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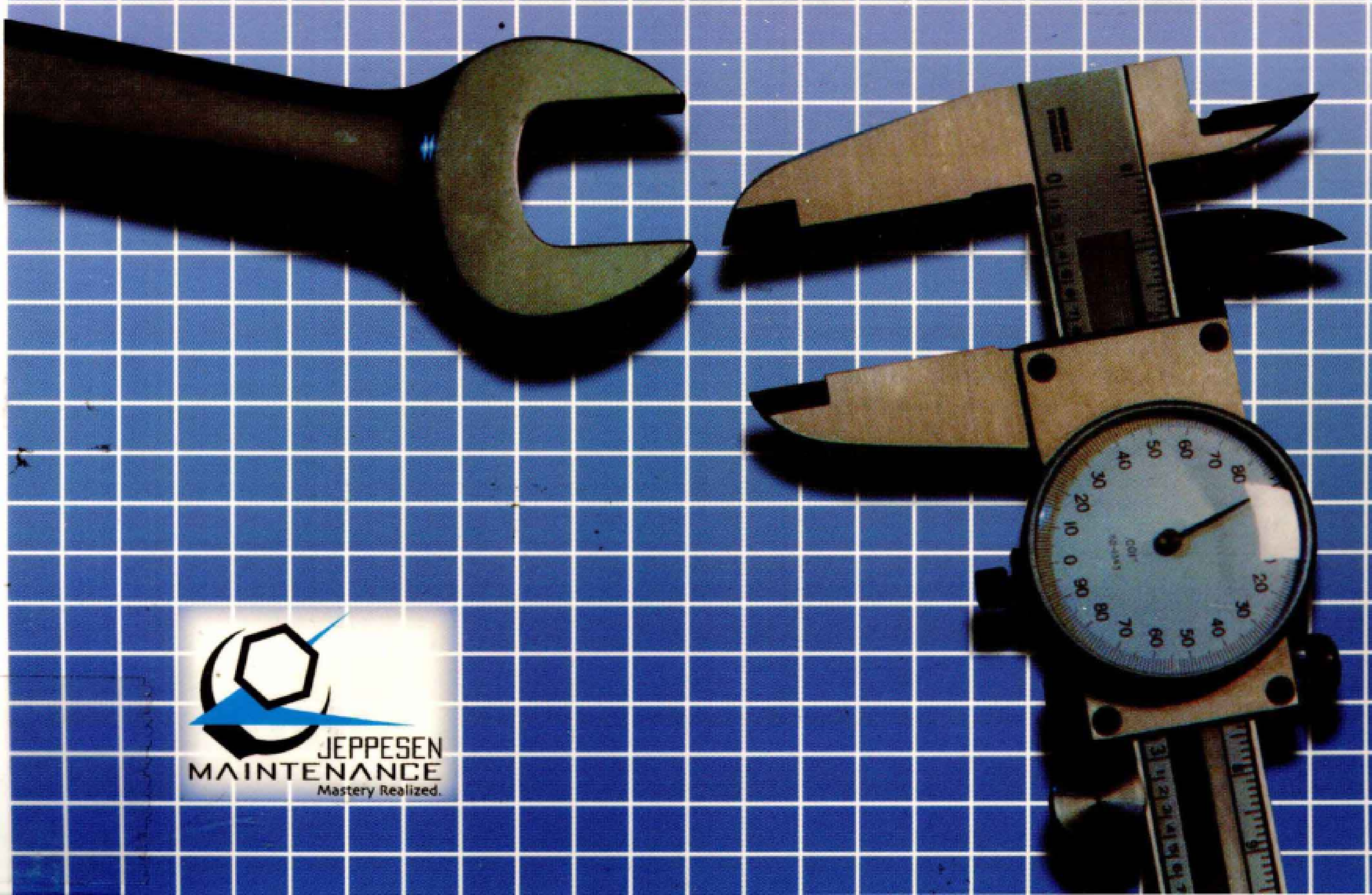

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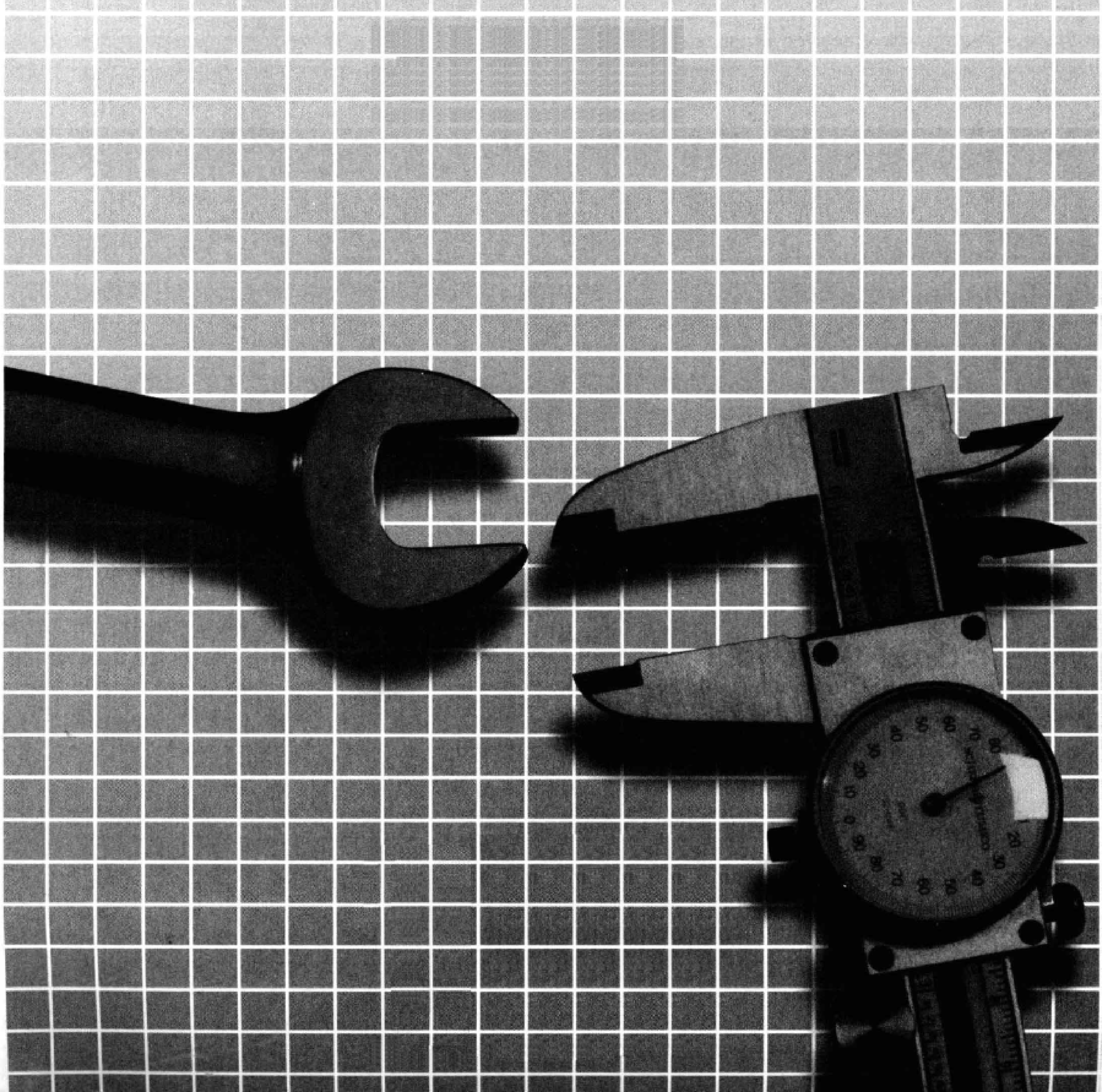

Support Materials

Look for these support materials to complement your A&P Technician General Textbook:

- **A&P Technician General Workbook**
- **A&P Technician General Study Guide**
- **Federal Aviation Regulations**
- **AC 43.13-1B/2A Acceptable Methods, Techniques and Practices/Aircraft Alterations**
- **Aircraft Technical Dictionary**
- **Standard Aviation Maintenance Handbook**

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PREFACE

Congratulations on taking the first step toward learning to becoming an Aviation Maintenance Technician. The *A&P Technician General Textbook* contains the answers to many of the questions you may have as you begin your training program. It is based on the "study/review" concept of learning. This means detailed material is presented in an uncomplicated way, then important points are summarized through the use of bold type and illustrations. The textbook incorporates many design features that will help you get the most out of your study and review efforts. These include:

Illustrations — Illustrations are carefully planned to complement and expand upon concepts introduced in the text. The use of bold in the accompanying caption flag them as items that warrant your attention during both initial study and review.

Bold Type — Important new terms in the text are printed in bold type, then defined.

Federal Aviation Regulations — Appropriate FARs are presented in the textbook. Furthermore, the workbook offers several exercises designed to test your understanding of pertinent regulations.

This textbook is the key element in the training materials. Although it can be studied alone, there are several other components which we recommend to make your training as complete as possible. These include the *A&P Technician General Workbook* and *Study Guide*, as well as *AC 43.13-1B/2A* and *FAR Handbook for Aviation Maintenance Technicians*. When used together, these various elements provide an ideal framework for you and your instructor as you prepare for the FAA computerized and practical tests.

The A&P Technician General course is the first segment of your training as an aviation maintenance technician. The General section introduces you the basic concepts, terms, and procedures that serve as the building blocks for the more complex material you will encounter later on in your training.

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CHAPTER 1

MATHEMATICS

INTRODUCTION

Mathematics is the basic language of science and technology. It is an exact language that has a vocabulary and meaning for every term. Since math follows definite rules and behaves in the same way every time, scientists and engineers use it as their basic tool. Long before any metal is cut for a new aircraft design, there are literally millions of mathematical computations made. Aviation maintenance technicians perform their duties with the aid of many different tools. Like the wrench or screwdriver, mathematics is an essential tool in the repair and fabrication of replacement parts. With this in mind, you can see why you must be able to use this important tool.

SECTION A

ARITHMETIC

Just as studying a new language begins with learning basic words, the study of mathematics begins with arithmetic, its most basic branch. Arithmetic uses real, non-negative numbers, which are also known as counting numbers, and consists of only four operations, addition, subtraction, multiplication, and division. While you have been using arithmetic since childhood, a review of its terms and operations will make learning the more difficult mathematical concepts much easier.

NUMBER SYSTEMS

Numbers are a large part of everyone's life, and you are constantly bombarded with figures. Yet little attention is paid to the basic structure of the numbering system. In daily life, most people typically use a "base ten" or **decimal system**. However, another numbering system that is used in computer calculations is the **binary**, or "base two" system.

THE DECIMAL SYSTEM

The decimal system is based on ten whole numbers, often called **integers**, from zero to nine. Above the number nine the digits are reused in various combinations to represent larger numbers. This is accomplished by arranging the numbers in columns based on a multiple of ten. With the addition of a negative (-) sign, numbers smaller than zero are indicated.

To describe quantities that fall between whole numbers, fractions are used. **Common fractions** are used when the space between two integers is divided into equal segments such as fourths. When the space between integers is divided into ten segments, **decimal fractions** are typically used.

THE BINARY SYSTEM

Because the only real option in an electrical circuit is ON or OFF, a number system based on only two digits is used to create electronic calculations. The base two, or binary system, only utilizes the digits zero and one. For example, when a circuit is ON a one is represented, and when a circuit is OFF a zero is indicated. By converting these ON or OFF messages to represent numbers found in the decimal system, a computer can perform complex tasks.

To build a binary number system that corresponds to the decimal system, begin with one switch. When this switch is in the OFF position, a zero is indicated. When it is in the ON position, a one is represented. Because these are the only possibilities for a single switch, additional switches must be added to represent larger quantities. For example, a second switch represents the quantity 2. When the first switch is OFF and the second switch is ON, the quantity 2 is indicated. When both the first and second switch are ON, the 1 and 2 are added to indicate the quantity 3. This procedure of adding switches continues with each switch value doubling as you progress. For example, the first 10 values in the binary system are 1, 2, 4, 8, 16, 32, 64, 128, 256, and 512. [Figure 1-1]

WHOLE NUMBERS

While integers are useful in communicating a given quantity, you must be able to manipulate them to discover their full power. There are four fundamental mathematical operations with which you must be familiar. They are addition, subtraction, multiplication, and division.

ADDITION

The process of finding the total of two or more numbers is called addition. This operation is indicated by the plus (+) symbol. When numbers are combined by addition, the resulting total is called the **sum**.

When adding whole numbers whose total is more than nine, it is necessary to arrange the numbers in columns so that the last digit of each number is in the same column. The ones column contains the values zero through nine, the tens column contains multiples of ten, up to ninety, and the hundreds column consists of multiples of one hundred.

Example:

hundreds	tens	ones
	$^{1}7$	8
$^{1}2$	4	3
+ 4	6	2
7	8	3

DECIMAL NUMBER	BINARY NUMBERS								BINARY NUMBER
	128	64	32	16	8	4	2	1	
1	0	0	0	0	0	0	0	1	1
2	0	0	0	0	0	0	1	0	10
3	0	0	0	0	0	0	1	1	11
4	0	0	0	0	0	1	0	0	100
5	0	0	0	0	0	1	0	1	101
27	0	0	0	1	1	0	1	1	11011
48	0	0	1	1	0	0	0	0	110000
92	0	1	0	1	1	1	0	0	1011100
117	0	1	1	1	0	1	0	1	1110101
168	1	0	1	0	1	0	0	0	10101000

Figure 1-1. This binary conversion chart illustrates how a decimal number is converted to a binary number. For example, the binary equivalent to 48 is 110000.

To check addition problems, add the figures again in the same manner, or in reverse order from bottom to top. It makes no difference in what sequence the numbers are combined.

SUBTRACTION

The process of finding the **difference** between two numbers is known as subtraction and is indicated by the minus (-) sign. Subtraction is accomplished by taking the quantity of one number away from another number. The number which is subtracted is known as the **subtrahend**, and the number from which the quantity is taken is known as the **minuend**.

To find the difference of two numbers, arrange them in the same manner used for addition. With the minuend on top and the subtrahend on the bottom, align the vertical columns so the last digits are in the same column. Beginning at the right, subtract the subtrahend from the minuend. Repeat this for each column.

Example:

hundreds	tens	ones
7	$^{5}\not{6}$	$^{1}4$
-4	3	6
3	2	8

To check a subtraction problem, you may add the difference to the subtrahend to find the minuend.

MULTIPLICATION

Multiplication is a special form of repetitive addition. When a given number is added to itself a specified number of times, the process is called multiplication. The sum of 4 + 4 + 4 + 4 + 4 = 20 is expressed by multiplication as 4 × 5 = 20. The numbers 4 and 5 are called **factors** and the answer, 20, represents the **product**. The number multiplied (4) is called the **multiplicand**, and the **multiplier** represents the number of times the multiplicand is added to itself. Multiplication is typically indicated by an (×), (•), or in certain equations, by the lack of any other operation sign.

One important fact to remember when multiplying is that the order in which numbers are multiplied does not change the product.

Example:

$$\begin{array}{r} 3 \\ \times\underline{4} \\ 12 \end{array} \quad \text{or} \quad \begin{array}{r} 4 \\ \times\underline{3} \\ 12 \end{array}$$

Like addition and subtraction, when multiplying large numbers it is important they be aligned vertically. Regardless of the number of digits in the multiplicand or the multiplier, the multiplicand should be written on top, and the multiplier beneath it. When multiplying numbers greater than nine, multiply each digit in the multiplicand by each digit in the multiplier. Once all multiplicands are used as a multiplier, the products of each multiplication operation are added to arrive at a total product.

Example:

532	Multiplicand
×24	Multiplier
2128	First partial product
1064	Second partial product
12,768	

DIVISION

Just as subtraction is the reverse of addition, division is the reverse of multiplication. Division is a means of finding out how many times a number is contained in another number. The number divided is called the **dividend**, the number you are dividing by is the **divisor**, and the result is the **quotient**. With some division problems, the quotient may include a **remainder**. A remainder represents that portion of the dividend that cannot be divided by the divisor.

Division is indicated by the use of the division sign (÷) with the dividend to the left and the divisor to the right of the sign, or a $\overline{)\ }$ with the dividend inside the sign and the divisor to the left. Division also is indicated in fractional form. For example, in the fraction $^3/_4$, the 3 is the dividend and the 4 is the divisor. When division is carried out, the quotient is .75.

The process of dividing large quantities is performed by breaking the problem down into a series of operations, each resulting in a single digit quotient. This is best illustrated by example.

Example:

$$\begin{array}{r} 52 \\ 8\overline{)416} \\ \underline{40} \\ 16 \\ \underline{16} \\ 0 \end{array}$$

To check a division problem for accuracy, multiply the quotient by the divisor and add the remainder (if any). If the operation is carried out properly, the result equals the dividend.

SIGNED NUMBERS

If zero is used as a starting point, all numbers larger than zero have a positive value, and those smaller than zero have a negative value. This is illustrated by constructing a **number line.** [Figure 1-2].

ADDING SIGNED NUMBERS

When adding two or more numbers with the same sign, ignore the sign and find the sum of the values and then place the common sign in front of the answer. In other words, adding two or more positive numbers always results in a positive sum, whereas adding two or more negative numbers results in a negative sum.

When adding a positive and negative number, find the difference between the two numbers and apply the sign (+ or -) of the larger number. In other words, adding a negative number is the same as subtracting a positive number. The result of adding or subtracting signed numbers is called the **algebraic sum** of those numbers.

Add 25 + (-15)

$$\begin{array}{r} 25 \\ \underline{+\,(-15)} \\ 10 \end{array} \quad \text{or} \quad \begin{array}{r} 25 \\ \underline{-\,15} \\ 10 \end{array}$$

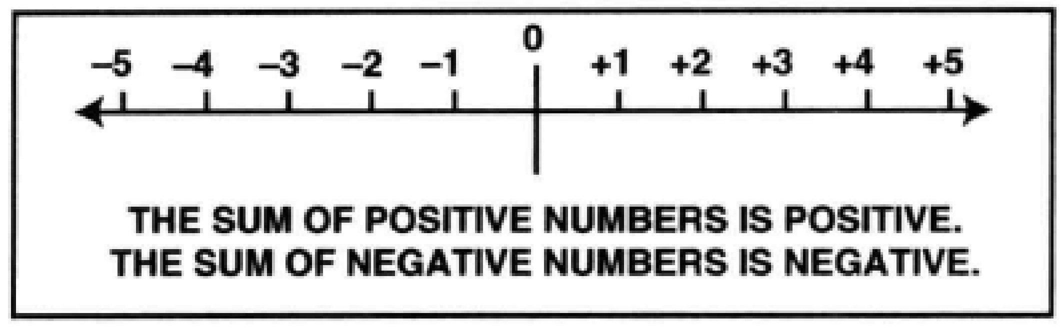

Figure 1-2. When creating a number line, negative values are identified with a minus sign (-), and positive values are identified by the plus (+) sign or by the absence of a sign.

SUBTRACTING SIGNED NUMBERS

When subtracting numbers with different signs, change the operation sign to plus and change the sign of the subtrahend. Once this is done, proceed as you do in addition. For example, +3 - -4 is the same as +3 + +4. It makes no difference if the subtrahend is larger than the minuend, since the operation is done as though the two quantities are added.

Example:

Subtract 48 from -216.

Step 1: Set up the subtraction problem.

-216 - 48

Step 2: Change the operation sign to a plus sign and change the sign of the subtrahend. Now add.

-216 + -48 = -264

MULTIPLYING SIGNED NUMBERS

Multiplication of signed numbers is accomplished in the same manner as multiplication of any other number. However, after multiplying, the product must be given a sign. There are three rules to follow when determining a product's sign.

1. The product of two positive numbers is always positive.
2. The product of two negative numbers is always positive.
3. The product of a positive and a negative number is always negative.

Example:

$6 \times 2 = 12$ $\qquad -6 \times -2 = 12$

$(-6) \times (-2) = 12$ $\qquad (-6) \times (2) = -12$

DIVIDING SIGNED NUMBERS

Like multiplying signed numbers, division of signed numbers is accomplished in the same manner as dividing any other number. The sign of the quotient is determined using rules identical to those used in multiplication.

1. The quotient of two positive numbers is always positive.
2. The quotient of two negative numbers is always positive.
3. The quotient of a positive and a negative number is always negative.

Example:

$$12 \div 3 = 4 \qquad 12 \div (-3) = -4$$
$$(-12) \div (-3) = 4 \qquad (-12) \div 3 = -4$$

COMMON FRACTIONS

A common fraction represents a portion or part of a quantity. For example, if a number is divided into three equal parts, each part is one-third ($^1/_3$) of the number. A fraction consists of two numbers, one above and one below a line, or **fraction bar**. The fraction bar indicates division of the top number, or **numerator**, by the bottom number, or **denominator**. For example, the fraction $^3/_4$ indicates that three is divided by four to find the decimal equivalent of .75.

When a fraction's numerator is smaller than the denominator, the fraction is called a **proper fraction**. A proper fraction is always less than 1. If the numerator is larger than the denominator, the fraction is called an **improper fraction**. In this situation the fraction is greater than 1. If the numerator and denominator are identical, the fraction is equal to 1.

A **mixed number** is the combination of a whole number and a proper fraction. Mixed numbers are expressed as $1\ ^5/_8$ and $29\ ^9/_{16}$ and are typically used in place of improper fractions.

The numerator and denominator of a fraction can be changed without changing the fraction's value. One way this is done is by multiplying the numerator and denominator by the same number.

Example:

$$\frac{3}{8} \times \frac{3}{3} = \frac{9}{24}$$

A fraction's value also remains the same if both the numerator and denominator are divided by the same number. This type of operation allows you to simplify, or reduce, large fractions to their smallest terms.

Example:

$$\frac{3}{9} \div \frac{3}{3} = \frac{1}{3}$$

$$\frac{21875}{100000} \div \frac{25}{25} = \frac{875}{4000} \div \frac{25}{25} = \frac{35}{160} \div \frac{5}{5} = \frac{7}{32}$$

REDUCING FRACTIONS

It is generally considered good practice to reduce fractions to their lowest terms. The simplest reductions occur when the denominator is divisible by the numerator. If the denominator is not evenly divided by the numerator, you must find a number by which the numerator and denominator are divided evenly. Here are a few tips to help in the selection of divisors:

1. If both numbers are even, divide by 2.
2. If both numbers end in 0 or 5, divide by 5.
3. If both numbers end in 0, divide by 10.

Example:

Reduce $^{15}/_{45}$ to its lowest terms.

Step 1: Divide both the numerator and denominator by 5.

$$\frac{15}{45} \div \frac{5}{5} = \frac{3}{9}$$

Step 2: Reduce further by dividing both terms by 3.

$$\frac{15}{45} = \frac{3}{9} \div \frac{3}{3} = \frac{1}{3}$$

When neither the numerator or denominator can be divided evenly, the fraction is reduced to its lowest terms.

LEAST COMMON DENOMINATOR

You cannot add or subtract common fractions without first converting all of the denominators into identical units. This process is known as finding the least common denominator (LCD). For example, the quickest way to find the least common denominator for $^1/_3$ and $^1/_2$ is to multiply the two denominators ($3 \times 2 = 6$). To determine the numerators, multiply the numerator by the same number used to obtain the LCD.

Example:

$$\frac{1}{3} \times \frac{2}{2} = \frac{2}{6}$$

$$\frac{1}{2} \times \frac{3}{3} = \frac{3}{6}$$

ADDING COMMON FRACTIONS

As mentioned earlier, you cannot add common fractions without first determining the least common denominator. However, once this is done, you only need to add the numerators to arrive at a sum. This answer is then reduced to its lowest terms.

Example:

Add $\frac{1}{12} + \frac{2}{6} + \frac{1}{3}$

Step 1: Rewrite using the least common denominator.

$$\frac{1}{12} + \frac{4}{12} + \frac{4}{12}$$

Step 2: Add the numerators and reduce to lowest terms, if possible.

$$\frac{1}{12} + \frac{4}{12} + \frac{4}{12} = \frac{9}{12} \div \frac{3}{3} = \frac{3}{4}$$

SUBTRACTING COMMON FRACTIONS

Subtracting fractions also requires an LCD to be determined. Once this is accomplished, subtract the numerators, express the difference over the LCD, and reduce the answer to its lowest terms.

Example:

Subtract $^2/_8$ from $^1/_3$

Step 1: Rewrite using the least common denominator.

$$\frac{8}{24} - \frac{6}{24}$$

Step 2: Subtract the numerators and reduce to lowest terms.

$$\frac{8}{24} - \frac{6}{24} = \frac{2}{24} \div \frac{2}{2} = \frac{1}{12}$$

MIXED NUMBERS

Mixed numbers contain both whole numbers and proper fractions. Before adding or subtracting mixed numbers, you must convert them to improper fractions. To convert a mixed number to an improper fraction, multiply the whole number by the denominator and add the product to the numerator. The sum of these two numbers becomes the numerator.

Example:

Convert 3 $^3/_4$ to an improper fraction.

$$3\,\frac{3}{4} = \frac{(4 \times 3) + 3}{4} = \frac{15}{4}$$

ADDING MIXED NUMBERS

When adding mixed numbers, either to other mixed numbers or to proper fractions, you must convert the mixed numbers to improper fractions. Once accomplished, determine the least common denominator and add in the same manner as with proper fractions.

When adding improper fractions, the sum is usually another improper fraction. When faced with an improper fraction in an answer, you should convert it to a mixed number. To do this, divide the numerator by the denominator to determine the whole number. If there is a remainder, leave it in fractional form.

Example:

Add the following:

$$2\,\frac{2}{3} + 3\,\frac{1}{4} + 5\,\frac{1}{2}$$

Step 1: Convert each to an improper fraction.

$$2\,\frac{2}{3} = \frac{(2 \times 3) + 2}{3} = \frac{8}{3}$$

$$3\,\frac{1}{4} = \frac{(3 \times 4) + 1}{4} = \frac{13}{4}$$

$$5\,\frac{1}{2} = \frac{(5 \times 2) + 1}{2} = \frac{11}{2}$$

Step 2: Find the LCD and add.

$$\frac{32}{12} + \frac{39}{12} + \frac{66}{12} = \frac{137}{12}$$

Step 3: Convert the improper fraction to a mixed number.

$$\frac{137}{12} = 11\ \frac{5}{12}$$

SUBTRACTING MIXED NUMBERS

To subtract a mixed number from another mixed number or proper fraction, begin by converting the mixed number to an improper fraction. Once converted, find the LCD and perform the subtraction. To complete the problem, convert the resulting improper fraction into a mixed number.

Example:

Subtract $2\ ^{1}/_{6}$ from $5\ ^{2}/_{3}$.

Step 1: Convert to improper fractions.

$$5\ \frac{2}{3} = \frac{(5 \times 3) + 2}{3} = \frac{17}{3}$$

$$2\ \frac{1}{6} = \frac{(2 \times 6) + 1}{6} = \frac{13}{6}$$

Step 2: Find the LCD and subtract.

$$\frac{34}{6} - \frac{13}{6} = \frac{21}{6}$$

Step 3: Convert to a mixed number.

$$\frac{21}{6} = 3\ \frac{3}{6} = 3\ \frac{1}{2}$$

MULTIPLYING FRACTIONS

Multiplication of fractions is performed by multiplying the numerators of each fraction to form the product numerator, and multiplying the individual denominators to form the product denominator. The resulting fraction is then reduced to its lowest terms.

Example:

Multiply the following: $^{8}/_{32} \times {}^{5}/_{8} \times {}^{4}/_{16}$

Step 1: Multiply the numerators and the denominators.

$$\frac{8}{32} \times \frac{5}{8} \times \frac{4}{16} = \frac{160}{4096}$$

Step 2: Reduce to lowest terms.

$$\frac{160}{4096} \div \frac{32}{32} = \frac{5}{128}$$

SIMPLIFY FRACTIONS FOR MULTIPLICATION

It was mentioned earlier that the value of a fraction does not change when you perform the same operation (multiplication or division) on both the numerator and denominator. You can use this principle to simplify the multiplication of fractions. For example, $^{8}/_{32} \times {}^{5}/_{8} \times {}^{4}/_{16}$ is equivalent to

$$\frac{8 \times 5 \times 4}{32 \times 8 \times 16}$$

Notice that there is an 8 in the numerator and denominator. Since these are equivalent values, they can be removed from the equation. Furthermore, the 16 in the denominator is divisible by the 4 in the numerator. Therefore, when both are divided by 4, the 4 in the numerator reduces to 1 and the 16 reduces to 4.

Example:

Simplify by cancellation, then multiply:

$$\frac{8}{32} \times \frac{5}{8} \times \frac{4}{16}$$

Step 1: Simplify

$$\frac{\overset{1}{\cancel{8}}}{32} \times \frac{5}{\underset{1}{\cancel{8}}} \times \frac{4}{16}$$

$$\frac{1}{32} \times \frac{5}{1} \times \frac{\overset{1}{\cancel{4}}}{\underset{4}{\cancel{16}}}$$

$$\frac{1}{32} \times \frac{5}{1} \times \frac{1}{4}$$

Step 2: Multiply and reduce, if possible.

$$\frac{1}{32} \times \frac{5}{1} \times \frac{1}{4} = \frac{5}{128}$$

DIVIDING FRACTIONS

Division of common fractions is accomplished by inverting, or turning over, the divisor and then multiplying. However, it is important that you invert the divisor only and not the dividend. Once the divisor is inverted, multiply the numerators to obtain a new numerator, multiply the denominators to obtain a new denominator, and reduce the quotient to its lowest terms.

Example:

Divide $^2/_3$ by $^1/_4$.

Step 1: Invert the divisor and multiply.

$$\frac{2}{3} \div \frac{1}{4} = \frac{2}{3} \times \frac{4}{1}$$

Step 2: Multiply and simplify the product.

$$\frac{2}{3} \times \frac{4}{1} = \frac{8}{3} = 2\,\frac{2}{3}$$

DECIMALS

Working with fractions is typically time consuming and complex. One way you can eliminate fractions in complex equations is by replacing them with **decimal fractions** or decimals. A common fraction is converted to a decimal fraction by dividing the numerator by the denominator. For example, $^3/_4$ is converted to a decimal by dividing the 3 by the 4. The decimal equivalent of $^3/_4$ is .75. Improper fractions are converted to decimals in the same manner. However, whole numbers appear to the left of the decimal point.

In a decimal, each digit represents a multiple of ten. The first digit represents tenths, the second hundredths, the third thousandths.

Example:

.5	is read as five tenths
.05	is read as five hundredths
.005	is read as five thousandths

When writing decimals, the number of zeros to the right of the decimal does not affect the value as long as no other number except zero appears. In other words, numerically, 2.5, 2.50, and 2.5000 are the same.

ADDING DECIMALS

The addition of decimals is done in the same manner as the addition of whole numbers. However, care must be taken to correctly align the decimal points vertically.

Example:

Add the following: 25.78 + 5.4 + 0.237

Step 1: Rewrite with the decimal points aligned, and add.

$$\begin{array}{r} 25.78 \\ 5.4 \\ +\ 0.237 \\ \hline 31.417 \end{array}$$

Once everything is added, the decimal point in the answer is placed directly below the other decimal points.

SUBTRACTING DECIMALS

Like adding, subtracting decimals is done in the same manner as with whole numbers. Again, it is important that you keep the decimal points aligned.

Example:

If you have 325.25 pounds of ballast on board and remove 30.75 pounds, how much ballast remains?

$$\begin{array}{r} 325.25 \\ -\ 30.75 \\ \hline 294.50 \end{array}$$

MULTIPLYING DECIMALS

When multiplying decimals, ignore the decimal points and multiply the resulting whole numbers. Once the product is calculated, count the number of digits to the right of the decimal point in both the multiplier and multiplicand. This number represents the number of places from the left the decimal point is placed in the product.

Example:

26.757	3 decimal places
× .32	2 decimal places
53514	
80271	
856224	Count 5 decimal places
8.56224	to the left of the 4

DIVIDING DECIMALS

When dividing decimals, the operation is carried out in the same manner as division of whole numbers. However, to ensure accurate placement of the decimal point in the quotient, two rules apply:

1. When the divisor is a whole number, the decimal point in the quotient aligns vertically with the decimal in the dividend when doing long division.
2. When the divisor is a decimal fraction, it should first be converted to a whole number by moving the decimal point to the right. However, when the decimal in the divisor is moved, the decimal in the dividend must also move in the same direction and the same number of spaces.

Example:

Divide 37.26 by 2.7

Step 1: Move the decimal in the divisor to the right to convert it to a whole number.

$$27.\overline{)37.26}$$

Step 2: Move the decimal in the dividend the same number of places to the right.

$$27\overline{)372.6}$$

Step 3: Divide.

```
      13.8
  27)372.6
     27
     102
      81
      216
```

CONVERTING DECIMALS TO FRACTIONS

Although decimals are typically easier to work with, there are times when the use of a fraction is more practical. For example, when measuring something, most scales are in fractional increments. For this reason it is important that you know how to convert a decimal number into a fraction. For example, .125 is read as 125 thousandths, which is written as 125/1000. This fraction is then reduced to its lowest terms.

Example:

Convert 0.625 into a common fraction.

Step 1: Rewrite as a fraction.

$$0.625 = \frac{625}{1000}$$

Step 2: Reduce to lowest terms.

$$\frac{625}{1000} \div \frac{25}{25} = \frac{25}{40} \div \frac{5}{5} = \frac{5}{8}$$

ROUNDING DECIMALS

Because decimal numbers can often be carried out an unreasonable number of places, they are usually limited to a workable size. This process of retaining a certain number of digits and discarding the rest is known as **rounding**. In other words, the retained number is an approximation of the computed number.

Rounding is accomplished by viewing the digit immediately to the right of the last retained digit. If this number is 5 or greater, increase the last retained digit to the next highest value. When the number to the right of the last retained digit is less than 5, leave the last retained digit unchanged. For example, when rounding 3.167 to 2 decimal places, the 7 determines what is done to the 6, which is the last retained digit. Since 7 is greater than 5, the rounded number is 3.17.

PERCENTAGE

Percentages are special fractions whose denominator is 100. The decimal fraction 0.33 is the same as $^{33}/_{100}$ and is equivalent to 33 percent or 33%. You can convert common fractions to percentages by first converting them to decimal fractions, and then multiplying by 100. For example, 5/8 expressed as a decimal is 0.625, and is converted to a percentage by moving the decimal right two places, becoming 62.5%.

To find the percentage of a number, multiply the number by the decimal equivalent of the percentage. For example, to find 10% of 200, begin by converting 10% to its decimal equivalent which is .10. Now multiply 200 by .10 to arrive at a value of 20.

If you want to find the percentage one number is of another, you must divide the first number by the second and multiply the quotient by 100. For instance, let's say an engine develops 85 horsepower of a possible 125 horsepower. What percentage of the total power available is developed? To solve this, divide 85 by 125 and multiply the quotient by 100.

Example:

$$85 \div 125 = .68 \times 100 = 68\% \text{ power is developed.}$$

Another way percentages are used is to determine a number when only a portion of the number is known. For example, if 4,180 rpm is 38% of the maximum speed, what is the maximum speed? To determine this, you must divide the known quantity, 4,180 rpm, by the decimal equivalent of the percentage.

Example:

$$4{,}180 \div .38 = 11{,}000 \text{ rpm maximum}$$

A common mistake made on this type of problem is multiplying by the percentage instead of dividing. One way to avoid making this error is to look at the problem and determine what exactly is being asked. In the problem above, if 4,180 rpm is 38% of the maximum, then the maximum rpm must be greater than 4,180. The only way to get an answer that meets this criterion is to divide by .38.

RATIO AND PROPORTION

A ratio provides a means of comparing one number to another. For example, if an engine turns at 4,000 rpm and the propeller turns at 2,400 rpm, the ratio of the two speeds is 4,000 to 2,400, or 5 to 3, when reduced to lowest terms. This relationship can also be expressed as $^5/_3$ or 5:3.

The use of ratios is common in aviation. One ratio you must be familiar with is compression ratio, which is the ratio of cylinder displacement when the piston is at bottom center to the cylinder displacement when the piston is at top center. For example, if the volume of a cylinder with the piston at bottom center is 96 cubic inches and the volume with the piston at top center is 12 cubic inches, the compression ratio is 96:12 or 8:1 when simplified.

Another typical ratio is that of different gear sizes. For example, the gear ratio of a drive gear with 15 teeth to a driven gear with 45 teeth is 15:45 or 1:3 when reduced. This means that for every one tooth on the drive gear there are three teeth on the driven gear. However, when working with gears, the ratio of teeth is opposite the ratio of revolutions. In other words, since the drive gear has one third as many teeth as the driven gear, the drive gear must complete three revolutions to turn the driven gear one revolution. This results in a revolution ratio of 3:1, which is opposite the ratio of teeth.

A proportion is a statement of equality between two or more ratios and represents a convenient way to solve problems involving ratios. For example, if an engine has a reduction gear ratio between the crankshaft and the propeller of 3:2, and the engine is turning 2,700 rpm, what is the speed of the propeller? In this problem, let "x" represent the unknown value, which in this case is the speed of the propeller. Next, set up a proportional statement using the fractional form, $^3/_2 = 2700/x$. To solve this equation, cross multiply to arrive at the equation 3x = 2 × 2,700, or 5,400. To solve for (x), divide 5,400 by 3. The speed of the propeller is 1,800 rpm.

$$\frac{3}{2} = \frac{\textit{Engine Speed}}{\textit{Propeller Speed}}$$

$$\frac{3}{2} = \frac{2700}{x}$$

$$3x = 5{,}400$$

$$x = 1{,}800 \text{ rpm}$$

This same proportion may also be expressed as 3:2 = 2,700 : x. The first and last terms of the proportion are called the **extremes**, and the second and third terms are called the **means**. In any proportion, the product of the extremes is equal to the product of the means. In this example, multiply the extremes to get 3x, and multiply the means to get 2 × 2,700, or 5,400. This results in the identical equation derived earlier; 3x = 5,400.

$$3:2 = \text{engine speed} : \text{propeller speed}$$

$$3:2 = 2{,}700 : x$$

$$3x = 2 : 2{,}700$$

$$3x = 5{,}400$$

$$x = 1{,}800 \text{ rpm}$$

POWERS AND ROOTS

When a number is multiplied by itself, it is said to be raised to a given power. For example, 6 × 6 = 36; therefore, $6^2 = 36$. The number of times a **base number** is multiplied by itself is expressed as an **exponent** and