**: The watt is a unit of power developed by James Watt, and is equal to 1 **joule per second**.

- **Pascal (Pa)** A Pascal is a unit of atmospheric pressure of 1 Newton per meter squared.

- **Calorie (cal)**: The calorie is the amount of energy needed to raise 1 gram of water 1° Centigrade. The temperature of the water is important relative to the actual amount of energy that would be required to raise the water 1 °Centigrade. The symbol for calorie may have several different subtexts, such as 15 °, 20 °, or **mean**, and the value of the constant will be dependant upon this criteria.

Often they are given a nickname to make it easier to talk about the specific quantity. For example, the metric unit for energy is the **Joule** (1 Joule = 1 kg-m^2/s^2).

Because the various scientific disciplines use different combinations of units, some even mixing English and metric units, and make measurements on different scales, it is necessary to convert within a given system and from system to system.

Unit Conversions

There are three methods by which one unit can be converted to another representing the same quantity. The first is by the use of conversion factors. If you have a table of conversion factors, and the factor you need is on the table, you can use the factor-label method directly.

The second method is the factor-label method (sometimes called dimensional analysis. If you only use the numbers in the conversion factor, instead of both the number and units, there is a high likelihood you will make a mistake. The factor-label method will substantially reduce the chance of error. The factor-label method can also be used to check work done with formulas and it can be used instead of formulas in simple problems.

Basic ideas of the factor-label method are that numbers with units are treated in exactly the same as coefficients associated with variables. You can multiply anything by 1 and not change its value.

- **Step 1**--Check to see that the unit given and the unit into which you want to change are the same dimension (feet into meters is correct, feet into pounds is not).
- **Step 2**--Find a conversion factor between the given units and the desired units and write it as an equation.
- **Step 3**--Convert the equation to a fraction, with the desired units in the numerator and the given units in the denominator.
- **Step 4**--Do this as many times as necessary to get from the initial given unit to the final desired unit.
- **Step 5**--Simplify by carrying out the arithmetic on the numbers and canceling the units. If the units become more complex, invert the fraction whose units have become more complex.

Example: How many meters are in 3.6 miles?

$$\text{? meters} = \frac{3.6\,miles}{1} \bullet \frac{5280\ feet}{1\,mile} \times \frac{12\,inches}{1\ foot} \times \frac{2.54\,cm}{1\,inch} \times \frac{1\,meter}{100\,cm}$$

The resulting product contains the unit dimensions (meter) that we seek.

$$\frac{579363.84\,meters}{100} = \frac{5793.36384\,meters}{1} = 5793.36\,meters$$

Computer conversion program programs make your work much easier, but, if you do not understand the conversion process, there is a high likelihood of error.

SCIENTIFIC NOTATION

In this course we will be working with some very large and very small numbers, and it is inconvenient to write the numbers with all their zeros. Scientific notation, expressing these numbers as a number between 1 and 10 times a power of 10, is a way of expressing and working with very large and very small numbers in exponential form.

Writing a number in scientific notation form [(number between 1 and 10) x 10^n]:

- Determine the number between 1 and 10 by writing the number in regular form and place a decimal point to the right of the last digit.

- Place a caret (^) to the right of the first nonzero digit.

- Write the resulting number between 1 and 10.

- Count the number of decimal places between the carot and the decimal place. This is the exponent, *n*, to which 10 is raised.

- If the number is a decimal fraction (less than 1.00) the sign on *n* should be negative.

- If the number is greater than 1.00, the sign on *n* should be positive.

- If the original number is between 1 and 10, *n* is zero and anything raised to the zero power is 1, so the number is written without a power of 10.

Positive and negative numbers and positive and negative exponents mean different things. Consider the following:

$$0.0045 = 4.5 \times 10^{-3}$$
$$-0.0045 = -4.5 \times 10^{-3}$$
$$4{,}500 = 4.5 \times 10^{3}$$
$$-4{,}500 = -4.5 \times 10^{3}$$

These numbers look similar but are very different. Be careful, and look carefully.

Multiplying or Dividing Numbers Using Scientific Notation.

- If you are multiplying two numbers, rearrange the terms so that the numbers are together and the powers of 10 are together.

- Multiply the numbers together.

- Multiply the powers of 10 together.

- Recombine the result into a single number between 1 and 10 and a power of ten.

UNCERTAINTY IN MEASUREMENT

Measurements are not exact. Significant figures are used to give some indication of the accuracy with which a measurement is made. The use of significant figures throughout calculations can also give an indication of the accuracy of the result.

Significant figures are those digits in a measured numbers that include all certain digits plus one having uncertainty. These guidelines are used when writing significant figures:

- Any nonzero digit is significant.
- Zeros between nonzero digits are significant.
- Zeros that are used to place a decimal point are not significant.
- Zeros to the right of nonzero digits are not significant unless the number contains a decimal point.

When multiplying or dividing numbers, the product should have the same number of significant figures as the least accurate component (if you multiply a 2-significant digit number times a 5-significant digit number, your result should have only two significant digits in the answer.

If a number is an exact number, rather than the result of a measurement, the number of digits in that number does not affect the number of significant digits in the result

Understanding significant digits is important with increased use of calculators. Some users write an answer with all of the digits shown on the calculator display when, in fact, the minimum number of significant figures in the component numbers should govern the number in the result. It is necessary to round off numbers that have more digits than are warranted by the data, and the following rules are used

- When the first digit dropped off is less than 5, the last digit remains unchanged.
- When the first digit dropped is 5 or greater, the last digit retained is increased by 1.
- For calculations involving more than one step, carry out the calculations without rounding off the intermediate results. Round the final result off to the correct number of significant figures.

GRAPHICAL RELATIONSHIPS

A direct mathematical relation exists when one variable increases in value while the other also increases, or the first decreases when the second decreases. An indirect or inverse relation exists when one variable increases in value while the other decreases. Experimental results in fire dynamics are often displayed in graphical form.

SUMMARY

As we have moved through this unit, you may have felt your instructor was belaboring the obvious while, at other times, you would have liked to have spent more time understanding a particular concept, We have tried to discuss the concepts that you will use in the rest of the course.

Fire dynamics uses the principles of algebra and geometry to define relationships among physical quantities and to solve for unknown variables in equations used in fire dynamics. You will find that it is important to make conversions between English and metric system units for physical quantities so we can have consistent units when doing fire dynamics problems. Using scientific notation when working with numbers of all orders of magnitude improves the accuracy of our work. The appropriate use of significant figures reflects the uncertainty of measurements and calculations made in fire dynamics. Results of fire dynamics experiments often are given in graphic form, and it is important for us to be able to read and interpret them.

APPENDIX

Formulas--Geometric Shapes

Variables

Circle	R--Radius	D--Diameter	
Square	S--Side		
Rectangle	L--Length	W--Width	H--Height

2-D Objects

	Perimeter	Area
Circle	$C=2\pi R=\pi D$	$A=\pi R^2=\frac{\pi D^2}{4}$
Square	$C=4S$	$A=S^2$
Rectangle	$C=2L+2w$	$A=LW$

3-D Objects

	Volume	Surface Area
Sphere	$V=\frac{4}{3}\pi R^3=\frac{\pi D^3}{6}$	$SA=4\pi R^2$
Cube	$V=S^3$	$SA=6S^2$
Rect. Solid	$V=LWH$	$SA=2LW+2LH+2HW$