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UNIT I – WHOLE NUMBERS AND FRACTIONS

It is possible that you will not have to study this Unit. Your answers to the following problems will determine your ability in working with whole numbers and fractions.

Solve the following problems:

1-1 2 1/4 + 5 3/8
1-2 7 1/16 – 3 5/8 + 2 1/4
1-3 1 5/16 x 1 1/7 x 1 2/3
1-4 3 3/8 ÷ 2 1/4
1-5 1 1/2 x 1 3/4 - 1 1/8 x 1 1/2
1-6 3 1/2 + 3 1/2 ÷ 1 1/5 – 4 1/6
1-7 1 1/4 ÷ 1 1/8 x 1 1/2
1-8 3 1/4 ÷ 1 1/5 – 1 1/2 x 1 1/4
1-9 4 3/5 – 1 5/6 x 2 1/4 + 3 3/4

If you have eight or nine answers correct, go on to Unit II.

If you have less than eight answers correct, complete this unit.

A Introduction

The set of numbers consisting of 0, 1, 2, 3, 4, 5, and so on is called the set of whole numbers. The operations of Addition, Subtraction, Multiplication, and Division are applied to these numbers in a manner with which you are familiar; however, there are two ideas that you should review. These are greatest common factor and least common multiple.

Given a whole number larger than 0, you can always find one or more numbers that will divide evenly into it. Numbers that divide evenly into a given number are called the factors of that number.

Example:
The factors of 18 are: 1, 2, 3, 6, 9, and 18.
The factors of 30 are: 1, 2, 3, 5, 6, 10, 15, and 30.

1-10 What are the factors of 16?
1-11 What are the factors of 24?

If you look at the factors of two or more whole numbers you can always find at least one number that is a factor of each number. These factors are known as common factors.

The common factors of 18 and 30 are: 1, 2, 3, and 6.

1-12 What are the common factors of 16 and 24?
1-13 What are the common factors of 12, 18, and 24?

The largest of the common factors of two or more whole numbers is called the Greatest Common Factor (G.C.F.) of the numbers.

The greatest common factor of 18 and 30 is: 6

1-14 Find the G.C.F. of 12, 18, and 24.
1-15 Find the G.C.F. of 8, 12, and 16.

If you multiply a given whole number by the numbers 1, 2, 3, 4, 5…and so on, you obtain the positive multiples.

For example, the first 5 positive multiples of 5 are:

1x5 = 5
2x5 = 10
3x5 = 15
4x5 = 20
5x5 = 25

1-16 List the first ten positive multiples of 4.
1-17 List the first seven positive multiples of 6.

If you look at the list of the positive multiples of two or more whole numbers you can see that they have some multiples in common. These are called the common positive multiples of the numbers.

1-18 Find three common positive multiples of 4 and 6.

The smallest of the common positive multiples between two or more whole numbers is called their Least Common Multiple (L.C.M.).

1-19 Find the L.C.M. of 4 and 6.
1-20 Find the L.C.M. of 6, 9, and 12.
1-21 Find the L.C.M. of 7, 14, and 21.

With these ideas concerning G.C.F. and L.C.M., along with your knowledge of the other operations on whole numbers, you can solve many problems. However, the solutions to all problems are not whole numbers.

Suppose, for example, a road crew can pave one mile of highway in 2 hours and we want to know how much they can pave in 1 hour.

Is the set of whole numbers adequate to answer this question?

The answer is no, for we need to have some way of expressing a part of the whole. We call these expressions fractions.

The expressions 3/4, 7/8, 16/3, and 9/7 are fractions.

The top number is called the numerator, the bottom number is called the denominator, and the line represents division.

In particular, fractions are divided into three categories.

Proper Fractions: Examples of this type of fraction are 1/2, 4/5, 2/3, 1/8, and 31/32. As you can see, in this type of fraction the numerator is always less than the denominator.

Improper Fractions: In this type of fraction the numerator is not less than the denominator.

For example, 3/2, 5/5, 9/4, 32/32, and 51/13 are all improper fractions. As you can see, the numerator is always greater than or equal to the denominator.

Mixed Fractions: A mixed fraction is a combination of a whole number and a fraction.

Examples of these are 2 3/5, 9 4/11, 1 1/8, and 4 6/31. Note that these mixed fractions may also be written as 2-3/5, 9-4/11, 1-1/8, and 4-6/31. A smaller dash is used to denote this is a mixed fraction and not a subtraction operation.

B. Addition of Fractions

In order to add two or more fractions with the same (or common) denominator add the numerators and keep the denominators the same.

For example, 1/5 + 2/5 = (1 + 2)/5 = 3/5.

1-22 Add 3/16, 5/16, and 1/16
1-23 Add 3/5 and 2/5
1-24 Add 3/20, 1/20, and 11/20
1-25 Add 3/24, 9/24, 1/24, and 5/24
1-26 Add 2/9, 4/9, and 7/9
1-27 Change 14/11 to a whole number or a mixed fraction.
1-28 Change 15/6 to a whole number or a mixed fraction.
1-29 Change 75/15 to a whole number or a mixed fraction.
1-30 Add 27/32 and 17/32
1-31 Add 71/100, 59/100, 41/100, and 61/100

You can also add combinations of whole numbers, mixed fractions, and proper fractions. Just add the whole numbers, then add the fractions, and simplify your answer.

1-32 Add 2 31/100 and 3 19/100
1-33 Add 2 4/5 and 3 2/5
1-34 Add 2 3/16, 4, and 4 9/16
1-35 Add 2 9/40, 17/40, and 8
1-36 Add 4 11/15, 7 11/15, 11/15, and 9

If you wish to add two or more fractions that do not have common denominators, you must first change them to a form in which they have a common denominator. The least common denominator is the L.C.M. of the denominators.

Example:

Find the least common multiple of 1/5 and 1/6

First find the multiples of each denominator:

1x5 = 5	1x6 = 6
2x5 = 10	2x6 = 12
3x5 = 15	3x6 = 18
4x5 = 20	4x6 = 24
5x5 = 25	5x6 = 30
6x5 = 30	6x6 = 36
7x5 = 35	7x6 = 42
8x5 = 40	8x6 = 48

The least common multiple is 30.

1-37 Find the least common denominator of 1/2, 1/3, and 1/4
1-38 Find the least common denominator of 1/6, 3/8, and 5/12

To change each fraction to common denominator form, multiply the numerator and denominator by the factor that changes each denominator to the least common denominator.

Consider the following example:
1/6 + 3/8 + 5/12

As you can see, the least common denominator is 24.

Note: 6x4 = 24, 8x3 = 24, and 12x2 = 24

Therefore, (1x4)/(6x4) = 4/24, (3x3)/(8x3) = 9/24, and (5x2)/(12x2) = 10/24

Hence, 1/6 + 3/8 + 5/12 = 4/24 + 9/24 + 10/24 = 23/24

1-39 Add 5/6, 1/9, and 3/4
1-40 Add 3 1/7, 4 5/14, and 17/21
1-41 Add 2, 4 5/7, 9/14, and 6 ½

C. Subtraction of Fractions

Two fractions to be subtracted may or may not have a common denominator. If they do not, find their least common denominator. To subtract two fractions with a common denominator, subtract their numerators and keep the same denominator. Remember to write all answers in simplified form.

1-42 Subtract 4/9 from 5/9
1-43 Subtract 9/42 from 19/42
1-44 Subtract 1/4 from 2/5
1-45 Subtract 1/2 from 4/8

To subtract a proper fraction or a mixed fraction from a whole number, follow these steps:
First Take note of the denominator of the fraction or mixed fraction.
Second Subtract 1 from the whole number and write this 1 as the given denominator over itself (5 – 1-3/8 becomes 4 8/8 – 1 3/8).

Third subtract the whole numbers and then the fractions to find the solution.

(5 – 1 3/8) = (4 8/8 – 1 3/8) = 3 5/8

1-46 Subtract 1 3/8 from 5
1-47 Subtract 2 7/16 from 9
1-48 Subtract 11/12 from 11

To subtract a whole number from a mixed fraction, subtract the whole numbers and keep the fraction. Consider the problem 4 27/32 – 2. Because 4 – 2 = 2, the answer becomes 2 27/32.

1-49 Subtract 21 from 64 4/25

To subtract two mixed fractions, make sure the denominators are the same. If the numerator of the second fraction is less than or equal to the numerator of the first fraction, subtract the whole numbers and then subtract the fractions to obtain the solution.

1-50 Subtract 2 2/3 from 7 7/8
1-51 Subtract 2 1/6 from 9 3/4

If the numerator of the second fraction is greater than the numerator of the first, you must subtract 1 from the first whole number and add it to the first fraction obtaining a whole number and an improper fraction. For instance, 6 3/8 – 2 5/8 becomes 5 11/8 – 2 5/8

(5 11/8 – 2 5/8) = 3 6/8 = 3 3/4

1-52 Subtract 2 5/8 from 6 3/8
1-53 Subtract 2 1/2 from 6 1/3
1-54 Subtract 6 11/16 from 7 3/8

D. Multiplication of Fractions

To multiply any combination of two or more proper and/or improper fractions, multiply the numerators to form the numerator of the solution and multiply the denominators to form the denominator of the solution. Then simplify your answer.

For instance, 7/8 x 1/4 = (7 x 1)/(8 x 4) = 7/32.

1-55 Multiply 16/5, 4/5, and 1/4
1-56 Multiply 5/6, 7/2, and 4/5
1-57 Multiply 1/4, 16/5, 9/11, and 5/3

To multiply when mixed fractions are involved, you must first change the mixed fractions to improper fractions.

To change a mixed fraction to an improper fraction, multiply the whole number by the denominator, add this value to the numerator, and put this result over the original denominator.

Example:

1 3/8 x 2 4/5

Convert each expression to an improper fraction
(8x1+3) = 11/8
(5x2+4) = 14/5

1-58 Change 4 1/3 to an improper fraction
1-59 Change 6 5/8 to an improper fraction

Once you have changed the mixed fractions to improper fractions, multiply as you learned earlier.

Example:

11/8 x 14/5 = 154/40 = 3 34/40 = 3 17/20

1-60 Multiply 1 1/2 and 2 3/4
1-61 Multiply 2 5/8 and 1/2
1-62 Multiply 2 2/5, 4 1/4, and 3 2/3
1-63 Multiply 4 1/4 and 6
1-64 Multiply 1 5/8, 4, 2 1/2, and ¾

E. Division of Fractions

To divide two fractions, invert the second fraction (the divisor) and then multiply (change any mixed fractions or whole numbers to improper fractions).

For example, 1/2÷2/3 = 1/2x3/2 = 3/4.

1-65 Divide 3/5 by 8/7
1-66 Divide 7 by 3/8
1-67 Divide 1 1/2 by 3/4
1-68 Divide 2 5/8 by 4
1-69 Divide 3 7/9 by 3 1/3

F. Mixed Operations

In some situations it is necessary to combine the operations of addition, subtraction, multiplication, and division. If this happens, first perform the multiplications and/or divisions in order from left to right and then perform the additions and/or subtractions in order from left to right.

Consider the problem 1/8 + 1/4 - 3/16.

First, perform the addition. (1/8 + 1/4 = 3/8)
Next, perform the subtraction from the number obtained. (3/8 – 3/16 = 3/16)

Therefore, the solution is 3/16.

1-70 Solve the problem 1/8 ÷ 3/4 x 11
1-71 Solve the problem 27/64 + 3/16 x 2/3
1-72 Solve the problem 3 x 7/32 – 3/8
1-73 Solve the problem 5/64 + 21/32 x 7 – 1/16
1-74 Solve the problem 1-3/64 – 2-1/4 ÷ 9 x 7/8

Supplementary Problems

1-75 3/8 + 1/8 + 3/8
1-76 5/16 + 7/16 + 9/16
1-77 7/12 – 3/12
1-78 3/4 - 5/8
1-79 2 1/2 + 3 3/4 + 1/4
1-80 1/6 + 3/8 +2 9/12
1-81 6 – 5/16
1-82 5 1/4 - 2 7/8
1-83 7 1/2 - 3/8 + 3 1/4 - 4 7/16
1-84 7 1/4 - 1 5/16 + 3 1/8 – 2 1/4
1-85 1/4 x 5/8
1-86 1/6 x 3/8 x 4/7
1-87 1/8 ÷ 3/4
1-88 7/16 ÷ 3/8
1-89 3 1/5 x 7/8
1-90 5 1/4 x 2 2/3 x 1/14
1-91 1 7/8 ÷ 1 1/4
1-92 1 1/11 ÷ 1 3/33
1-93 7/8 x 4/9 ÷ 7/12
1-94 6 1/4 ÷ 1 5/16 x 2 5/8 ÷ 3 3/4
1-95 3 1/2 x 2 1/4 x 1 1/3 – 4 3/16
1-96 7 divided by 1 3/4 + 2 3/8 – 5 3/4
1-97 1 3/8 ÷ 2 1/4 ÷ 7 1/3 x 1 1/7
1-98 3 1/2 x 1 1/3 + 5 7/12 – 1
1-99 15/16 x 1 3/5 + 3 3/4 - 3 1/2 ÷ 1 1/3

UNIT II – DECIMALS

It is possible that you will not have to study this unit. Your answers to the following problems will determine your ability in working with decimals.

Solve the following problems.

2-1 Round 1.141 to the nearest tenth.
2-2 Round 15.650 to the nearest whole number.
2-3 .31 + 3.91 + .4 (write your answer precise to the nearest tenth)
2-4 13.24 – 12.224 (write your answer precise to the nearest hundredth)
2-5 5.94 + 1.919 – 4.29 (write your answer precise to the nearest hundredth)
2-6 5.123 x 41.413 x 32.25 (write your answer precise to the nearest tenth)
2-7 64.4 ÷ 25.21 (write your answer precise to the nearest tenth)
2-8 .626 ÷ .632 (write your answer precise to the nearest hundredth)
2-9 91.4 divided by .235 (write your answer precise to the nearest tenth)

If you have eight or nine answers correct, go on to Unit III.

If you have less than eight answers correct, complete this unit.

A. Introduction

Fractions which have 10, 100, 1000, 10,000 and so on as their denominators can easily be expressed as decimal fractions. For example:

3/10 = .3
27/100 = .27
3/1000 = .003
7 2/10 = 7.2
17/10 = 1-7/10 = 1.7
2 30/100 = 2.3

The dot used in each case above is called a decimal point. As you can see, fractions with 10 in the denominator can be written as decimals with one place to the right of the decimal point; fractions with 100 in the denominator can be written as decimals with two places to the right of the decimal point; fractions with 1000 in the denominator can be written as decimals with three places to the right of the decimal point, and so on. The first place to the right of the decimal point is called the tenths place, the second place is called the hundredths place, the third the thousandth place, and so on.

A fraction ending in a 5 is rounded up. For example, 1.05, rounded to the nearest tenth, would be 1.1.

B. Rounding Decimals

Numbers are commonly rounded up or down after measurement or calculation. For example 53.67 would be rounded to 53.7 and 53.43 would be rounded to 53.4, if rounding were required. The first number would be rounded up because 53.67 is closer to 53.7 than to 53.6. Likewise, the second number was rounded down because 53.43 is closer to 53.4 than to 53.5. The reasons for rounding are covered in the next section on "Significant figures".

If the number being rounded ends with a 5, two possibilities exist. In the more mathematically sound approach, numbers are rounded up or down depending on whether the number to the left of the 5 is odd or even. Thus, 102.25 would be rounded down to 102.2, while 102.35 would be rounded up to 102.4. This procedure avoids the bias that would exist if all numbers ending in 5 were rounded up or all numbers were rounded down. In some calculators, however, all rounding is up. This does result in some bias, or skewing of data, but the significance of the bias may or may not be significant to the calculations at hand.

As noted, the method above is the mathematically sound approach. Then there is the ODOT way, as defined in Section 00190 of the Standard Specifications for construction.

The final significant digit will not be changed when the succeeding digit is less than 5.

The final significant digit will be increased by one when the succeeding digit is 5 or greater.

This document uses the ODOT method of rounding.

C. Significant Figures

All non-zero digits are significant. Example: the number 123.45 has five significant figures: 1, 2, 3, 4, & 5.

Zeros appearing in between two non-zero digits are significant. Example: the number 101.12 has five significant figures: 1, 0, 1, 1, & 2.

All zeros appearing to the right of an understood decimal point or non-zeros appearing to the right of a decimal after the decimal point are significant. Example: the number 12.2300 has six significant figures: 1, 2, 2, 3, 0, & 0. The number 0.00122300 has only six significant figures (the zeros before the '1' are not significant). In addition, the number 12.00 has four significant figures.

All zeros appearing in a number without a decimal point and to the right of the last non-zero digit are not significant unless indicated by a bar. Example: the number 1300 has significant figures: 1 and 3. The zeros are not considered significant because they don't have a bar. However, the number 1300.0 has five significant figures.

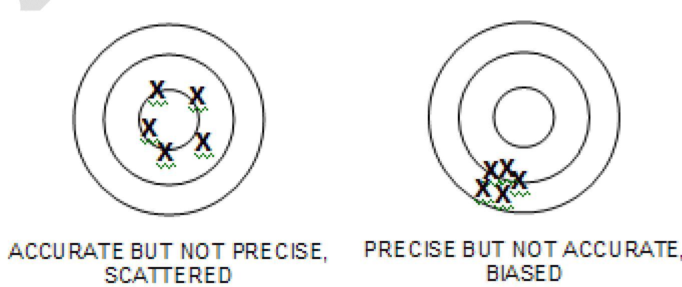
However, this last convention is not universally used; it is often necessary to determine from context whether trailing zeros in a number without a decimal point are intended to be significant.

Digits may be important without being "significant" in this usage. For instance, the zeros in the numbers 1300 or 0.005 are not considered significant digits, but are still important as placeholders that establish the number's magnitude.

D. Accuracy and Precision

Although often used interchangeably, the terms accuracy and precision do not mean the same thing. In an engineering sense, accuracy denotes nearness to the truth or some value accepted as the truth, while precision relates to the degree of refinement or repeatability of a measurement.

Two bull's-eye targets are shown below. The left one indicates hits that are scattered and, yet, are very close to the center. The right one has a tight pattern, but all the shots are biased from the center. The left one is more accurate, while the right one is more precise. A biased, but precise, instrument can often be adjusted physically or mathematically to provide reliable single measurements. A scattered, but accurate, instrument can be used if enough measurements are made to provide a valid average.



E. Addition and Subtraction of Decimals

In addition and subtraction of decimals, write the numbers so that the decimal points are directly under each other. Then, add or subtract as with whole numbers, placing the decimal point in the answer directly under the other decimal points.

For example:

$$\begin{array}{r} 21.3 \\ +\ 6.4 \\ \hline 27.7 \end{array}$$

2-10 Add 13.2 and 1.3
2-11 Subtract 4.21 from 6.87
2-12 Add 27.261, 429.524, and 3.512
2-13 Add 16.02, 0.91, and 0.03.
2-14 Add 13.5 and 2.67 and round to the nearest tenth
2-15 Round 23.24 to the nearest tenth
2-16 Round 0.685 to the nearest hundredth
2-17 Round 7.38546 to the nearest thousandth
2-18 Add 17.1, 2.35, and 186.4 and round to the nearest tenth
2-19 Subtract 9.4709 from 14.238 and round to the nearest thousandth
2-20 Add 7.395, 0.195, 0.6935, and 2.695 and round to the nearest thousandth

F. Multiplication of Decimals

To multiply two decimals, temporarily disregard the decimal points and multiply as you would whole numbers. Find the total number of places to the right of the decimal point in the numbers you are multiplying. Place the decimal point in your answer so that this total is the number of places to the right of the decimal point.

For example: 12.2 x 3.6 = 43.92

As you can see, the total number of places to the right of the decimal point of the two numbers multiplied is two; therefore; two places to the right of the decimal point are shown in the final answer.

2-21 Multiply 5.25 and 42.1
2-22 Multiply 0.13 and 1.78
2-23 Multiply 46 and 121.4
2-24 Multiply 3.14, 4.6, and 4.6

Since the numbers you use in construction work are measured quantities, the precision of your answers must be consistent. Therefore, you must round all answers to the precision required by your job situation.

For example, your job situation illustrated in the first example of this section could require precision to the nearest tenth.

2-25 Round 43.92 to the nearest tenth.

Referring back to question 2-21, if 42.1 represents the length of a section of corrugated pipe in feet, and if 5.25 represents the cost per linear foot of the pipe, then 221.025 represents the total cost of the pipe.

2-26 Round 221.025 to the nearest cent (hundredth).

If in question 2-24, 4.6 represents the radius of a test pile, then 66.4424 represents the circular cross-sectional area of the pile, which must be rounded to the nearest tenth.

2-27 Round 66.4424 to the nearest tenth.

G. Division of Decimals

To divide a decimal by a whole number, divide as you would with whole numbers and place the decimal point in your quotient directly above the decimal point in your dividend.

For example, let's divide 3.6 by 6.

```
   .6
6)3.6
  3.6
```

In the above example, the term .6 is the quotient, the term 3.6 is the dividend, and the term 6 is the divisor.

2-28 Divide 2.45 by 5
2-29 Divide 0.36 by 6
2-30 Divide 7.26 by 6

To divide a decimal by a decimal, move the decimal point in the divisor to the right of all the digits in the divisor to form a whole number. Move the decimal point in the dividend the same number of places to the right. Then divide as instructed in the above example.

6.60 divided by 1.2 =

```
     5.5
12√66.0
   60.
    60
    60
     0
```

2-31 Divide 13.34 by 2.3
2-32 Divide 88.346 by 5.42

2-33 Divide 35.187 by 3.7
2-34 Divide 8.988 by 0.6 (Round to the nearest tenth)
2-35 Divide 0.009 by 4.5
2-36 Divide 65.325 by 7.5
2-37 Divide 0.25 by 0.125
2-38 Divide 0.6 by 0.375
2-39 To find the volume of a test hole in which there are 285.3 pounds of dry sand whose density is 96.8 pounds per cubic foot you must divide 285.3 by 96.8. Round your answer to the nearest tenth.

2-40 To find the in-place wet density of soil from a test hole whose weight is 291.8 pounds, and where the volume of the hole is 3.1 cubic feet, you must divide 291.8 by 3.1. Round your answer to the nearest thousandth.

Supplementary Problems

2-41 Round 7.62 to the nearest tenth.
2-42 Round 7.161 to the nearest tenth.
2-43 Round 0.261 to the nearest hundredth.
2-44 Round 1.71 to the nearest whole number.
2-45 Round 235.185 to the nearest hundredth.
2-46 Round 64.485 to the nearest whole number.
2-47 617.626 + 53.162
2-48 13.5 + 6.12 (Round to the nearest tenth)
2-49 124.7 – 86.1
2-50 2.47 − 0.865
2-51 **0**.41 − 0.31 (Round to the nearest hundredth)
2-52 1.25 − .535 + 3.16 (Round to the nearest hundredth)
2-53 5.611 + 16.9 + 16.3 – 22.5 (Round to the nearest tenth)
2-54 25.50 – 1.00 + 1.00 – 16.24 + 32.00
2-55 1.2 x 4.8 (answer precise to the nearest whole number)
2-56 824.36 x 108.12 (answer precise to the nearest hundredth)
2-57 6.8 x 66.12 x 18.24 (answer precise to the nearest tenth)
2-58 3.0 x 3.0 x 6.4 x 2.48 (answer precise to the nearest tenth)
2-59 2.34 ÷ 2.4 (answer precise to the nearest tenth)
2-60 12.6 ÷ 1.21 (answer precise to the nearest tenth)
2-61 14.8 ÷ 21 (answer precise to the nearest whole number)
2-62 3.201 ÷ 1.201 (answer precise to the nearest hundredth)
2-63 24.9 ÷ 241.2 (answer precise to the nearest tenth)
2-64 2.9 ÷ .97 (answer precise to the nearest tenth)

UNIT III – MIXED OPERATIONS: FRACTIONS AND DECIMALS

It is possible that you may not have to study this unit.

Your answers to the following problems will determine your ability in doing mixed decimal and fraction operations.

3-1 Convert 3/5 to a decimal precise to the nearest tenth.
3-2 Convert 35/8 to a decimal precise to the nearest hundredth.
3-3 Convert 6/13 to a decimal precise to the nearest thousandth.
3-4 5.29 + 5/6 − .13 (answer precise to the nearest hundredth)
3-5 9-7/8 x .46 + 2/3 (answer precise to the nearest hundredth)
3-6 3.2 − .9 ÷ 2/5 (answer precise to the nearest tenth)
3-7 9/5 x .25 + 2.1 ÷ 8.5 (answer precise to the nearest tenth)
3-8 ((.78 + 8.94 + .08) / 3) ÷ 1.29 (answer precise to the nearest tenth)
3-9 ((7.75 + .50)(1.42 − .50)) / .9 (answer precise to the nearest hundredth)

If you have eight or nine answers correct, go on to Unit IV.

If you have less than eight answers correct, complete this unit.

A. Conversion of Fractions to Decimals

To convert a fraction to a decimal, divide the numerator by the denominator and round your answer to the precision required by the job situation.
For example,
Convert 1/8 to a decimal (This job requires precision to the thousandth)

$$1/8 = 8\overline{)1.000} = 0.125$$

$$\begin{array}{r} 0.125 \\ 8\overline{)1.000} \\ -\underline{8} \\ 20 \\ -\underline{16} \\ 40 \\ -\underline{40} \\ 0 \end{array}$$

3-10 Convert 3/5 to a decimal. (This job requires precision to the nearest tenth.)
3-11 Convert 4-8/25 to a decimal. (This job requires precision to the nearest hundredth.)
3-12 Convert 7/9 to a decimal. (This job requires precision to the nearest thousandth.)
3-13 Convert 15/8 to a decimal. (This job requires precision to the nearest hundredth.)
3-14 Convert 9/11 to a decimal. (This job requires precision to the nearest hundredth.)

B. Problems Involving Fractions and Decimals

Generally, the easiest method of performing operations involving fractions and decimals is to convert all fractions to decimals and then perform the indicated operations.

3-15 3/8 + 25.8 (one decimal place precision required)
3-16 3/4 - .7 (one decimal place precision required)
3-17 2.54 x 3/7 (one decimal place precision required)
3-18 46.50 ÷ 4-2/3 (two decimal place precision required)
3-19 .42 + 525.80 – 5/8 (two decimal place precision required)
3-20 733.94 – 1-4/9 x 2.38 (one decimal place precision required)
3-21 11-4/5 + 6.6 ÷ 1.3 (one decimal place precision required)
3-22 3-1/2 x .75 ÷ 2/3 (two decimal place precision required)
3-23 1/2 + 2.6 – 3.0 x 1/8 ÷ .2 (one decimal place precision required)

C. Grouping Using Parentheses

When parentheses are used in a problem involving two or more operations, they indicate the order in which the operations are to be performed. The operation(s) within the parentheses must be performed first; then, perform the remaining operations according to the order of operations you have already learned.
For example,

$$(3.4 \times (4.0 + 6.1))/2$$
$$= (3.4 \times 10.1)/2$$
$$= 34.34 / 2$$
$$= 17.17$$

3-24 3.14/4(3.6 + 3.0)(3.6 – 3.0) (one decimal place precision required)

3-25 A certain trench has a cross-section whose area in square feet is found by the expression: (1.7(2.1 +4.8))/2. Calculate the area to the nearest tenth of a square foot.

3-26 To find the in-place dry density in pounds per cubic foot of a soil sample whose in-place wet density is 52.7 pounds per cubic foot, and whose moisture content is 6.4%, you must evaluate to the nearest tenth the following mathematical expression: (52.7/(100 + 6.4))(100).

3-27 To find the average altitude of the side of a certain cut to the nearest hundredth of a foot for seeding and mulching purposes, you must evaluate the expression: (23.40 + 27.44 + 28.96 + 21.77)/4.

3-28 Find the average altitude of the side of a certain cut to the nearest hundredth of a foot if the measured altitudes are 13.47 feet, 12.84 feet, and 13.85 feet.

3-29 To construct a certain sub grade drain, a trench was dug with cross-sectional areas of 8.54 square feet, 9.63 square feet, 8.52 square feet, 7.89 square feet, and 8.30 square feet. Find the average cross-sectional area to the nearest hundredth of a square foot.

Supplementary Problems

3-30 Convert 1/3 to a decimal precise to the nearest hundredth.
3-31 Convert 3/8 to a decimal precise to the nearest thousandth.
3-32 Convert 5-1/8 to a decimal precise to the nearest hundredth.
3-33 Convert 29/8 to a decimal precise to the nearest thousandth.
3-34 Convert 9-5/7 to a decimal precise to the nearest tenth.
3-35 Convert 10/23 to a decimal precise to the nearest hundredth.
3-36 7/12 + 12.5 − .70 (answer precise to the nearest tenth)
3-37 8.493 x 8/11 + 4/7 (answer precise to the nearest thousandth)
3-38 .007 + 8.951 ÷ 6/13 (answer precise to the nearest tenth)
3-39 3.1 x 8.9 x 5/11 x .01 (answer precise to the nearest tenth)
3-40 7.4 ÷ 11/15 ÷ 1/2 (answer precise to the nearest tenth)
3-41 5/23 − .004 + 7.82 x 7/11 (answer precise to the nearest tenth)
3-42 9.52 + 5.23 ÷ 1/2 – 3/10 x .421 (answer precise to the nearest hundredth)
3-43 7/18 x 2.69 + 26.9 x 3.45 ÷ .47 – 23/5 + .259 (answer precise to the nearest tenth)
3-44 (4.2 + 8.4)4.1 (answer precise to the nearest tenth)
3-45 (3.14/7)(3.431 – 2.89) (answer precise to the nearest hundredth)
3-46 [(7.4/(3.8 + 100)](47.1 – 2.3) (answer precise to the nearest tenth)
3-47 [(4.1 – 2.3)(4.1 + 2.3)]/4 (answer precise to the nearest tenth)
3-48 [(3.14 x 6.0 x 6.0)/3][(8.4 + 5.5)/2] (answer precise to the nearest tenth)
3-49 4(.007 + 9.631) − .7(9.211 + 8.002) (answer precise to the nearest tenth)

UNIT IV – FORMULA EVALUATION

In each of the previous units you were given the option of bypassing the unit. However, in this unit the material is such that the format involved in the solution of the problems may be new to you. Therefore, you must study this unit to ensure consistency in methods of solution.

A. Introduction

A formula is a method or rule for finding a certain quantity when other quantities are known. For example, to find the area (A) of a rectangle you use the formula A = L x W, where you know the length (L) and the width (W).
For example,

Evaluate the formula: Area = Length x Width, where Length = 15 and Width = 11

A = L x W
A = 15 x 11
A = 165

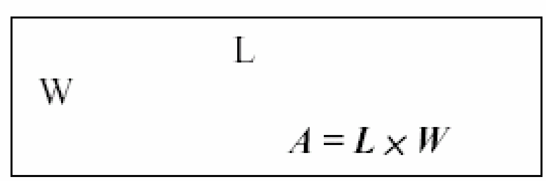
4-1 Evaluate the formula: B = P + I, where P = 100 and I = 30.
4-2 Evaluate the formula: T = D/R, where D = 560 and R = 392 (precision to the nearest tenth).
4-3 Evaluate the formula: $A = ((b_1 + b_2)/2)h$, where $b_1 = 29.3$, $b_2 = 10.7$, and h = 5.6 (precision to the nearest tenth).

To make sure that your calculations may be easily checked by others, follow the standard procedure in evaluating formulas illustrated by the previous three problems.

1. Write the formula
2. Write the step showing the given values being substituted into the formula
3. Perform the indicated operations
4. Round your answer to the required precision

B. Geometric Shapes and Formulas

The area of a rectangle of length (L) and width (W) is given by the formula A = L·W.



4-4 Find the area of a rectangle in square feet given the length is 5.4 feet and the width is 3.8 feet (precision to the nearest tenth).

4-5 Find the area of a rectangle in square feet, whose length is 66.70 feet and whose width is 1.25 feet (precision to the nearest tenth).

4-6 Find the area of a rectangle in square feet, whose length is 7.8 feet and whose width is 7.8 feet (precision to the nearest tenth). This is a special type of rectangle known as a square. A square is a rectangle whose width and length are equal.

4-7 Find the area of a rectangle in square feet whose length is 169.84 feet and whose width is 12.00 feet (precision to the nearest hundredth).

Suppose the rectangle in the previous problem represents a portion of one lane of a paved highway and the job situation requires the area to be expressed to the nearest tenth of a square yard. To find the number of square yards in this section of roadway you must first find the number of square feet as in problem **4-7**; divide this result by 9, and round your answer to the required precision.

4-8 Change 2038.08 square feet to the nearest tenth of a square yard.

4-9 Find the area of a rectangular section of embankment for seeding and mulching purposes if the length is 56.4 feet and the width is 38.9 feet. Express the answer to the nearest square yard.

4-10 Find the surface area of a rectangular section of a concrete sidewalk with length 13.4 feet and width of 3.5 feet. Express your answer to the nearest hundredth of a foot.

One of the most convenient methods for measuring distances in the field involves the use of Stations. The starting point for Station measurements is Station 0+00. Station 5+75, for example, is located 575 feet from the starting point and Station 9+32.78 is located 932.78 feet from the starting point.

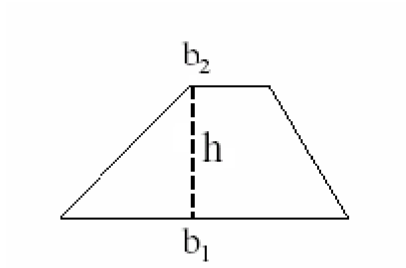
4-11 Find the distance between Stations 5+75 and 9+32.

4-12 Find the distance between Stations 16+33.24 and 38+44.31.

4-13 How many square yards of sod are needed to cover a 15-foot wide median strip between Station 80+29 and Station 84+36? Express your answer to the nearest tenth of a square yard.

4-14 Find the total surface area to be covered by asphalt on as two-lane highway that is 24.00 feet wide between Station 5+35.00 and Station 46+12.35. Express your answer to the nearest hundredth of a square yard.

The trapezoid is another figure for which you must be able to compute the area. An example of trapezoids is as follows:



As you can see, sides b_1 and b_2 (known as the bases of the trapezoid) are parallel and h is the altitude (height). The altitude must be perpendicular (measured at right angles) to the bases. The formula for the area of a trapezoid is: $A = ((b_1 + b_2)/2)\ h$
For example,

Find the area of a trapezoid whose bases are 13 feet and 15 feet and whose height is 10.

Area = $((Base_1 + Base_2)/2)$ Height
Area = (13 feet + 15 feet)/2) 10 feet
Area = (28 feet/2) 10 feet
Area = 14 feet x 10 feet
Area = 140 $feet^2$

4-15 Find the area of a trapezoid to the nearest square foot whose bases are 27.3 feet and 12.7 feet and whose altitude is 5 feet.

4-16 Find the area of a trapezoid to the nearest tenth of a square foot whose bases are 7.0 feet and 13.7 feet and whose altitude is 4.2 feet.

4-17 The cross-section of a concrete bridge support is shaped like a trapezoid. The altitude of this support is 8.31 feet and its bases are 39.27 feet and 31.89 feet. Find the cross-sectional area of the support to the nearest hundredth of a square foot.

4-18 The depth of a trapezoidal concrete drainage ditch is 3.2 feet. The distance across the top of the ditch is 5.8 feet and the width of the bottom of the ditch is 4.0 feet. Find the cross-sectional area of the ditch to the nearest hundredth of a square foot.

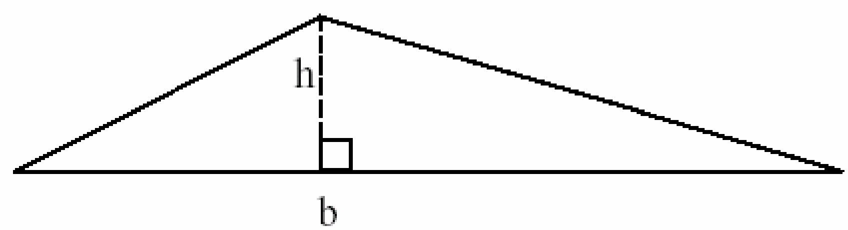
To find the area of shapes that have sloping sides you can divide the entire area into trapezoids of differing sizes – making sure that the entire interior of the shape is comprised of trapezoids. The next step is to find the area of each individual trapezoid and then add these areas together to find the total area of the slope-sided area.

4-19 Determine the area of a shape with sloping sides given the following information:
Shape 1 – b1 = 81.40 feet, b2 = 82.70 feet, and h = 50 feet.
Shape 2 – b1 = 82.70 feet, b2 = 83.94 feet, and h = 50 feet.
Shape 3 – b1 = 83.94 feet, b2 = 85.41 feet, and h = 50 feet.
Shape 4 – b1 = 85.41 feet, b2 = 84.28 feet, and h = 50 feet.
Shape 5 – b1 = 84.28 feet, b2 = 82.04 feet, and h = 50 feet.
Shape 6 – b1 = 82.04 feet, b2 = 81.98 feet, and h = 50 feet.

Shape 7 – b1 = 81.98 feet, b2 = 81.77 feet, and h = 50 feet.
Shape 8 – b1 = 81.77 feet, b2 = 81.60 feet, and h = 50 feet.
Show your answer to the nearest hundredth of a square foot.

4-20 Determine the area of a shape with sloping sides given the following information:
Shape 1 – b1 = 40.21 feet, b2 = 52.80 feet, and h = 50 feet.
Shape 2 – b1 = 52.80 feet, b2 = 52.80 feet, and h = 50 feet.
Shape 3 – b1 = 52.80 feet, b2 = 47.87 feet, and h = 50 feet.
Shape 4 – b1 = 47.87 feet, b2 = 53.00 feet, and h = 50 feet.
Show your answer to the nearest hundredth of a square foot.

The triangle is the third type of figure for which you must be able to compute the area. A triangle is a three-sided figure as illustrated below:



The formula for finding the area of a triangle is: A = 1/2b·h or A = (b·h)/2, where b is the base and h is the altitude.

By looking at the above picture you can see that any of the three sides may be chosen as the base and the altitude is drawn at right angles to the base you choose.
For example,

Find the area of a triangle whose base is 9 feet and whose height is 6 feet.

Area = (Base x Height)/2
Area = (9 feet x 6 feet)/2
Area = 54 $feet^2/2$
Area = 27 $feet^2$

4-21 Find the area of a triangle to the nearest tenth of a square foot whose base is 3.8 feet and whose altitude is 9.3 feet.

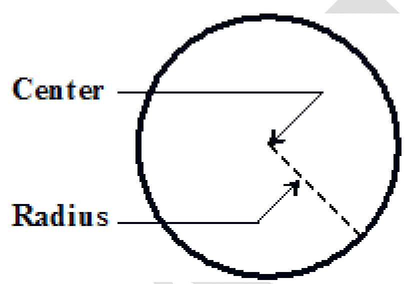
4-22 Find the area of a triangle whose base is 124.0 feet and whose altitude is 93.5 feet. Express your answer to the nearest tenth of a square yard.

4-23 A triangular section of ground at a highway interchange is to be seeded. If the base of the triangle is 61.7 feet and its altitude is 56.8 feet, find the area to be seeded to the nearest square yard.

4-24 A concrete retaining wall has a triangular cross-section with a base of 2.98 feet and an altitude of 4.0 feet. Find the cross-sectional area of the retaining wall to the nearest hundredth of a square foot.

4-25 Backfill is to be placed behind a bridge abutment. A cross-section of the fill is in the shape of a triangle whose base is 14.5 feet and whose altitude is 27.8 feet. Find the cross-sectional area to the nearest tenth of a square foot.

A fourth geometric figure with which you must be familiar is the circle.
The radius (r) of a circle is the distance from the center of the circle to a point on the circle. The diameter (D) is twice the radius.
$D = 2r$ or $r = D/2$
You will be concerned with the formulas for the area and circumference of a circle.



The area (A) is found by: $A = \pi \cdot r^2 = \pi(D/2)^2$, where π has the approximate value 3.14 and r^2 means r x r.
The circumference "C" (the distance around the outside of the circle) is found by: $C = 2\pi \cdot r$.
For example,

Find the area of a circle with a diameter of 8 feet.

$$\text{Area} = \pi \times (\text{Diameter}/2)^2$$
$$\text{Area} = 3.14(8\text{ feet}/2)^2$$
$$\text{Area} = 3.14\ (4\text{ feet})^2$$
$$\text{Area} = 3.14 \times 16\text{ feet}^2$$
$$\text{Area} = 50.24\text{ feet}^2$$

4-26 Find the area of a circle to the nearest tenth of a square foot if the radius is 7.2 feet.

4-27 Find the circumference of a circle to the nearest tenth of a foot if the radius is 8.7 feet.

4-28 Find the circumference and area of a circle if the radius is 14.7 feet. Express your answers to the nearest tenth.

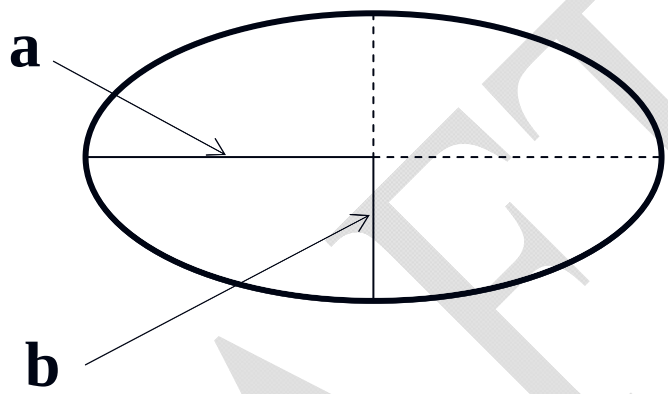
4-29 Find the cross-sectional area of a piece of corrugated pipe whose diameter is 2.25 feet. Express your answer to the nearest tenth.

4-30 You must put a guardrail around a circular island in a roadway. If the radius of the island is 25.0 feet, find the amount of guardrail needed to the nearest tenth of a foot.

4-31 A certain circular area has been stripped during construction. How many square yards of topsoil are needed to provide a growing medium and re-establish the turf if the diameter of the circle is 12.0 feet?
Express your answer to the nearest square yard.

4-32 Find the cross-sectional area of a circular pile to the nearest tenth of a square foot whose radius is .71 feet.

The ellipse is the fifth figure for which you must be able to compute the area.



The formula for the area of an ellipse is $A = \pi \cdot a \cdot b$, where a is one-half of the length of the ellipse and b is one-half the width of the ellipse.
For example,

Find the area of an ellipse whose length is 10 feet and whose width is 6 feet.

Area = $\pi \cdot a \cdot b$
Area = π x (Length/2) x (Width/2)
Area = 3.14 x (10 feet/2) x (6 feet/2)
Area = 3.14 x 5 feet x 3 feet
Area = 15.7 feet x 3 feet
Area = 47.1 $feet^2$

4-33 Find the area of an ellipse to the nearest tenth of a square foot if the length is 14.0 feet and the width is 6.4 feet.

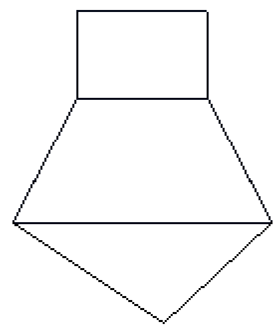
4-34 Find the area of an ellipse to the nearest tenth of a square foot if the length is 54.2 feet and the width is 23.0 feet.

4-35 A circular pipe makes an elliptical opening in a certain skewed wall. Find the area of the ellipse to the nearest tenth of a square foot if its length is 5.08 feet and its width is 5.00 feet.

4-36 Find the cross-sectional area of an elliptical storm-drain pipe whose cross-sectional dimensions are 5.82 feet by 4.12 feet. Express your answer to the nearest tenth of a square foot.

The area of any irregular shape that you will find in the field may be computed by combinations of the 5 basic geometric figures that you have just studied.

For example, suppose you wish to calculate the area of the following figure to the nearest square foot, given the following information:



The length of the rectangle is 6.0 feet and its width is 4.7 feet.
The length of the other side of the trapezoid is 11.1 feet and its altitude is 5.9 feet.
The altitude of the triangle is 6.2 feet.

4-37 Compute the areas for the rectangle, trapezoid, and triangle. Express your answer to the nearest tenth.

4-38 Determine the total area for the above figure. Express your answer to the nearest tenth.

4-39 Again using the figure above, calculate its total area to the nearest square yard, given the following information:
The length of the rectangle is 13.0 feet and its width is 4.2 feet.
The length of the other side of the trapezoid is 17.1 feet and its altitude is 5.0 feet.
The altitude of the triangle is 8.2 feet.

A slope between Station 57+25 and Station 59+75 is to be seeded. The distance from the shoulder of the road to the top of the slope is measured at 50-foot intervals between these two Stations as follows:

Station Number	Distance to top Of Slope
57+25	0.0 feet
57+75	28.7 feet
58+25	37.4 feet
58+75	26.9 feet
59+25	10.1 feet

4-40 Compute the area of the slope to the nearest square yard.
*** HINT – Draw a diagram and divide into a triangle and trapezoids.***

In many cases you will need to compute the volume of many three dimensional solids. The solids with which you will be working have two bases and a height or length between these bases. These bases can be squares, rectangles, circles, ellipses, or triangles. Where the bases are parallel and have the same size, and the edges are perpendicular to the bases, you find the volume (V) by multiplying the area (B) of either base by the height or length (H).

$V = B \cdot H$, or volume = base x height

Since the area (B) of a base that is in the shape of a rectangle can be found by the equation $B = L \times W$, then the original volume formula, $V = B \cdot H$, can also be written in the form $V = L \times W \times H$.

4-41 Find the volume to the nearest tenth of a cubic foot of a large square concrete pad whose base is 14.8 square feet and whose length is 3.6 feet.

4-42 Find the volume to the nearest hundredth of a cubic foot of a corrugated metal pipe whose opening (base) is 124.6 square feet and whose length is 7.8 feet.

In general, to change cubic feet to cubic yards you must divide the number of cubic feet by 27. If in the previous problem you had been asked to express your answer in cubic yards, you would have divided the answer in cubic feet by 27.

4-43 Change the answer from problem **4-42** to the nearest tenth of a cubic yard.

4-44 A piece of sheet metal fabricated in the shape of a prism is given to be 18.2 square feet at its base with a length of 32.5 feet. Find the volume of the prism to the nearest tenth of a cubic yard.

Since the area (B) of the base of a circular cylinder is $B = \pi \cdot r^2$, then the original volume formula $V = B \cdot H$, can also be written as $V = \pi \cdot r^2 \cdot h$.

4-45 Find the volume of a circular column of a bridge pier if the radius of the base is 1.3 feet and the height of the column is 12.8 feet. Express your answer to the nearest tenth of a cubic yard.

4-46 Find the number of cubic yards of Portland cement concrete needed to construct a trapezoidal bridge support whose two sides measure 7.3 feet and 6.7 feet, has an altitude of 4.3 feet, and a length of 55.6 feet. Find your answer to the nearest tenth of a cubic yard.

4-47 What is the volume of an elliptical pipe that has a base width of 2.4 feet, a base height of 1.6 feet, and a length of 25 feet? Find the volume to the nearest cubic yard.

4-48 A cylindrical column rests on a rectangular concrete pad. The column has a base diameter of 3.1 feet and a length of 15.0 feet. The sides of the rectangular concrete pad are 11.0 feet and 5.6 feet in length, and the depth of the pad is 2.0 feet. Find the total volume of the column and pad assembly to the nearest tenth of a cubic foot.

4-49 A trench 47.0 feet long is to be excavated. The area of one trapezoidal end is 48.7 square feet. The area of the other trapezoidal end is 36.4 square feet. Since the two bases of this trench are not the same size, you must first find the average of the end areas and then multiply that average area by the length of the trench to find the volume. Find the volume of dirt to be removed to the nearest cubic yard.

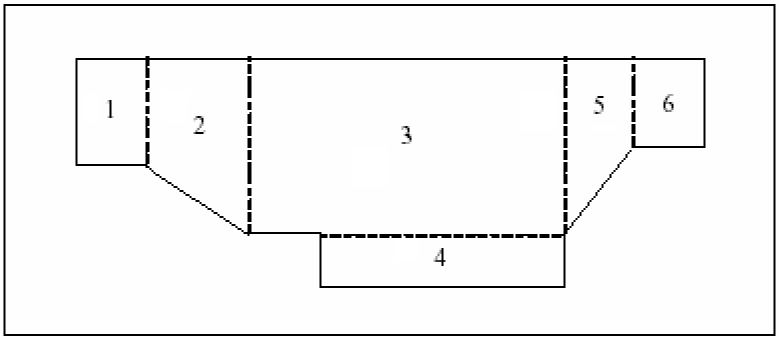
4-50 A triangular cut is to be made for a drain. If the areas of the triangular ends are 9.8 square feet and 12.3 square feet, and the length is 14.3 feet, find the volume of dirt to be removed, to the nearest cubic yard, using the average end area method.

The method of average end areas on rough or uneven terrain does not give you the precise amount of dirt removed, but it does tell the contractor the number of cubic yards of excavation he will be paid for. The accuracy is sufficient for our purposes and the method is commonly used in the construction industry for earthwork computations. Sometimes it is necessary to use more than two end areas to calculate the volume of an irregular solid.

4-51 Find the volume of a trapezoidal base trench to the nearest cubic yard using the following information:

STATION	B1	B2	H
17+00	11.8 feet	8.2 feet	6.0 feet
17+50	10.2 feet	5.6 feet	5.7 feet
18+00	10.9 feet	5.5 feet	5.9 feet

In constructing a bridge pier it is necessary, due to sub-soil conditions, to excavate beyond the specifications of the original plan. The end areas of this additional excavation channel have the following shape:



Each of the end areas of the area of excavation has different dimensions and is shown in the following table:

LEFT END

SHAPE	LENGTH	WIDTH	SIDE 1	SIDE 2	ALTITUDE
1	1.20 FEET	3.20 FEET			
2			3.20 FEET	4.16 FEET	2.69 FEET
3	14.61 FEET	4.16 FEET			
4	12.40 FEET	.89 FEET			
5			4.16 FEET	2.72 FEET	3.00 FEET
6	1.50 FEET	2.72 FEET			

RIGHT END

SHAPE	LENGTH	WIDTH	SIDE 1	SIDE 2	ALTITUDE
1	1.20 FEET	3.00 FEET			
2			3.00 FEET	4.12 FEET	2.69 FEET
3	14.61 FEET	4.12 FEET			
4	12.40 FEET	.81 FEET			
5			4.12 FEET	2.65 FEET	3.00 FEET
6	1.50 FEET	2.65 FEET			

4-52 Using the information from the chart above, calculate to the nearest hundredth of a cubic yard the amount of additional soil that must be excavated given that the length of the channel is 84 feet.

UNIT V – TECHNIQUES OF ALGEBRA

It is possible that you will not have to study this unit. Your solutions to the following problems will determine your ability in certain algebraic skills.

Solve the following equations:

5-1 $y + 6 = 14$
5-2 $4r + 7 = 31$
5-3 $w/5 = 4$
5-4 $9r – 5 = 67$
5-5 $w/.6 + 2.4 = 3.9$
5-6 $.5n = 6$
5-7 $3.5y + 7.03 = 21.38$
5-8 $r/2.06 + 1.3 = 8.2$

If you have seven or eight solutions correct, go on to Unit VI.

If you have less than seven solutions correct, complete this unit.

A. Introduction

There will be many situations in which you will be required to answer questions similar to the following:

1a) What number added to 8 gives you 34?
2a) What number multiplied by 12 gives you 30?
3a) What number subtracted from 500 leaves 385?

Each of these statements can be written as an equation. They could be stated as follows, where “N” represents the unknown value:

1b) $N + 8 = 34$
2b) $12N = 30$
3b) $500 – N = 385$

The techniques of algebra that you will learn in this section will enable you to find the solutions to these types of equations.

B. Solution of Equations

$3 + 2 = 5$ is an equation. If you subtract 2 from both sides of the equation, you get a new statement that says $3+2–2 = 5 – 2$. It can easily be seen that the left-hand side and the right-hand side are still equal. This means that we still have an equation. Similarly, if we subtracted 4 from both sides of the equation $n + 4 = 7$, we would get a new equation that states $n + 4 – 4 = 7 – 4$, which can be written as $n = 3$.

In general, you can subtract the same value from both sides of an equation and form a new statement that is still an equation (both sides are still equal).

5-9 Subtract 1 from both sides of the equation $n + 1 = 8$.
5-10 Subtract 13 from both sides of the equation $n + 13 = 25$.
5-11 Subtract 1.5 from both sides of the equation $n + 1.5 = 8.4$.
5-12 Subtract .54 from both sides of the equation $n + .54 = 6.38$.

Similarly, you may add the same number to both sides of an equation, multiply both sides of an equation by the same number (other than zero), or divide both sides of an equation by the same number (other than zero). In all cases, your result is a new statement that is still an equation.

5-13 Add 3 to both sides of the equation $n – 3 = 8$.
5-14 Multiply both sides of the equation $n/4 = 3$ by 4.
5-15 Divide both sides of the equation $5n = 20$ by 5.

Solving an equation means using the above rules to get the unknown value by itself on one side of the equation.

5-16 Solve the equation n + 13 = 25 by subtracting 13 from both sides.

The value "12" from problem **5-16** is called the solution of the equation. If you substitute the solution value of the unknown into the original equation, then a true statement will result. You should use this fact to check your solution.

5-17 If you substitute n = 12 into the equation n + 13 = 25, do you get a true statement?
5-18 Solve the equation n – 7 = 11 by adding 7 to both sides.
5-19 Does the solution to problem **5-18** make the equation n – 7 = 11 a true statement?
5-20 Solve the equation n/8 = 4 by multiplying both sides by 8.
5-21 Solve the equation 3n = 21 by dividing both sides by 3.
5-22 Solve the equation n – 14 = 37 by addition.
5-23 Solve the equation y – 14 = 37 by addition.

As you can see, it does not matter what letter is used to indicate the unknown value. The method of solution is the same.

5-24 Solve the equation 14y = 42 by division.
5-25 Solve the equation n/12 = 9 by multiplication.
5-26 In question **5-25** what does the answer represent?
5-27 Solve the equation y + 4.3 = 8.5 by subtraction.
5-28 Solve the equation y + 18 = 74.
5-29 Solve the equation n/11 = 1.
5-30 Solve the equation r – 2.4 = 10.0.
5-31 Solve the equation 4y = 28.
5-32 Solve the equation w + 1.4 = 20.
5-33 Solve the equation 2n = 1000.

In many equations it is necessary to perform two operations in order to obtain the solution. For example, if you want to solve the equation 2n + 3 = 7, you must first subtract 3 from both sides, leaving you with the equation 2n= 4. Then you must divide both sides of this new equation by 2, resulting in n = 2.

5-34 What does the value n = 2 represent?
5-35 Subtract 5 from both sides of the equation 3n + 5 = 14.
5-36 Divide both sides of the resulting equation from problem **5-35** by 3 to obtain the solution of the original equation 3n + 5 = 14.
5-37 Does the value obtained in problem **5-36** make the original equation 3n + 5 = 14 a true statement?
5-38 Add 7 to both sides of the equation 4n – 7 = 29.
5-39 Now, divide both sides of the new equation from problem **5-38** by 4.
5-40 Subtract 1.4 from both sides of the equation n/2 + 1.4 = 6.8.
5-41 Now, multiply both sides of the new equation from problem **5-40** by 2.
5-42 Solve the equation 8n – 18 = 22 by first adding 18 to both sides of the equation and then dividing both sides of the new equation by 8.

5-43 Solve the equation n/14 + 3 = 9 by first subtracting 3 from both sides of the equation and then multiplying both sides of the new equation by 14.
5-44 Solve the equation y/9 – 6 = 11 by first adding 6 to both sides of the equation and then multiplying both sides of the new equation by 9.

In problems 5-34 through 5-44, where you had to perform two operations, first you added or subtracted the same value from both sides of the equation and then multiplied or divided both sides of your new equation by a common value.

In general, when two or more operations are needed to solve an equation, first perform the additions or subtractions and then perform the multiplications or divisions.

5-45 Solve the equation 4n + 9 = 25
5-46 Solve the equation 6 n – 5 = 25
5-47 Solve the equation r/3 – 4 =8
5-48 Solve the equation y/6 - .3 = 1.4
5-49 Solve the equation 8w + .9 = 7.3
5-50 Solve the equation 1.2n – 2.3 = 6.1
5-51 Solve the equation r/.6 – 3 = 2.8
5-52 Solve the equation 7w + 1.8 = 10.9
5-53 Solve the equation 4.06n – 1.431 = 3.441

Supplementary Problems

Solve the following equations:

5-54 y + 8 = 12
5-55 3y = 15
5-56 w/5 = 8
5-57 m – 6 = 8
5-58 4y = 24
5-59 n + .25 = 3.68
5-60 r/.6 = 7
5-61 3n + 4 = 16
5-62 n/6 – 4 = 2
5-63 w/3 - .5 = 1.2
5-64 5w + .7 = 3.2
5-65 1.8r + 1.87 = 6.01
5-66 w/2.4 – 3 = 1
5-67 5.17n – 3.012 = 2.675
5-68 80.7r + 3.682 = 86.803

UNIT VI – RATIO AND PROPORTION

It is possible that you will not have to study this unit. Your solutions to the following problems will determine your ability in working with ratios and proportions. You may either use formulas you have available in this manual or in any other references.

Answer the following questions:

6-1 Solve for n in the following proportion: 2/5 = N/20.

6-2 If 20 pounds of coarse aggregate are mixed with 50 pounds of fine aggregate, what is the ratio of coarse aggregate to fine aggregate?

6-3 If 12 pounds of fine aggregate are mixed with 60 pounds of coarse aggregate, what is the ratio of fine aggregate to the total mixture?

6-4 A certain concrete mixture contains sand, gravel, and cement in a ratio of 3:7:2. If 140 pounds of gravel are used, how many pounds of cement would be needed, and how many pounds of sand would be needed?

6-5 In an 1,800 pound mixture of concrete, the gravel, cement, sand, and water ingredients are in a ratio of 6:2:3:1. What is the weight of each ingredient?

6-6 If it takes 600 gallons of tack coat to cover 3,200 square yards of roadway, how many gallons of tack coat will it take to cover 4,800 square yards?

6-7 Find the slope of an embankment between two points if the difference in elevation of the two points is 12.7 feet, and the horizontal distance between the two points is 66.4 feet. Express your answer to the nearest tenth.

6-8 The slope of a certain cut is 3:1. If the vertical distance is 15.5 feet, find the horizontal distance. Express your answer to the nearest tenth of a foot.

6-9 Find the in-place wet density of a test hole sample if the weight of the wet soil is 20.5 pounds and the volume of the test hole is .173 cubic feet. Express your answer to the nearest hundredth.

6-10 Find the specific gravity of a test sample whose density is 47.6 pounds per cubic foot. Express your answer to the nearest tenth.

If you have 9 or 10 answers correct, go on to Unit VII.

If you have less than 9 answers correct, complete this unit.

A. Introduction

A ratio is the comparison of two numbers by division. Some examples of ratios include 3/4, 1:2, 5/n, 5/6, and 5:6. Notice that a ratio can be written using a fraction bar (/) or a colon (:). Ratios are read as follows:

3/4 is the ratio of 3 to 4.
1:2 is the ratio of 1 to 2.
5/n is the ratio of 5 to n (where n is an unknown).
5/6 is the ratio of 5 to 6.
5:6 is the ratio of 5 to 6 (notice, 5/6 = 5:6)

6-11 Write the ratio of 7 to 8, using a fraction bar.
6-12 Write the ratio of 5.3 to 7, using a colon.
6-13 Write the ratio of 6 to w, using a colon.
6-14 Write 9/13, using a colon.
6-15 Write 7:9, using a fraction bar.
6-16 Write the ratio of 6 to 11 both with a colon and with a fraction bar.
6-17 Write the ratio of 7.23 to 8.98 both with a colon and with a fraction bar.

Multiplying or dividing each term in a ratio by the same <u>nonzero</u> number will produce an equal ratio. A proportion is a statement that two ratios are equal.

For example, the ratio 1/2 equals the ratio 2/4, since

$$\frac{1}{2}*\frac{2}{2}=\frac{2}{4}$$ Therefore, 1/2= 2/4 is a proportion.

The ratio 3/8 equals the ratio 12/32, since

$$\frac{3}{8}*\frac{4}{4}=\frac{12}{32}$$ Therefore, 3/8 = 12/32 is a proportion.

The ratio 4:6 equals the ratio 2:6, since

$$\frac{4}{6}\div\frac{2}{2}=\frac{2}{3}$$ Therefore, 4:6 = 2:3 is a proportion.

The ratio 9.3:3 equals the ratio 3.1:1, since

$$\frac{9.3}{3}\div\frac{3}{3}=\frac{3.1}{1}$$ Therefore, 9.3:3 = 3.1:1 is a proportion.

6-18 Write as a proportion, the ratio 2/3 equals the ratio 8/12
6-19 Write as a proportion, the ratio n/3 equals the ratio 8/12
6-20 Write as a proportion, the fact that the ratio 27:36 equals the ratio 3:4
6-21 Write as a proportion, the fact that the ratio 27/b equals the ratio 3/4
6-22 Write as a proportion, the fact that the ratio 11:12 equals the ratio n:24

6-23 Write as a proportion, the fact that the ratio a/14 equals the ratio c/7
6-24 Write as a proportion, the fact that the ratio 5/b equals the ratio c/d
6-25 Write as a proportion, the fact that the ratio a/b equals the ratio c/d

Two ratios are equal when the cross products of the ratios are equal. A cross product is found by multiplying the numerator of one fraction by the denominator of a second fraction and the denominator of the first fraction by the numerator of the second.
For example,

Given the proportions $\frac{a}{b}$ and $\frac{c}{d}$.

The ratios would be equal if $\frac{a}{b} \times \frac{c}{d}$ or $a \times d = b \times c$

6-26 In the proportion 2/3 = 8/12 (from problem **6-18**) does 2 x 12 equal 3 x 8?
6-27 In the proportion 27/36 = 3/4 (from problem **6-20**) what is the relationship between 27 x 4 and 36 x 3?
6-28 In the proportion 1/1.20 = 2/2.40 what is the relationship between 1 x 2.40 and 1.20 x 2?
6-29 In the general proportion a/b = c/d what should be the relationship between a x d and b x c?

B. Solving Proportions

Whenever an equation contains an unknown value (for example, 2/3 = 8/n), your job is to find the value of the unknown which makes the proportion a true statement. In other words, you must solve the proportion. To do this, you first use the principle from the previous example to write the proportion as an equation in the form a x d = b x c; then solve this equation using the algebraic techniques you have already learned.
For example,

Solve the proportion $\frac{1}{10} = \frac{z}{100}$

Finding the cross product gives us $10z = 100$

Solving this equation gives us $\frac{\cancel{10}z}{\cancel{10}} = \frac{100}{10} \text{ or } z = 10$

6-30 Use the principle from problem **6-29** above to write the proportion 2/3 = 8/n in the form a x d = b x c.
6-31 Solve the equation 2n = 24
6-32 If you substitute n = 12 into the proportion 2/3 = 8/n, do you get a true statement?
6-33 Write the proportion n/4 = 15/20 in the form a x b = c x d.
6-34 Solve the equation 20n = 60
6-35 What does the value n = 3 represent for the proportion n/4 = 15/20?
6-36 Solve the proportion 12/14 = 6/n

6-37 Solve the proportion n/16 = 3/8.
6-38 Solve the proportion 12/24 = n/6
6-39 Solve the proportion 18/30 = n/25
6-40 Solve the proportion 5:n = 15:18
6-41 Solve the proportion 4/n = 5/8 (Express your answer in decimal form).
6-42 Solve the proportion 6:1.3 = 9:n
6-43 Solve the proportion n/9 = 8.2/.4

C. Applications

In many situations you are interested in the ratio of two quantities. For example, in preparing a roadbed you would be concerned with the ratio of coarse aggregate to fine aggregate; in checking compaction you would be interested in the ratio of the weight of moisture to the weight of dry soil, and in reading blueprints you would be concerned with the ratio of distance on the blueprint to distance on the ground.
For example,

In a certain stockpile there are two sizes of rock, larger than 3 inches and smaller than 3 inches. The ratio of rock smaller than 3 inches to larger than 3 inches is 5/2. If there is 360000 pounds of smaller rock in the stockpile, how much larger rock is there?
Using the given ratio, set up the proportion (Let "L" be the amount of larger rock)

$$\frac{smaller}{larger} = \frac{5}{2} = \frac{360000}{L}$$

Find the cross product and solve for the variable "L"

$$5L = 720000 \qquad \frac{\cancel{5}L}{\cancel{5}} = \frac{720000}{5}$$

Answer "L" = 144000 or There is 144000 pounds of larger rock in the stockpile.

6-44 In constructing a certain roadbed, for every 45 pounds of coarse aggregate, 15 pounds of fine aggregate must be added. What is the ratio of coarse aggregate to fine aggregate?

6-45 If 55 pounds of coarse aggregate are mixed with 22 pounds of fine aggregate, what is the ratio of coarse aggregate to fine aggregate?

6-46 On a compaction report it was found that the weight of moisture in a certain soil sample was 65 grams and the weight of the dry soil was 455 grams. What is the ratio of the weight of the moisture to the weight of the dry soil?

6-47 A certain concrete mixture contains 45 pounds of cement, 90 pounds of sand, and 135 pounds of gravel. What is the ratio of cement to sand?

6-48 In problem **6-47**, what is the ratio of sand to gravel?

6-49 In problem **6-47**, what is the ratio of cement to gravel?

6-50 In a certain roadbed the ratio of coarse aggregate to fine aggregate is to be 3:2. How many pounds of fine aggregate must be added to 75 pounds of coarse aggregate to give the desired ratio? (Hint: Let n = the number of pounds of fine aggregate and use a proportion to solve the problem).

6-51 On another roadbed the ratio of coarse aggregate to fine aggregate is to be 4:1. How many pounds of coarse aggregate must be added to 72 pounds of fine aggregate to give the desired ratio? (Hint – Let n = the number of pounds of coarse aggregate in your proportion).

6-52 If water and cement are mixed in the ratio 1.5:3.2, and 4.5 pounds of water are used, how much cement is used? (Hint – Let n = the number of pounds of cement to be used).

6-53 If gravel and sand are in a certain concrete mix in the ratio 2:2.70 and 3,051 pounds of sand is used, how much gravel must be used?

6-54 If it takes 1,200 gallons of tack coat to cover 7,200 square yards of roadway, how many gallons will it take to cover 6,000 square yards? (Hint – If 1,200 gallons of tack coat covers 7,200 square yards of roadway, then the ratio of the amount of tack coat to the area covered is 1,200:7,200).

6-55 A concrete mix contains cement, sand, and gravel in the ratio 2:3:5. If 500 pounds of cement are used in the mixture, how many pounds of sand are needed? (Hint – The ratio of cement to sand is 2:3).

6-56 In problem **6-55**, how many pounds of gravel are needed? (Hint – The ratio of cement to gravel is 2:5).

6-57 In a certain concrete mix, the ratio of cement to sand to gravel is 1:3:4. How many pounds of cement and how many pounds of gravel must be added to 150 pounds of sand to give the desired mixture? (Hint – Solve this problem as two separate problems as in problems **6-55** and **6-56**).

If, in a certain soil sample, the ratio of coarse aggregate to fine aggregate is 4:5, then the total soil sample could be thought of as having 4 + 5, or 9, parts. This means that the ratio of coarse aggregate to the total sample is 4/9 and the ratio of fine aggregate to the total sample is 5/9.

6-58 If coarse aggregate and fine aggregate are in the ratio 7:3, what is the ratio of coarse aggregate to the total sample?

6-59 Using the ratio from problem **6-58**, what is the ratio of fine aggregate to the total sample?

6-60 Water and cement are mixed in the ratio 1:3. What is the ratio of the amount of water to the total mixture?

6-61 Using the ratio from problem **6-60**, what is the ratio of the amount of cement to the total mixture?

6-62 If the total mixture in problems **6-60** and **6-61** weighs 60 pounds, what is the amount of water in the mixture?

6-63 If a certain soil sample weighs 80.4 pounds and the ratio of coarse aggregate to fine aggregate is 1.3:5.4, find the weight of coarse aggregate and the weight of fine aggregate in the sample.

6-64 The ratio of cement to sand to gravel in a concrete mix is 1:2.5:3. If the concrete weighs 3,250 pounds, find the amount of cement, sand, and gravel needed.

Another application of ratio and proportion that you must study involves the idea of slope. Slope is the ratio of horizontal distance to vertical distance. For instance, the slope between any two points of an embankment is the ratio of the horizontal distance between the two points to the vertical distance between the two points. Always express slope ratios so that the second number in the ratio is "1."
For example,

A wheelchair ramp is 72 inches long (horizontally) and drops a total of 6 inches vertically. What is the slope of the ramp? Set up the ratio of horizontal distance to vertical distance and reduce it so that the vertical distance is 1.

$$\frac{horizontal}{vertical} = \frac{72"}{6"} \div \frac{6}{6} = \frac{12"}{1"}$$ The slope of the ramp is 12:1.

6-65 Find the slope of a hill if the horizontal distance is 200 feet and the vertical distance is 50 feet.

6-66 A surface drain ditch is 9 feet from the edge of the shoulder of a road and 1.5 feet below the level of the road. Find the slope between the ditch and the shoulder of the road.

6-67 A cut has a 40.1-foot depth corresponding to a horizontal distance of 60.15 feet. Find the slope of the cut.

6-68 An exit ramp has a slope of 5:1. How far does the ramp fall vertically for every 75 feet of horizontal distance?

6-69 An embankment has a slope of 6:1. If the difference in elevation between the top of slope and old ground is 21.0 feet, find the horizontal distance to the toe of slope.

6-70 A cut has a slope of 2:1. If the vertical distance is 40.1 feet, find the horizontal distance.

6-71 A fill is to be constructed against a hillside whose slope is 4:1. If the height of the top of the hill is 53.2 feet, find the horizontal distance corresponding to this vertical distance.

6-72 An embankment has a slope of 2:1. If the difference in elevation between the top of slope and old ground is 28.5 feet, find the horizontal distance to the toe of slope.

Another ratio that is needed is the ratio of the weight of an item to its volume. This ratio is known as the density of the item, which can be expressed as follows:

Density = (weight)/(volume)

6-73 Find the density of the wet soil in a test hole if the wet soil weighs 8.4 pounds and the volume of the hole is .07 cubic feet.

6-74 A Proctor mold whose volume is .05 cubic feet contains a sample whose weight is 4.108 pounds. Find the density of the sample to the nearest hundredth of a pound per cubic foot.

6-75 Find the in-place wet density of a soil sample if the weight of the wet soil is 8.7 pounds and the volume of the test hole is .068 cubic feet. Express your answer to the nearest hundredth.

6-76 The density of asphalt is 63.58 pounds per cubic foot and the volume of asphalt on a certain section of roadway is 126,720 cubic feet. Find the weight of the asphalt on the roadway to the nearest hundredth. (Hint – Solve using algebraic techniques).

6-77 If the density of asphalt is 62.71 pounds per cubic foot and the volume of asphalt on a certain bridge is 7,920 cubic feet, find the weight of the asphalt on the bridge to the nearest hundredth.

The usual unit of measurement for asphalt is gallons rather than pounds.

6-78 If it takes 8.5 pounds of asphalt in problem **6-77** to equal one gallon of asphalt, how many gallons of asphalt are needed?

6-79 A truckload of wet aggregate of density 72.3 pounds per cubic foot has a capacity of 260 cubic feet. What is the weight of the aggregate to the nearest pound?

You will also need to work with another ratio that is called Specific Gravity. The specific gravity of a substance is the ratio of the density of the substance to the density of water (62.4 pounds per cubic foot).

6-80 Find the specific gravity of a sample of a substance whose density is 58.6 pounds per cubic foot. Express your answer to the nearest tenth.

6-81 A certain sample of asphalt has a density of 69.4 pounds per cubic foot. Find the specific gravity of the asphalt to the nearest tenth.

6-82 A sample of concrete was taken. The volume of the sample was .018 cubic feet and its weight was 3.120 pounds. Find the density to the nearest hundredth and the specific gravity to the nearest tenth of the test sample.

UNIT VII – PERCENTAGE

It is possible that you will not have to study this Unit. Your answers to the following problems will determine your ability in working with percentages.

Answer the following questions:

7-1 If 60% of 377,000 cubic yards of cut have been removed, what is the number of cubic yards of cut that must still be removed?

7-2 What is the percent of fines in a soil sample that contains .75 pounds of fines if the total sample weighs 9.68 pounds? Express your answer to the nearest tenth of a percent.

7-3 What is the total amount of uncompacted bituminous concrete needed for 350 cubic yards of compacted concrete, if the compaction rate is 19%? Express your answer to the nearest tenth of a cubic yard.

7-4 What is the percent of moisture based on the dry weight of a soil sample if the weight of the moisture is 68.5 grams and the weight of the dry soil is 472.6 grams? Express your answer to the nearest tenth of a percent.

7-5 What is the percent of grade of a certain roadway if it falls 7 feet in 196 feet of horizontal distance? Express your answer to the nearest tenth of a percent.

7-6 How much does a roadway rise from the shoulder to center of the roadway if the percent grade between these two points is 1.7% and the horizontal distance from the shoulder to the center is 12.0 feet? Express your answer to the nearest hundredth of a foot.

7-7 A certain concrete mixture is composed of 52 pounds of cement, 156 pounds of sand, and 260 pounds of gravel. What is the percent of cement in the mixture to the nearest tenth of a percent?

7-8 The elevation of the Profile Grade Line (P.G.L.) of a certain section of superelevated roadway is 56.00 feet. Find the elevation of one edge of the road if the percent grade to the edge of the road is +3.8% and the horizontal distance from the P.G.L. to the edge of the road is 12.0 feet. Express your answer to the nearest hundredth of a foot.

If you have seven or eight answers correct, go on to Unit VIII.

If you have less than seven answers correct, complete this Unit.

A. Introduction

In this Unit you will be working with another way of expressing a ratio which is called a percent. To change a ratio to percent form, convert the fraction (ratio) to a decimal by dividing the denominator into the numerator, multiply this decimal by 100, and then attach a percent sign (%).

For example, the fraction 3/4 is first converted to the decimal .75 by dividing 4 into 3. Then, the decimal .75 is multiplied by 100 to become 75. Finally, a percent sign is attached to become 75%. Therefore, 3/4 = 75%.

7-9 Change 3/5 to percent form.
7-10 Change 5:8 to percent form.
7-11 Change 2/3 to percent form, precise to the nearest tenth.
7-12 Change 6/11 to percent form, precise to the nearest tenth.
7-13 Change 5/2 to percent form.

To change from percent form to ratio form, remove the percent sign and write the number over 100. For example, 15% can be written as 15/100. Your answer need not be simplified.

7-14 Change 16.2% to ratio form.

B. Applications of Percentages

In all applications of percentages, a percent means a part of the whole. It represents the part you have or want compared to the total amount. In other words:

Percent (in ratio form) = (part you have or want)/(total amount).

For example,

> 425,000 cubic yards of cut are to be excavated, and you know that 60% has already been removed, you can determine how many cubic yards have been removed by using the formula just explained. The expression is written as 60/100 = (n)/(425,000) where n is the number of cubic yards already removed.

7-15 Determine how many cubic yards of cut have already been removed, in the previous example, using the techniques learned in the previous unit.

7-16 A 5,000-foot stretch of roadway is to be constructed. If 36% of the job is completed, how many feet of roadway are completed?

7-17 A soil sample weighing 15 pounds contains 6.2% fines. How many pounds of fines are in the sample?

7-18 12,000 pounds of aggregate is to have 62% coarse aggregate. How many pounds of fine aggregate are needed?

7-19 A 1,500-pound mixture of cement and sand contains 80% sand. How many pounds of cement are in the mixture?

7-20 What is the percent of fines in a soil sample if the fines weigh .62 pounds and the total sample weighs 9.35 pounds? Write your answer to the nearest tenth of a percent.

7-21 A cement and sand mixture contains 96 pounds of cement and 276 pounds of sand. What is the percent of cement in the total mixture to the nearest tenth of a percent?

7-22 A certain concrete mixture contains 192 pounds of cement, 480 pounds of sand, and 576 pounds of gravel. What is the percent of each ingredient in the concrete mixture? Express your answer to the nearest tenth of a percent.

7-23 What is the total amount, to the nearest hundredth of a cubic yard, of uncompacted bituminous concrete needed for 200 cubic yards of compacted concrete, if the compacted concrete is 80% of the un-compacted concrete?

7-24 What is the total amount, to the nearest tenth of a cubic yard, of uncompacted fill needed for 7.12 cubic yards of compacted fill, if the compaction rate is 9%? (Hint: If the compaction rate is 9%, then the amount of compacted soil is 91% of the uncompacted soil.)

In a compaction test, the percent of moisture based on dry weight is the ratio of the weight of the moisture to the weight of the dry soil and should be expressed as a percent.

$$\frac{\text{weight of moisture}}{\text{weight of dry soil}} * 100$$

7-25 Find the percent of moisture based on dry weight in a certain soil sample, if the weight of the moisture is 72.8 grams and the weight of the dry soil is 451.6 grams. Express your answer to the nearest tenth of a percent.

7-26 Find the percent of moisture based on dry weight in a certain soil sample if the weight of the moisture is 56.7 grams and the weight of the dry soil is 467.8 grams. Express your answer to the nearest tenth of a percent.

Another important application of percentages is the idea of percent of grade. Percent of grade is an expression of a rise or fall of a roadway as a ratio of the vertical distance to the horizontal distance and is expressed as a percent.

$$\frac{\text{vertical distance}}{\text{horizontal distance}} * 100$$

7-27 Given a length of road that rises 20 feet for every 500 feet of horizontal distance, what is the percent of grade?

7-28 Given a length of road that falls 20 feet for every 500 feet of horizontal distance, what is the percent of grade?

Notice that in Problem **7-27** the grade was expressed as positive (+) because the roadway was rising, and in Problem **7-28** the grade was expressed as negative (-) because the roadway was falling.

7-29 What is the percent of grade of a ramp that falls 13 feet for every 142 feet of horizontal distance? Express your answer to the nearest tenth of a percent.

7-30 The horizontal distance between two points on a roadway is 37.7 feet. The difference in elevation between these points is 5.5 feet. Find the percent of grade of the roadway to the nearest tenth of a percent if the roadway rises between the two points.

7-31 The elevations of points A and B on a certain roadway have been determined as 50.00 feet and 53.60 feet, respectively. If the horizontal distance between the two points is 87.3 feet, find the percent of grade of the roadway from point A to point B to the nearest tenth of a percent.

7-32 Find the rise of a roadway to the nearest tenth of a foot if the horizontal distance is 973.3 feet at a grade of 1.6%. (Hint: Change the percent to ratio form and then work as a proportion.)

7-33 Find the width of a ravine to be spanned by a bridge whose percent of grade is –5.6% and whose fall is 5.44 feet. Express your answer to the nearest tenth of a foot. (Hint – 5.6% = 5.6/100).

You will be concerned with calculating percent of grade for cross-sections of roadways for banking and draining purposes. The cross slope of a roadway (the percent of grade from the centerline to the shoulder) is normally measured from the Profile Grade Line (P.G.L). The P.G.L. of many roadways is the centerline.

7-34 A certain roadway has a 12.0-foot wide travel lane with a grade (cross slope) of 1.3%. Find the fall of the travel lane measured to the nearest hundredth of a foot.

7-35 A certain shoulder of a roadway is 10.0 feet wide and has a grade (cross slope) of 5.0%. Find the fall of the shoulder measured to the nearest hundredth of a foot.

When one lane of a roadway has a positive (+) percent of grade and the other lane has a negative (-) percent of grade, then the roadway is said to be superelevated. A certain roadway is constructed as follows, with the P.G.L being between the left and right lanes.

SECTION	WIDTH	GRADE
LEFT SHOULDER	10.0 feet	-1.9%
LEFT LANE	12.0 feet	+4.1%
RIGHT LANE	12.0 feet	-4.1%
RIGHT SHOULDER	10.0 feet	-5.9%

7-36 Using the information from the chart above, find the fall of the right lane, the rise of the left lane, and the fall of each of the two shoulders. Express all your answers to the nearest hundredth of a foot.

7-37 Using the information from the chart above, calculate the amount of fall 3 feet to the right of the P.G.L. Express your answer to the nearest hundredth of a foot.

7-38 If the elevation of the P.G.L. from the chart above is 65.00 feet, calculate the elevations of the two edges of the road to the nearest hundredth of a foot.

UNIT VIII – ANGLE MEASUREMENT

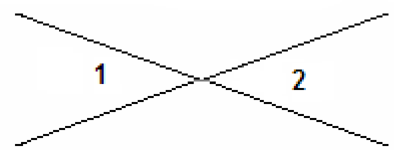
It is possible that you will not have to study this Unit. Your solutions to the following problems will determine your ability in working with the concepts of angle measure presented in this Unit.

Solve the following problems:

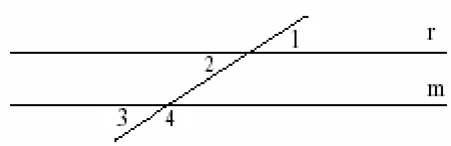
8-1 Find the measure of an angle that is complementary to another angle whose measure is 28°.

8-2 Find the measure of an angle that is supplementary to another angle whose measure is 89°.

8-3 Find the measure of angle 2 in the following diagram if angle 1 has a measure of 8° 15' 28".



8-4 Find the measure of angle 3 in the following diagram if angle 1 has a measure of 83° 15' and lines r and m are parallel.



8-5 Find the measure of angle 2 in the previous diagram if angle 4 has a measure of 141° 10' 16" and lines r and m are parallel.

8-6 Find the sum of the measures of three angles if their measures are 8° 21' 18", 27° 42' 15", and 89° 36' 45".

8-7 Subtract 17° 37' 21" from 28° 14' 8".

8-8 Find the measure of the third angle of a triangle if the sum of the measures of the other two angles is 76° 21' 18".

8-9 Find the measure of angle 3 of a triangle if the measure of angle 1 is 84° 56' 49" and the measure of angle 2 is 17° 42' 37".

8-10 Find the area of a sector of a circle whose central angle is 30 if the radius of the circle is 1.2 feet. Express your answer to the nearest tenth of a square foot.

If you have nine or ten solutions correct, go on to Unit IX.

If you have less than nine solutions correct, complete this Unit.

A. Introduction

In your work there are many situations in which you must work with angles. As examples, if two roadways intersect, an angle is formed, a pile may be driven into the ground on an angle, an embankment is sloped at an angle to a road, a retaining wall makes an angle with the shoulder of a road, and a bridge may be skewed at an angle to a road.

Angles are determined by the intersection of two straight lines.

The usual method of measuring an angle is with an instrument known as a protractor which is scaled in degrees (°) from 0° to 360°.

At a construction site, there is a protractor built into your transit.

B. Types of Angles

Angles whose measures are less than 90° are called acute angles. Angles whose measures are 90° are called right angles. Angles whose measures are between 90° and 180° are called obtuse angles. Angles whose measures are 180° are called straight angles and form a straight line.

8-11 Which type of angle has a measure of 48°?
8-12 Which type of angle has a measure of 173°?
8-13 Which type of angle has a measure of 90°?
8-14 Perpendicular lines form which type of angle?
8-15 An acute angle whose measure is 30° is added to an acute angle whose measure is 75°. What is the measure of the resulting angle and which type of angle is it?

If the sum of the measures of two angles is 90°, then the two angles are complementary.
For example,

The angles 35° and 55° are complementary because they equal 90° when added together.

8-16 What is the measure of an angle that is complementary to a 47° angle?

8-17 If the measure of angle 1 is 38° and if angle 1 and angle 2 are complementary, what is the measure of angle 2?

8-18 If the measure of angle 2 is 34-1/2°, what is the measure of angle 1 if the two angles are complementary?

If the sum of the measures of two angles is 180°, then the two angles are supplementary.

8-19 What is the measure of an angle that is supplementary to a 47° angle?

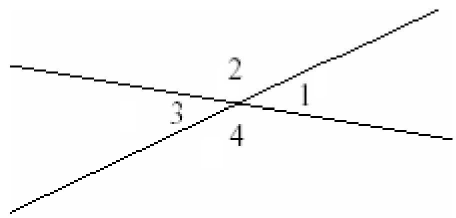
8-20 If angle 1 and angle 2 are supplementary, and if the measure of angle 1 is 64°, what is the measure of angle 2?

8-21 If the measure of angle 1 is 168°, what is the measure of angle 2 if the two angles are supplementary?

8-22 The measure of angle 1 is 19°. If angle 1 is complementary to angle 2 and supplementary to angle 3, what is the measure of angle 2 and what is the measure of angle 3?

8-23 The measure of angle 1 is 74°. If angle 1 is complementary to angle 2 and supplementary to angle 3, what is the measure of angle 2 and what is the measure of angle 3?

In the diagram below, angle 1 and angle 3 are a pair of vertical angles, and angle 2 and angle 4 are another pair of vertical angles. Vertical angles have equal measure.

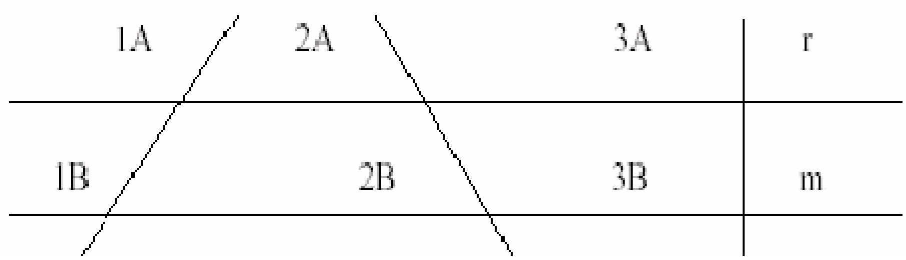


8-24 If angle 1 in the above diagram has a measure of 38°, what is the measure of angle 3?

8-25 If angle 1 in the above diagram has a measure of 38°, what is the measure of angle 4? (Hint angle 1 and angle 4 are supplementary).

8-26 Using the information from the previous problem, what is the measure of angle 2 in the above diagram?

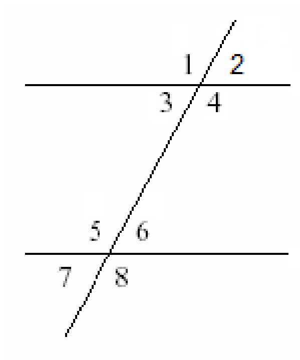
8-27 If angle 2 in the above diagram has a measure of 123°, find the measures of angles 1, 3, and 4.



In the diagram above, lines r and m are parallel. If a line intersects two parallel lines, four pairs of corresponding angles are formed. Each of the sets of numbered angles above illustrates a possible pair of corresponding angles. Each pair of corresponding angles is equal.

8-28 If, in the above diagram, the measure of angle 1A is 115°, what is the measure of angle 1B?

Use the following diagram to answer questions **8-29** through **8-35**. The two horizontal lines in the diagram are parallel to each other.



8-29 If the measure of angle 2 is 81°, what is the measure of angle 7?
8-30 If the measure of angle 3 is 72°, find the measure of angle 6.
8-31 If the measure of angle 5 is 141°, what is the measure of angle 4?
8-32 If the measure of angle 1 is 133°, find the measure of angle 6.
8-33 If the measure of angle 7 is 66°, find the measure of angle 4.
8-34 If the measure of angle 1 is 80°, what is the measure of angle 7?
8-35 If the measure of angle 1 is 117°, find the measure of each of the other numbered angles.

C. Dividing Degrees into Minutes and Seconds

A degree can be divided into 60 parts. Each of these parts is known as a minute (**'**).
Therefore, 1° = 60**'**.
For example,

How many degrees are in 240 minutes.

$$240 \text{ minutes} * \frac{\text{degree}}{60 \text{ minutes}} = 4 \text{ degrees or } 4°$$

8-36 How many minutes are 3°?
8-37 How many minutes are in 17 1/2°?
8-38 How many minutes are in 1/2°?
8-39 How many minutes are in 13/60°?
8-40 What part of a degree is 30**'**? (Hint – Since 1 = 60**'**, then 1**'** = 1/60)
8-41 What part of a degree is 15**'**?
8-42 How many degrees are in 127**'**?
8-43 Convert 196**'** to degrees and minutes.
8-44 Convert 87**'** to degrees and minutes.
8-45 Convert 116**'** to degrees and minutes.

A minute can also be divided into 60 parts. Each part is known as a second (**"**).
Therefore, 1**'** = 60**"**.

8-46 How many seconds are in 5**'**?
8-47 How many seconds are in 1/2**'**?
8-48 What part of a minute is 45**"**? (Hint – Since 1**'** = 60**"**, then 1**"** = 1/60**'**)

8-49 What part of a minute is 30”?
8-50 Convert 169” to minutes and seconds.
8-51 Convert 78” to minutes and seconds.
8-52 If angle 1 has a measure of 45° 22’ and angle 2 has a measure of 16° 27’, find the sum of the measures of angles 1 and 2.

In general, when simplifying an angle measure involving degrees, minutes, and seconds, you must do the necessary converting to make sure that your final answer does not have any more than 59 minutes or 59 seconds.
For example,

Two angles are to be added together. One angle is 25° 40’ and the other is 20° 39’. Add the angles and simplify your answer.

First, add the degrees together and the minutes together

25°	40’	
+20°	+39’	Then, reduce the number of minutes into an equal amount of whole degrees and minutes
45°	79’	

$$79 \text{ minutes} * \frac{\text{degree}}{60 \text{ minutes}} = 1 \text{ degree and } 19 \text{ minutes}$$

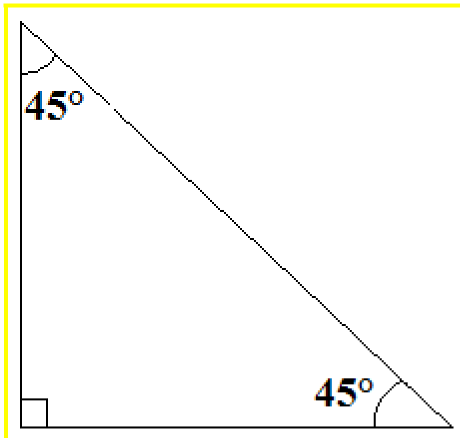
Last, add the number of degrees and minutes, converted from minutes, to the original number of degrees.

45° + 1°19’= 46°19’

8-53 Angle 1 has a measure of 15° 43’ and angle 2 has a measure of 83° 32’. Find the sum of the measures of angles 1 and 2.
8-54 A certain angle whose measure is 17° 41’ 38” is added to another angle whose measure is 44° 31’ 36”. Find their sum.
8-55 Add 45°, 8° 27’, 15° 43”, and 10° 47’ 24”. Simplify your answer.
8-56 Subtract 16° 22’ from 24° 41’.
8-57 Subtract 12° 13’ 14” from 15° 16’ 17”.
8-58 Subtract 29° 37’ from 67° 29’. (Hint – Since 37’ is larger than 29’, write 67° as 66° 60’ so that 67° 29’ = 66° 89’)
8-59 Subtract 123° 48’ from 180.
8-60 Subtract 49° 28’ 35” from 118° 46’ 23”.
8-61 Subtract 3° 54’ 4” from 11° 49’ 2”.
8-62 The measure of angle 1 is 104° 16’ 43” and angle 2 is supplementary to angle 1. Find the measure of angle 2.

D. The Measures of the Angles of Triangles

The sum of the measures of the three angles of any triangle is always 180°.
The drawing of the isosceles triangle below illustrates this rule. An isosceles triangle has two equal sides and two equal angles.

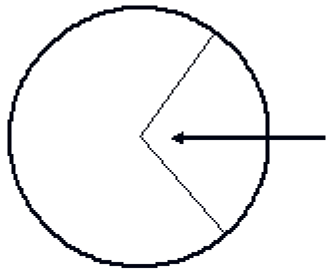


45° + 45° + 90° = 180°

8-63 If the sum of the measures of two angles of a triangle is 140°, find the measure of the third angle.
8-64 If the sum of the measures of two angles of a triangle is 126° 28**'**, find the measure of the third angle.
8-65 Two angles of a triangle measure 48° and 62°. Find the measure of the third angle.
8-66 Two angles of a triangle measure 89° 20**'** and 32° 30**'.** Find the measure of the third angle.
8-67 Two angles of a triangle measure 132° 30**'** and 30° 30**'.** Find the measure of the third angle.
8-68 Two angles of a triangle measure 39° 31**'** 49**"** and 50° 28**'** 11**"**. Find the measure of the third angle.

E. Angles and Circles

An angle whose sides intersect at the center of a circle is called a central angle.



Angle 1 is a central angle. It determines a section of the circle and determines the size of the sector (also known as a pie piece). The size of the sector is the ratio of the measure of the central angle to 360° (the number of degrees in the whole circle).
For example,

A pie piece that has a central angle of 90° produces a sector of what size?

First set up the ratio, then reduce the resulting fraction. $\frac{90°}{360°} = \frac{9\not{0}°}{36\not{0}°} = \frac{1}{4}$

A central angle of 90° produces a sector that is $\frac{1}{4}$ of a circle.

8-69 What is the size of the sector represented in the previous figure if the measure of angle 1 is 60°?
8-70 What is the size of the sector determined by a central angle whose measure is 135°?
8-71 If the area of the circle in problem **8-70** is 48 square feet, what is the area of the sector?
8-72 Find the area of a sector whose central angle is 120° if the area of the circle is 68.1 square feet.
8-73 Find the area of a sector of a circle whose central angle is 108° if the radius of the circle is 6.31 feet. Express your answer to the nearest hundredth of a square foot. (Hint: $A = \pi r^2$ is the formula for the area of a circle.)
8-74 A circular sector has been stripped during construction. Find the number of square yards of sod (to the nearest square yard) needed to cover the sector if the radius of the circle is 28.2 feet and the measure of the central angle is 45°.

UNIT IX – RIGHT TRIANGLES

It is possible that you will not have to study this Unit. Your solutions to the following problems will determine your ability in working with the material on right triangles presented in this Unit.

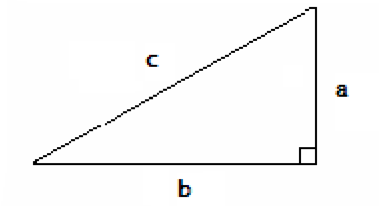
9-1 What is the square root of 121?
9-2 What is the square root of 6.25?
9-3 Find the hypotenuse of a right triangle whose legs are 6 and 8.
9-4 Find the hypotenuse of a right triangle whose legs are 2.5 and 6.
9-5 Find the length of one leg of a right triangle if the other leg is 48 and the hypotenuse is 52.
9-6 Find the length of one leg of a right triangle if the other leg is 4.6 and the hypotenuse is 7.0. (Express your answer to the nearest tenth)
9-7 Find the horizontal length of a 52.24-foot section of sidewalk that falls 3.30 feet over this distance. (Express your answer to the nearest hundredth of a foot.)
9-8 What length of pipe is needed for a drain under a roadway if the roadway is 42.00 feet wide and the pipe will drop 38.65 feet? (Express your answer to the nearest hundredth of a foot.)

If you have seven or eight answers correct you may omit this Unit.

If you have less than seven answers correct, complete this Unit.

A. Introduction

A triangle that has a right angle (90°) is a right triangle.



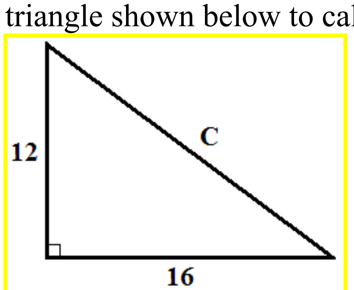
In any triangle, such as the one above, the side "c" (opposite the right angle) is called the hypotenuse, and the other two sides "a" and "b" are called the legs. A basic principle of right triangles is that the square of the hypotenuse equals the sum of the squares of the two legs. That is, $c^2 = a^2 + b^2$, where c^2 means $c \times c$, a^2 means $a \times a$, and $b^2 = b \times b$. In general, squaring a number means multiplying the number by itself.

9-9 Find 6^2.
9-10 Find 13^2.
9-11 Find $(8.7)^2$.
9-12 If $a = 3$, find a^2.
9-13 If $b = 4$, find b^2.
9-14 If $a = 3$ and $b = 4$, find $a^2 + b^2$.
9-15 If $c^2 = a^2 + b^2$, and $a = 3$, and $b = 4$, find c^2.
9-16 In problem **9-15**, c represents the hypotenuse of a right triangle whose legs are 3 and 4. Since $c^2 = 25$, find c (the hypotenuse). (Hint – Find the number that gives 25 when multiplied by itself. This can be easily accomplished by using the square root key on your calculator, commonly shown as $\sqrt{\ }$)
9-17 If $c^2 = a^2 + b^2$, and $a = 6$, and $b = 8$, find c^2.
9-18 If $c^2 = 100$, find c.
9-19 If $c^2 = a^2 + b^2$, and $a = 5$, and $b = 12$, find c.

B. Application of the Pythagorean Theorem

The formula $c^2 = a^2 + b^2$ is called the Pythagorean Theorem. You will use this formula to find a side of a right triangle given two other sides.
For example,

Use the measurements of the triangle shown below to calculate the missing length.



Set up the formula, substitute the variables for the known lengths and solve for the unknown.

$c^2 = a^2 + b^2$ $c^2 = 12^2 + 16^2$ $c^2 = 144 + 256$ $c^2 = 400$ $\sqrt{c^2} = \sqrt{400}$

Therefore c = 20

9-20 Find the hypotenuse of a right triangle that has legs of 7 and 24.

The square roots of numbers can be found by many methods such as square root tables, a slide rule, a calculator, etc.

9-21 Find the hypotenuse (c) of a right triangle whose legs are a = 10, and b = 24.

9-22 Find the hypotenuse of a right triangle whose legs are 9 and 12.

9-23 Find the hypotenuse of a right triangle whose legs are .5 and 1.2.

9-24 Find the hypotenuse of a right triangle whose legs are 1 and 2.4.

9-25 Find the leg of a right triangle whose other leg is 24 and has a hypotenuse of 25.

9-26 Find the unknown leg in a right triangle whose hypotenuse is 2.5 and whose other leg is 1.5.

9-27 Find the unknown leg in a right triangle whose hypotenuse is 17.8 and whose other leg is 8.7. (Express your answer to the nearest tenth.)

9-28 Find the hypotenuse of a right triangle whose legs are 4.9 and 3.1. (Express your answer to the nearest tenth.)

9-29 Find the hypotenuse of a right triangle whose legs are 26.0 feet and 8.0 feet. (Express your answer to the nearest hundredth of a foot.)

9-30 Find the hypotenuse of a right triangle whose legs are 12.0 feet and 5.0 feet. (Express your answer to the nearest hundredth of a foot.)

9-31 Find the hypotenuse of a right triangle whose legs are 2.5 feet and .25 feet. (Express your answer to the nearest hundredth of a foot.)

9-32 A 500-foot stretch of roadway falls 27 feet. Find the corresponding horizontal distance to the nearest tenth of a foot.

9-33 The difference in elevation between Station 40+30 and Station 45+10 along a certain slope is 214.7 feet. Find the horizontal distance to the nearest tenth of a foot.

Notes for Basic Highway Math

1-12: The factors of 16 are: **1**, **2**, **4**, **8**, and 16. The factors of 24 are: **1**, **2**, 3, **4**, 6, **8**, and 12. The common factors for 16 and 24 are **1, 2, 4,** and **8**.

1-13: The factors of 12 are **1**, **2**, **3**, 4, **6**, and 12. The factors of 18 are: **1**, **2**, **3**, **6**, 9, and 18. The factors for 24 are **1**, **2**, **3**, 4, **6**, 8, 12, and 24. The common factors of 12, 18, and 24 are: **1, 2, 3**, and **6**.

1-14: As you saw for Question 1-13, the common factors of 12, 18 and 24 is 1, 2, 3, and **6**. The largest of these is **6**. Therefore, the **G.C.F**. (greatest common factor) for 12, 18, and 24 is **6**.

1-15: The factors of 8 are 1, 2, **4,** and 8. The factors for 12 are: 1, 2, 3, **4**, 6, and 12. The factors for 16 are 1, 2, **4**, 8, and 16. The common factors of 8, 12, and 16 are: 1, 2, and 4. Therefore, the **G.C.F.** of 8, 12, and 16 is **4**.

1-16: 1 X 4 = **4**
2 X 4 = **8**
3 X 4 = **12**
4 X 4 = **16**
5 X 4 = **20**
6 X 4 = **24**
7 X 4 = **28**
8 X 4 = **32**
9 X 4 = **36**
10 X 4 = **40**

Therefore, the first ten positive multiples are the boldface numbers counting by 4 through 40.

1-18: If you look at the answers for **1-16** and **1-17**, you see that 12, 24, and 36 are multiples of both 4 and 6. Therefore three common multiples for 4 and 6 are **12, 24,** & **36**.

1-19: From the answer for **1-18** you can see that the smallest of the common multiples is 12. Therefore the **L.C.M.** of 4 and 6 is 12.

1-20: The multiples of 6 are: 6, 12, 18, 24, 30, **36**, 42... The multiples of 9 are 9, 18, 27, **36**, 45... The multiples of 12 are 12, 24, **36**, 48... The L.C.M. of 6, 9, and 12 is **36**.

1-23: 5/5 = 1. If the numerator (top number) and denominator (bottom number) are equal, the improper fraction may be written as 1.

1-24: 15/20 = 3/4. In this case we have obtained divided the numerator and denominator by their G.C.F. (Greatest Common Factor) to produce a simplified fraction. In general write all fractional answers in simplified or lowest common denominator form.

1-26: 13/9 = 1 4/9. In this case we have obtained an improper fraction and changed it to a mixed fraction by dividing the denominator (9) into the numerator (13) and placing the remainder (4) over the denominator. In general, to change from an improper fraction to a whole number or mixed fraction (combination of a whole number and a fraction) divide the denominator into the numerator to obtain the whole number. Then if there is a remainder, write it over the original denominator to obtain a proper fraction. Then, if necessary, reduce the fraction to its lowest common denominator.

1-32: The answer, 5 1/2, was obtained by adding the whole numbers (2 + 3 = 5) first. Then adding the numerators (31 + 19 = 50) and keeping the denominator of 100. Then the fraction was reduced to its lowest common denominator.

1-37: Multiples of 2 are 2, 4, 6, 8, 10, 12, 14, 16... Multiples of 3 are 6, 9, 12, 15, 18... Multiples of 4 are 4, 8, 12 ... The least common multiple of 2, 3 and 4 is 12.

1-46: 5 - 1 3/8 = 4 8/8 - 1 3/8 = 3 5/8.

1-50: 7 7/8 - 2 2/3 = 7 21/24 - 2 16/24 = 5 5/24.

1-52: 6 3/8 - 2 5/8 = 5 11/8 - 2 5/8 = 3 6/8 = 3 3/4.

1-58: 4 x 3 = 12and 12 + 1 = 13 Therefore the answer is 13/3.

1-60: 1 1/2 x 2 3/4 = 3/2 x 11/4 = 33/8 = 4 1/8.

2-14: 16.2. In doing this problem you obtained 16.17. This is not exactly correct. To see why, observe that 13.5 has only one place to the right of the decimal point, whereas, 2.67 has two places. In general, you must use the following rule for precision.

In adding or subtracting decimals, the answer must have the same number of places to the right of the decimal point as the LEAST NUMBER of places to the right of the decimal point in any of the given numbers.

Therefore 16.17 can have at the most one place to the right of the decimal point. You can see that 16.17 is between 16.1 and 6.2. You should choose 16.2 in this case because 16.17 is closer to 16.2. The rule to follow for this rounding procedure is:

To round a number to a given place, look at the digit in the next place to the right. If this digit is less than 5, keep the digit in the given place and delete all digits to the right of the given place. If the given digit is greater than or equal to 5, increase the digit in the given place by one and delete all digits to the right of the given place.

2-18: 205.85 which must be rounded to 205.9.

2-19: 4.7671 which must be rounded to 4.767

2-50: The answer was given to two decimal places because the least number was only to two decimal places. See Note 2-14 for a further explanation.

3-15: In this case, 3/8 was written as 0.38 (because 3 ÷8=0.38), which has one decimal place more than the required precision. In general, in any intermediate division step, round your result to one decimal place more than the required precision.

3-24: 3.1. As you can see, in this problem parentheses were used to indicate not only order of operations but also multiplication. If a set of parentheses is immediately preceded by a number or by another set of parentheses, then multiplication is understood.

3-27: 25.39. In this problem, to find the average of two or more measured quantities, you add the quantities together and divide by the number of given quantities.

4-38: The area of the **rectangle:** 28.2 square feet
The area of the **trapezoid**: 50.4 square feet
The area of the **triangle**: +34.4 square feet
The total area of the figure: **113.0 square feet**

5-17: Yes, because n + 13 = 25
12 + 13 = 25
25 = 25, a true statement

6-49: 1/3. From problems 6-47, **6-48** and **6-49**, you saw that the cement to sand ratio is 1:2, the sand to gravel ratio is 2:3 and the cement to gravel is 1:3. We can write these three ideas in one expression as cement: sand: gravel =1:2:3 which means the ratio cement to sand to gravel equals the ratio of 1 to 2 to 3.

6-76: 8,056,857.60 pounds. NOTE – when pounds per cubic foot are multiplied by cubic feet the result is pounds.

6-80: .9. Note: Specific Gravity (S.G.) has no units associated with it because pounds per cubic foot in the numerator and pounds per cubic feet denominator offset each other.

8-24: 38°. Since angle 1 and angle 3 are equal and the measure of angle 1 is 38, the measure of angle 3 is **38.**

8-27: 123°. Since angle 1 and angle 2 are supplementary, angle 1 has a measure of 57°. Since angle 1 and angle 3 are vertical, angle 3 has a measure of 57°. Since angle 2 and angle 4 are vertical angles, angle 4 has a measure of 123°.

8-28: 115°**.** Since angle 1A and angle 1B are corresponding angles they are equal, therefore the measure of angle 1B is 115°.

8-29: 81°. Since angle 2 and angle 6 are corresponding angles, angle 6 has a measure of 81°. Since angles 6 and 7 are vertical angles, angle 7 has a measure of 81.

8-30: 72°. Since the measure of angle 3 equals the measure of angle 7, the measure of angle 7 equals 72° (corresponding angles are equal).

Also since the measure of angle 7 equals the angle 6, the measure of angle 6 equals 72°.

8-31: 141°. The measure of angle 5 equals the measure of angle 1, and the measure of angle 1 equals the measure of angle 4. Therefore, the measure of angle 4 equals 141°.

8-32: 47°. The measure of angle 5 is 133°. Since angle 5 and 6 are supplementary the measure of angle 6 is 47°.

9-18: Since 100 = 10 x 10, c = 10. The number 10 is called the square root of 100.

Answers

Chapter 1

1-1: 7 5/8
1-2: 5 11/16
1-3: 2 1/2
1-4: 1 1/2
1-5: 15/16
1-6: 2 1/4
1-7: 1 2/3
1-8: 5/6
1-9: 16 3/5
1-10: 1, 2, 4, 8, and 16
1-11: 1, 2, 3, 4, 6, 8, 12, and 24
1-12: 1, 2, 4, 8 (See Note 1-12)
1-13: 1, 2, 3, 6 (See Note 1-13)
1-14: GCF=6 (See Note 1-14)
1-15: GCF=4 (See Note 1-15)
1-16: 4, 8, 12, 16, 20, 24, 28, 32, 36, 40 (See Note 1-16)
1-17: 6, 12, 18, 24, 30, 36, and 42
1-18: 12, 24, 36 (See Note 1-18)
1-19: 12 (See Note 1-19)
1-20: 36 (See Note 1-20)
1-21: 42
1-22: 9/16
1-23: 5/5 or 1 (See Note 1-23)
1-24: 15/20=3/4 (See Note 1-24)
1-25: 18/24=3/4
1-26: 13/9= 1 4/9 (See Note 1-26)
1-27: 1 3/11
1-28: 2 3/6=2 1/2
1-29: 5
1-30: 44/32=1 12/32= 1 3/8
1-31: 2 8/25
1-32: 5 50/100=5 1/2 (See Note 1-32)
1-33: 5 6/5=6 1/5
1-34: 10 12/16=10 3/4
1-35: 10 26/40=10 13/20
1-36: 20 33/15=22 3/15=22 1/5
1-37: 12 (See note 1-37)
1-38: 24
1-39: 61/36=1 25/36
1-40: 7 55/42=8 13/42
1-41: 12 26/14= 13 12/14=13 6/7

Chapter 1

1-42: 1/9
1-43: 10/42=5/21
1-44: 3/20
1-45: 0
1-46: 3 5/8 (See Note 1-46)
1-47: 6 9/16
1-48: 10 1/12
1-49: 43 4/25
1-50: 5 5/24 (See Note 1-50)
1-51: 7 7/12
1-52: 3 3/4 (See Note 1-52)
1-53: 3 5/6
1-54: 11/16
1-55: 16/25
1-56: 2 1/3
1-57: 1 1/11
1-58: 13/3 (See Note 1-58)
1-59: 53/8
1-60: 4 1/8 (See Note 1-60)
1-61: 1 5/16
1-62: 37 2/5
1-63: 25 1/2
1-64: 12 3/16
1-65: 21/40
1-66: 18 2/3
1-67: 2
1-68: 21/32
1-69: 1 2/15
1-70: 1 5/6
1-71: 35/64
1-72: 9/32
1-73: 7/64
1-74: 53/64
1-75: 7/8
1-76: 1 15/16
1-77: 1/3
1-78: 1/8
1-79: 6 1/2
1-80: 3 7/24
1-81: 5 11/16
1-82: 2 3/8
1-83: 5 15/16
1-84: 6 13/16
1-85: 5/32

Chapter 1

1-86: 1/28
1-87: 1/6
1-88: 1 1/6
1-89: 2 4/5
1-90: 1
1-91: 1 1/2
1-92: 1
1-93: 2/3
1-94: 3 1/3
1-95: 6 5/16
1-96: 5/8
1-97: 2/21
1-98: 9 1/4
1-99: 2 5/8

Chapter 2

2-1: 1.1
2-2: 16
2-3: 6.6
2-4: 1.02
2-5: 3.57
2-6: 6,842.1
2-7: 2.6
2-8: .99
2-9: 88.9
2-10: 14.5
2-11: 2.66
2-12: 460.297
2-13: 16.96
2-14: 16.2 (See Note 2-14)
2-15: 23.2
2-16: .69
2-17: 7.385
2-18: 205.85=205.9 (See Note 2-18)
2-19: 4.7671=4.767 (See Note 2-19)
2-20: 10.979
2-21: 221.025
2-22: .2314
2-23: 5,584.4
2-24: 66.4424
2-25: 43.9
2-26: 221.03
2-27: 66.4
2-28: .49
2-29: .06
2-30: 1.21
2-31: 5.8
2-32: 16.3
2-33: 9.51
2-34: 15.0
2-35: .002
2-36: 8.71
2-37: 2
2-38: 1.6
2-39: 2.9
2-40: 94.129
2-41: 7.6
2-42: 7.2
2-43: .26
2-44: 2

Chapter 2

2-45: 235.19
2-46: 64
2-47: 670.788
2-48: 19.6
2-49: 38.6
2-50: 1.61
2-51: .10
2-52: 3.88
2-53: 16.3
2-54: 41.26
2-55: 6
2-56: 89,129.80
2-57: 8,201.0
2-58: 142.8
2-59: 1.0
2-60: 10.4
2-61: 1
2-62: 2.67
2-63: .1
2-64: 3.0

Chapter 3

3-1: .6
3-2: 4.38
3-3: .462
3-4: 5.99
3-5: 5.21
3-6: 1.0
3-7: .7
3-8: 2.5
3-9: 8.43
3-10: .6
3-11: 4.32
3-12: .778
3-13: 1.88
3-14: .82
3-15: 26.2 (See Note 3-15)
3-16: .1
3-17: 1.1
3-18: 9.96
3-19: 525.60
3-20: 730.5
3-21: 16.9
3-22: 3.94
3-23: 1.2
3-24: 3.1 (See Note 3-24)
3-25: 5.9
3-26: 49.5 lbs. per cubic foot
3-27: 25.39 (See Note 3-27)
3-28: 13.39 feet
3-29: 8.58 square feet
3-30: .33
3-31: .375
3-32: 5.13
3-33: 3.625
3-34: 9.7
3-35: .43
3-36: 12.4
3-37: 6.748
3-38: 19.4
3-39: .1
3-40: 20.2
3-41: 5.2
3-42: 19.85
3-43: 194.2
3-44: 51.7

Chapter 3

3-45: .24
3-46: 3.2
3-47: 2.9
3-48: 261.9
3-49: 26.5

Chapter 4

4-1: B=130
4-2: T=1.4
4-3: A=112.0
4-4: A=20.5 square feet
4-5: A=83.4 square feet
4-6: A=60.8 square feet
4-7: A=2,038.08 square feet
4-8: A=226.5 square yards
4-9: A=244 square yards
4-10: 46.90 square feet
4-11: 357 feet
4-12: 2,211.07 feet
4-13: A=678.3 square yards
4-14: A=10,872.93 square yards
4-15: A=100 square feet
4-16: A=43.5 square feet
4-17: A=295.67 square feet
4-18: A=15.68 square feet
4-19: 33,181.00 square feet
4-20: 10,003.75 square feet
4-21: A=17.7 square feet
4-22: A=644.1 square feet
4-23: A=195 square feet
4-24: A=5.96 square feet
4-25: A=201.6 square feet
4-26: A=162.8 square feet
4-27: C=54.6 feet
4-28: C=92.3 feet
A=678.5 square feet
4-29: A=4.0 square feet
4-30: 157.0 feet
4-31: 13 square feet
4-32: A=1.6 square feet
4-33: A=70.3 square feet
4-34: A=978.6 square feet
4-35: A=19.9 square feet
4-36: 18.8 square feet
4-37: Rectangle: A=28.2 square feet
Trapezoid: A=50.4 square feet
Triangle: A=34.4 square feet
4-38: Total is 113.0 square feet (See Note 4-38)
4-39: A=22 square yards
4-40: A=545 square yards
4-41: V=53.3 cubic feet

Chapter 4

4-42: V=971.88 cubic feet
4-43: V=36 cubic yards
4-44: V=21.9 cubic yards
4-45: V=2.5 cubic yards
4-46: V=62.0 cubic yards
4-47: V=3 cubic yards
4-48: 236.4 cubic feet
4-49: 74 cubic yards
4-50: 6 cubic yards
4-51: 184 cubic yards
4-52: 307.21 cubic yards

Chapter 5

5-1: y=8
5-2: r=6
5-3: w=20
5-4: r=8
5-5: w=.90
5-6: n=12
5-7: y=4.1
5-8: r=14.214
5-9: n=7
5-10: n=12
5-11: n=6.9
5-12: n=5.84
5-13: n=11
5-14: n=12
5-15: n=4
5-16: n=12
5-17: yes (See Note 5-17)
5-18: n=18
5-19: yes
5-20: n=32
5-21: n=7
5-22: n=51
5-23: y=51
5-24: y=3
5-25: n=108
5-26: It is the solution to n/12=9
5-27: y=4.2
5-28: y=56
5-29: n=11
5-30: r=12.4
5-31: y=7
5-32: w=18.6
5-33: n=500
5-34: It is the solution to 2n+3=7
5-35: 3n=9
5-36: n=3
5-37: yes
5-38: 4n=36
5-39: n=9
5-40: n/2=5.4
5-41: n=10.8
5-42: n=5
5-43: n=84
5-44: y=153

Chapter 5

5-45: n=4
5-46: n=5
5-47: r=36
5-48: y=10.2
5-49: w=.8
5-50: n=7.0
5-51: r=3.48
5-52: w=1.3
5-53: n=1.2
5-54: y=4
5-55: y=5
5-56: w=40
5-57: m=14
5-58: y=6
5-59: n=3.43
5-60: r=4.2
5-61: n=4
5-62: n=36
5-63: w=5.1
5-64: w=.5
5-65: r=2.3
5-66: w=9.6
5-67: n=1.1
5-68: r=1.03

Chapter 6

6-1: n=8
6-2: 2/5 or 2:5
6-3: 1/6 or 1:6
6-4: 60 lbs. of sand and 40 lbs. of cement
6-5: 900 lbs. of gravel, 300 lbs. of cement, 450 lbs. of sand and 150 lbs. of water
6-6: 900 gallons
6-7: 5.2:1
6-8: 46.5 feet
6-9: 118.50 lbs. per cubic foot
6-10: .8
6-11: 7/8
6-12: 5.3:7
6-13: 6:w
6-14: 9:13
6-15: 7/9
6-16: 6:11 and 6/11
6-17: 7.23:8.98 and 7.23/8.98
6-18: 2/3=8/12
6-19: n/3=8/12
6-20: 27:36=3:4 or 27/36=3/4
6-21: 27/b=3/4 or 27:b=3:4
6-22: 11:12=n:24 or 11/12=n/24
6-23: a/14=c/7 or a:14=c:7
6-24: 5/b=c/d or 5:b=c:d
6-25: a/b=c/d or a:b=c:d
6-26: Yes, the common product is 24
6-27: They are equal
6-28: They are equal
6-29: They are equal
6-30: 2 x n=3 x 8 or 2n=24
6-31: n=12
6-32: yes
6-33: n x 20= 4 x 15 or 20n=60
6-34: n=3
6-35: It represents the solution because 3/4=15/20
6-36: n=7
6-37: n=6
6-38: 3=n (It does not matter on which side of the equation it appears; the method for solving for the unknown is the same.)
6-39: 15=n
6-40: 6=n
6-41: 6.4=n
6-42: n=1.95
6-43: n=184.5

Chapter 6

6-44: 3/1 or 3:1
6-45: 5/2 or 5:2
6-46: 1/7 or 1:7
6-47: 1/2 or 1:2
6-48: 2/3 or 2:3
6-49: 1/3 (See Note 6-49)
6-50: 50=n; therefore, 50 lbs. of fine aggregate are needed
6-51: n-288; therefore, 288 pounds of course aggregate must be added
6-52: 9.6n
6-53: n=2,260
6-54: 1,000 gallons prime needed
6-55: 750 lbs.
6-56: 1250 lbs.
6-57: 50 lbs. cement and 200 lbs. gravel
6-58: 7/10 or 7:10
6-59: 3/10 or 3:10
6-60: 1/4 or 1:4
6-61: 3/4 or 3:4
6-62: 15 lbs. of water
6-63: 15.6 lbs course and 64.8 lbs. fine
6-64: 500 lbs. cement
1,250 lbs. sand
1,500 lbs. gravel
6-65: 4:1
6-66: 6:1
6-67: 1.5:1
6-68: 15 feet
6-69: 126.0 feet
6-70: 80.2 feet
6-71: 212.8 feet
6-72: 57.0 feet
6-73: 120 pounds per cubic feet.
6-74: 82.16 pounds per cubic foot
6-75: 127.94 pounds per cubic foot
6-76: 8,056,857.60 pounds. (See Note 6-76)
6-77: 496,663.20 pounds
6-78: 58,430.96 gallons
6-79: 18,798 pounds
6-80: .9 (See Note 6-80)
6-81: 1.1
6-82: Density=173.33 lbs/cf
Specific Gravity = 2.8

Chapter 7

7-1: 150,800 cubic yards
7-2: 7.7%
7-3: 432.1 cubic yards
7-4: 14.5%
7-5: -3.6%
7-6: .20 feet
7-7: 11.1%
7-8: 56.46 feet
7-9: 60%
7-10: 62.5%
7-11: 66.7%. When changing a ratio to percent form, round your decimal to two more places than the required precision.
7-12: 54.5%
7-13: 250%
7-14: 16.2/100
7-15: 255,000 cubic yards have been removed.
7-16: 1,800 feet have been completed.
7-17: .93 pounds of fines.
7-18: 4,560 pounds of fine aggregate.
7-19: 300 pounds of cement in the mixture.
7-20: 6.6% of fines.
7-21: 25.8% cement in the mixture.
7-22: There is 15.4% cement, 38.5% sand, and 46.2% gravel in the mixture.
7-23: There are 250.00 cubic yards of uncompacted concrete needed.
7-24: There are 7.8 pounds of uncompacted soil needed.
7-25: There is 16.1% moisture in the sample.
7-26: There is 12.1% moisture in the sample.
7-27: The percent of grade is +4%.
7-28: The percent of grade is -4%.
7-29: The percent of grade is -9.2%.
7-30: The percent of grade is +14.6%.
7-31: The percent of grade from point A to point B is +4.1%.
7-32: The vertical distance is 15.6 feet.
7-33: The width is 97.1 feet.
7-34: The fall of the lane is .16 feet.
7-35: The fall of the shoulder is .50 feet.
7-36: The fall of the right lane is .49 feet.
The rise of the left lane is .49 feet.
The fall of the shoulder is .19 feet.
The rise of the right shoulder is .59 feet.
7-37: The fall is .12 feet.
7-38: The elevation of the right-hand edge is 64.51 feet and the elevation of the left-hand edge is 65.49 feet.

Chapter 8

8-1: 62°
8-2: 91°
8-3: 8° 15' 28"
8-4: 83° 15'
8-5: 38° 49' 44"
8-6: 125° 40' 18"
8-7: 10° 36' 47"
8-8: 103° 38' 42"
8-9: 77° 20' 34"
8-10: .4 square feet
8-11: Acute angle
8-12: Obtuse angle
8-13: Right angle
8-14: Right angle
8-15: 105°; obtuse angle
8-16: 90° - 47° = 43°; therefore, the angle has a measure of 43°.
8-17: 52°
8-18: 55-1/2°
8-19: 180° - 47° = 133°; therefore, the angle has a measure of 133°.
8-20: 116°
8-21: 12°
8-22: The measure of angle 2 is 71° and the measure of angle 3 is 161°.
8-23: The measure of angle 2 is 16° and the measure of angle 3 is 106°.
8-24: Since angle 1 and angle 3 are equal and the measure of angle 1 is 38°, the measure of angle 3 is 38°. (See Note 8-24)
8-25: The measure of angle 4 is 142°.
8-26: 142°
8-27: Since angle 1 and angle 2 are supplementary, angle 1 has a measure of 57°.
Since angle 1 and angle 3 are vertical angles, angle 3 has a measure of 57°.
Since angle 2 and angle 4 are vertical angles, angle 4 has a measure of 123°.
(See Note 8-27)
8-28: 115° (See Note 8-28)
8-29: 81° (See Note 8-29)
8-30: 72° (See Note 8-30)
8-31: 141° (See Note 8-31)
8-32: 47° (See Note 8-32)
8-33: 114°
8-34: 100°
8-35: The measure of angles 2, 3, 6, and 7 is 63°, and the measure of angles 4, 5, and 8 is 117°.
8-36: 3 x 60 = 180; therefore, there are 180' in 3°.
8-37: 1050'
8-38: 30'
8-39: 13'

Chapter 8

8-40: 30 x 1/60 = 1/2; therefore, 30' is 1/2°.
8-41: 1/4°
8-42: 127 x 1/60 = 2-7/60; therefore, there are 2-7/60° in 127'.
8-43: 196 x 1/60 = 3 16/60; therefore, there are 3° 16' in 196'.
8-44: 1° 27'
8-45: 1° 56'
8-46: 5 x 60 = 300; therefore, there are 300" in 5'.
8-47: 30"
8-48: 45 x 1/60 = 3/4; therefore, 45" = 3/4'.
8-49: 1/2'
8-50: 169 x 1/60 = 2-49/60; therefore, 169" = 2' 49".
8-51: 1' 18"
8-52: 61° 49'
8-53: 99° 15'
8-54: 62° 13' 14"
8-55: 79° 15' 7"
8-56: 8° 19'
8-57: 3° 3' 3"
8-58: 37° 52'
8-59: 56° 12'
8-60: 69° 17' 48"
8-61: 7° 54' 58"
8-62: 75° 43' 17"
8-63: 180 - 140 = 40; therefore, the measure of the third angle is 40°
8-64: 53° 32'
8-65: 70°
8-66: 58° 10'
8-67: 17°
8-68: 90° (the third angle is a right angle)
8-69: (measure of the central angle)/(360) = 60/360 = 1/6; therefore, the sector is 1/6 of the circle.
8-70: 3/8
8-71: Area of sector = (size of sector) × (area of circle) = 3/8 × 48 square feet = 18 square feet.
8-72: 22.7 square feet
8-73: 37.51 square feet
8-74: 34.7 square yards

Chapter 9

9-1: 11
9-2: 2.5
9-3: 10
9-4: 6.5
9-5: 20
9-6: 5.3
9-7: 52.14 feet
9-8: 57.08 feet
9-9: $6^2 = 6 \times 6 = 36$
9-10: 169
9-11: 75.69
9-12: $a^2 = 3^2 = 9$
9-13: 16
9-14: 25
9-15: 25
9-16: 5
9-17: 100
9-18: $c = 10$ (See Note 9-18)
9-19: 13
9-20: 25
9-21: 26
9-22: 15
9-23: 1.3
9-24: 2.6
9-25: 7
9-26: 2.0
9-27: 15.5
9-28: 5.8
9-29: 27.20 feet
9-30: 13.00 feet
9-31: 2.51 feet
9-32: 499.3 feet
9-33: 429.3 feet