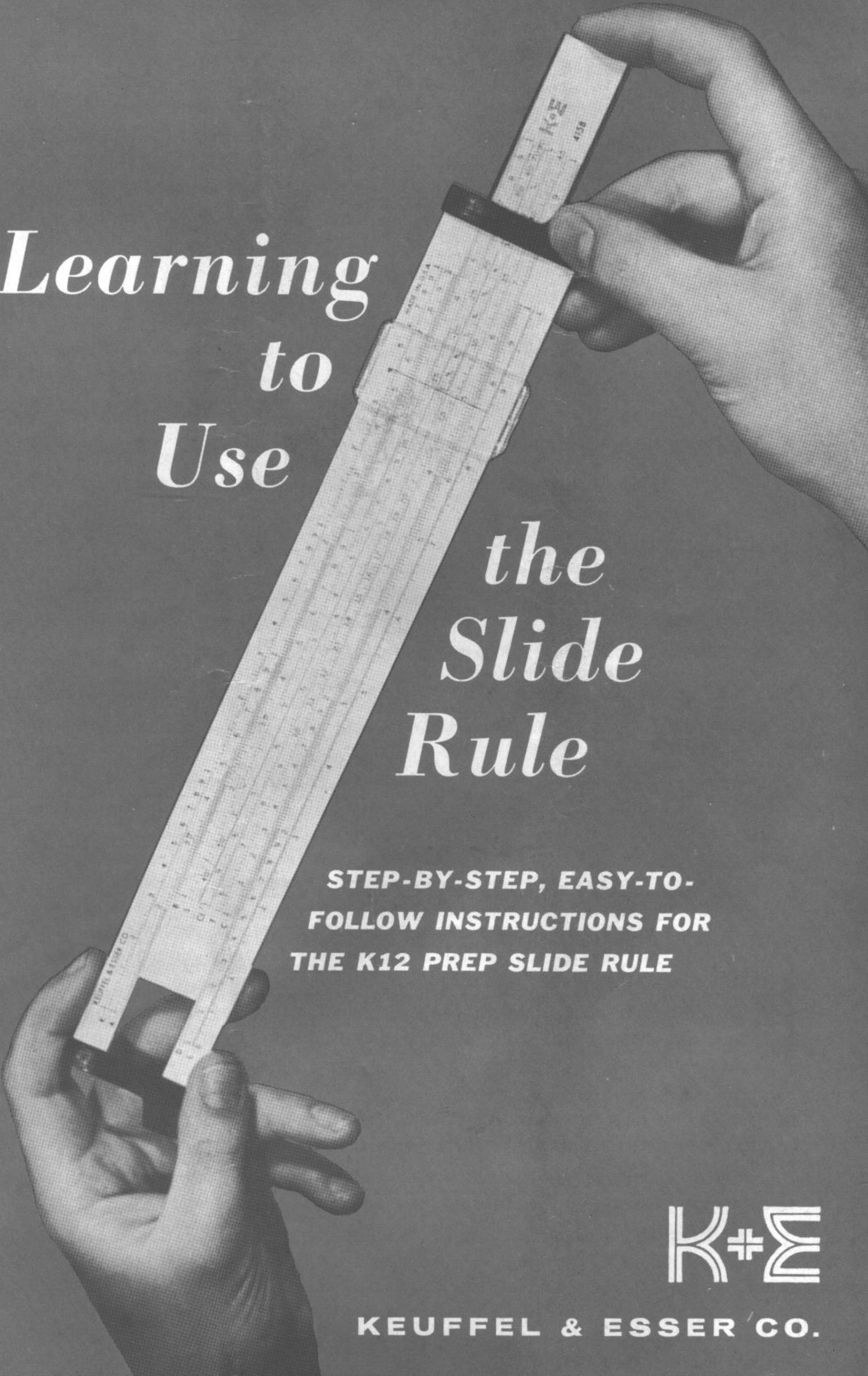
Learning to Use the Slide Rule



STEP-BY-STEP, EASY-TO-FOLLOW INSTRUCTIONS FOR THE K12 PREP SLIDE RULE

K+E

KEUFFEL & ESSER CO.

Contents

WORDS TO THE WISE...

1 Your slide rule is accurate to within a fraction of one percent. Therefore, how accurate your answers are depends largely on how carefully you make your settings and take your readings.

2 With continual practice, you'll achieve great speed in operating your slide rule. But until you're familiar with its operation, don't even think about speed. Accuracy is far more important.

3 Study the directions carefully, with great attention to every detail. It may be necessary to read the instructions over several times. But this effort will pay off in a thorough understanding of the function of the rule.

4 By all means, have the slide rule handy and actually carry out the directions, step by step, as you read them in the manual.

5 Practice makes perfect. Use your slide rule *often*.

The Slide Rule Does It Quicker!

Years ago, when the slide rule was introduced, many people said, "Why didn't they think of this sooner. It's so simple!"

You, too, will find that the slide rule is simple. You'll find it so easy and so convenient to use that you'll wish you had known about it sooner.

In a short time from now, you will be solving mathematical problems in a fraction of the time it now takes you.

In future years, whether you make a career of engineering, business, astronomy, physics, architecture, chemistry, or merchandising — in any field where numbers are used — your slide rule will save you countless hours of labor.

One important thing to remember: the slide rule is *not* a substitute for thinking. Mathematics is a creative science which demands mental effort. But the slide rule helps you take short cuts, helps speed you to a solution much faster than is possible by standard arithmetic methods.

The slide rule appears at first glance similar to an ordinary ruler. But, "there's more than meets the eye."

Actually, the slide rule is a masterpiece of efficiency which, if correctly used, makes solutions to mathematical problems pop up almost as if by magic.

Before you begin to learn the functions of this amazing instrument, you may be interested in some very basic background information.

• *In 1614, John Napier, a Scottish mathematician, theologian, and inventor, first substituted "artificial" numbers for whole numbers. These artificial values made it possible to solve many mathematical problems more easily and rapidly than ever before.*

Napier called his artificial values "logarithms", the Greek word for "ratio-number".

• *In 1620, Edmund Gunter, an English mathematician, astronomer and inventor, created Gunter's Line — a logarithmic line, 2 feet long, on which whole numbers were spaced at intervals proportionate to their respective logarithms. With this embryonic slide rule, Gunter was able to solve multiplication and division problems by manipulating dividers.*

Ten years later, William Oughtred eliminated the dividers simply by sliding Gunter's scales against each other.

The modern slide rule was born.

• *Another 220 years elapsed before the logarithmic scale was incorporated into what we now recognize as the slide rule. In 1850, Lt. Amedee Mannheim of the French Army introduced a 10-inch slide rule similar to the one you will soon learn to use.*

The Mannheim type slide rule you now have consists of three parts: a body, a slide and an indicator.

1. The body has four scales marked K, A, D and L.

2. The slide fits into, and slides in grooves on the body. The slide has the B, S, CI, T and C scales.

3. The indicator (also called the "runner") consists of a window carrying a *vertical hairline. It slides to the left or right over the face of the rule and makes readings easier.*

With the slide rule you can solve all sorts of problems in a jiffy: multiplication, division, proportion, and percentages. Also, combined multiplication-division, squares and square roots, cubes and cube roots, reciprocals, trigonometric functions . . . but first things first.

Start at the *beginning* and take the first step. You'll find yourself on the brink of an intriguing new world where math becomes fun!

Understanding Why Your Slide Rule Works...

Your slide rule is an instrument which solves mathematical problems for you by the use of logarithms.

Just as it's true that you don't have to understand the principle of the gasoline engine to drive a car, it's not necessary for you to understand the theory of logarithms in order to use your slide rule.

But, if you proceed on that basis, you'll find yourself depending blindly on rules without any appreciation of their origins or limitations.

THE THEORY BEHIND LOGARITHMS

If someone told you to solve a multiplication problem by adding, or to solve a division problem by subtracting, you might blink once or twice — and wonder how. But think about it for a moment. When you multiply 3×7, for instance, you are taking a string of seven 3's and *adding* them together. And when you divide 3 into 21, you actually *subtract* 3 from 21, seven times, don't you?

Unfortunately, adding and subtracting like this takes a lot longer than the method you are already using. But adding and subtracting is *much* faster . . . if you add or subtract logarithms instead of real numbers.

Logarithms are consistent, related values which we substitute for real numbers. Here are a few logarithmic values of real numbers:

The log*, or artificial value, of the real number 1 is 0. The log of the real number 10 has a value of 1. The log of 100 has a value of 2. The log of 1,000 is 3.

Any number falling between the real numbers 1 and 10 has a log value between 0 and 1. Any number between 10 and 100 has a log value between 1 and 2. And any number between 100 and 1,000 has a log value between 2 and 3.

For instance, the log of 1.8 is .25527. The log of 1.146 is .05918. The log of 3.3770 is .52853.

All of these, as you can see, have log values falling between 0 and 1 since their whole number values fall between 1 and 10.

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* "log" is an accepted shortcut for the word "logarithm".

Here are two simple examples of how logarithms work:

To multiply 10 x 1,000, simply *add* their logarithmic values:

$$\begin{array}{r} \text{log of } 10 = 1 \\ + \text{ log of } 1{,}000 = 3 \\ \hline 4 \end{array}$$

The logarithmic value 4 equals the natural number 10,000 — your answer.

To divide 1,000 by 10, simply *subtract* the logarithm of the divisor from the logarithm of the dividend:

$$\begin{array}{r} \text{log of } 1{,}000 = 3 \\ - \text{ log of } 10 = 1 \\ \hline 2 \end{array}$$

The logarithmic value 2 equals the natural number 100 — your answer.

You can, of course, solve these last two problems just as quickly in your head. But the logarithmic system enables you to solve problems like 3897 x 85.5 or 626 ÷ 53.3 just as quickly and easily as the simpler problems.

To do these mentally is next to impossible, and to do them arithmetically, with pencil and paper, takes much more time.

WHOLE NUMBER POSITIONS ON THE SLIDE RULE

Take a good look at your slide rule. Upon examining it, you may wonder why the whole numbers are not equidistant from each other, as the numbers on a ruler are spaced equally apart. There is a very good reason for their being spaced disproportionately to their whole number values.

To help you understand why, visualize for the moment that the slide rule scale is divided into 1,000 equal, imaginary parts.

- Since the log of 2 is .301, the number 2 is located at the 301st imaginary mark.
- Since the log of 3 is .477, the number 3 is located at the 477th imaginary mark.
- The log of 4 is .602. Thus, the number 4 is on the 602nd mark.
- The log of 10 is 1.000. Thus, the whole number 10 is at the extreme right of the rule on the 1,000th imaginary mark.

You can see then that the whole numbers on the slide rule are spaced at distances proportionate not to their real number values, but to their respective logarithmic values. Since the log of 8 is .903 and the log of 9 is .9542, whole numbers 8 and 9 are located much closer to each other than whole numbers 1 and 2 which have logarithmic values much farther apart (0 and .301).

Number Divisions on the Slide Rule . . .

It's important to become completely familiar with the number divisions on your slide rule before trying to solve any problems.

Since all scales on the slide rule are read in the same manner, we can demonstrate the system with just one scale. We'll use the D scale (exactly like the C scale) for our example:

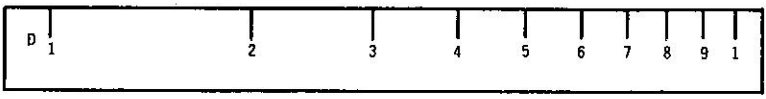

Fig. 1

The D scale of your slide rule consists of ten Primary Divisions. The spaces between these Primary Divisions are further divided into fractional elements. But it's important to note that each space does not have the same number of subdivisions. This is due to the fact that the spaces between Primary Divisions grow smaller towards the right end of the scale, and it's practically impossible to make as many divisions between 9 and 10, for instance, as there are between 1 and 2.

Fig. 2 10 spaces, each = 1

(a) The space between Primary Divisions 1 and 2 is divided into tenths. The space between each of these Secondary Divisions is further divided into tenths. Thus, there are 100 spaces between Primary Divisions 1 and 2, and *each of these Tertiary Divisions has a value of 1.*

Fig. 3 5 spaces, each = 2

(b) The spaces between Primary Divisions 2 and 3, and 3 and 4 are also divided into tenths, just as between 1 and 2. But the spaces between the Secondary Divisions are subdivided into *fifths,* not tenths. Thus, there are 50 spaces between 2 and 3, and fifty between 3 and 4. *Each of these Tertiary Divisions has a value of 2.*

Fig. 4 2 spaces, each = 5

(c) For the remainder of the scale, 4 through 10, the spaces between Primary Divisions are divided into tenths by Secondary Divisions. But the spaces between these Secondary Divisions are divided in *half,* not fifths or tenths. Thus, between 4 and 5 . . . 9 and 10 there are 20 spaces, and *each of these Tertiary Divisions has a value of 5.* This part of the scale is so condensed that it would be impossible to crowd in more subdivisions.

First Significant Figure...

Before beginning any work with the slide rule, you should understand the meaning of the term "significant figure".

DEFINITION: The first significant figure of a number is the first numeral that is *not* zero.

Thus, 2 is the first significant figure of the numbers 0.00246, 0.0246 or 2.460.

If the first significant figure is 1, the number will lie between primary divisions 1 and 2. If it is 2, the number will lie between 2 and 3. If 3, between 3 and 4, etc.

It's important that you determine the first significant figure of the number you are working with before you attempt to solve any problem.

How to Locate Numbers on the Slide Rule...

We'll use the D scale for our example. Follow each step with the hairline on your indicator.

SINGLE-DIGIT NUMBERS

Single-digit numbers are located on the Primary Divisions:

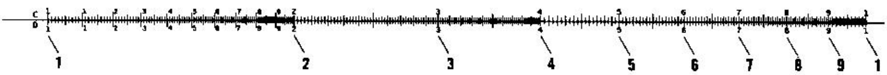

Fig. 5

TWO-DIGIT NUMBERS

Two-digit numbers are located on the Secondary Divisions.

Fig. 6

THREE-DIGIT NUMBERS

Three-digit numbers are located on or between the Tertiary Divisions.

EXAMPLE: Find the three-digit number, 246.

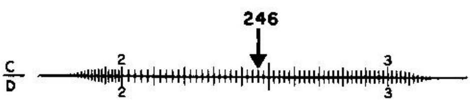

Fig. 7

1. Locate the first digit by moving the indicator to Primary Division 2.
2. The second digit, 4, is four Secondary Divisions to the right.
3. To locate the third digit, 6, move the indicator three Tertiary Divisions to the right since each of these Tertiary Divisions has a value of 2.

MORE THAN THREE DIGITS

Numbers with more than three digits need only be set to the third or fourth place, since the percentage of error in your final answer will be so tiny that it will be insignificant in most problems.

Thus, the number 186,530 should be called 186,500 and set as follows:

Fig. 8

You should practice setting and reading numbers until you feel sure that you can do so accurately and without hesitation. Then you will be ready to solve simple multiplication problems.

FOR PRACTICE, locate the following numbers:

25, 800, 760, 109, 230, 530, 18, 450, 832, 127880.

Multiplication...

The first graduation mark associated with the primary number 1 on any scale is called the index of the scale. On looking at the D scale of your slide rule, you will find it has two indices, one at the left end, the other at the right end.

RULE: *To multiply two factors, set the index of the C scale (either the left or right end) so that it is directly above one of the factors on the D scale. Move the indicator to the other factor on the C scale. Your answer will be directly below, on the D scale.*

FOR EXAMPLE: $2 \times 3 = x$

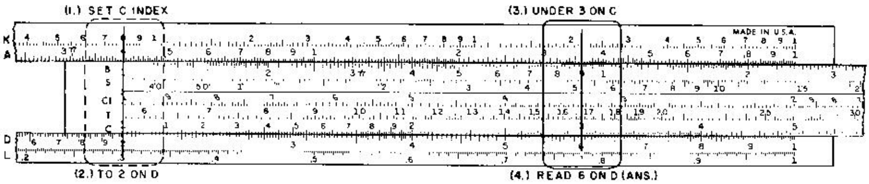

Fig. 9

1. Set the C index above 2 on D.
2. Move indicator to 3 on C. Directly below will be your answer (6) on the D scale.

ANOTHER EXAMPLE: $18 \times 26 = x$

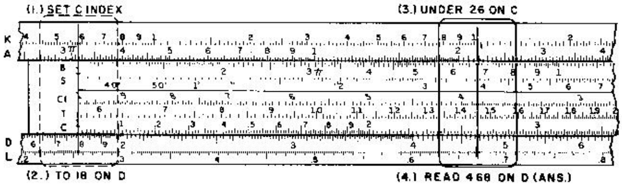

Fig. 10

1. Set the C index above 18 on D.
2. Move indicator to 26 on C. Directly below will be your answer (468) on the D scale.

ANOTHER EXAMPLE: $72 \times 51 = x$

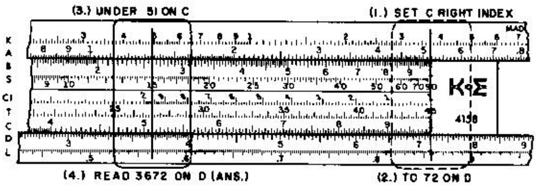

Fig. 11

1. Set the C right index above 72 on D.
2. Move indicator to 51 on C. Directly below will be your answer (3672) on the D scale.

NOTE: In making your setting to solve the last problem, the right index on C must be used, instead of the left, as was used on the first two problems. If the slide projects too far to the right when the left C index is used, use the right C index.

PRACTICE EXERCISES: Solve the following multiplication problems with your slide rule.

(1) 85×7	(3) 17×35	(5) 5×350
(2) 108×9	(4) 68×35	(6) 63×31

(Answers on page 21)

The Decimal Point: Where to Place It...

In problems involving a decimal point, make the setting in the regular way without regard to the decimal point. When your answer is obtained, the correct position of the decimal point will often be apparent. In some cases, however, you should round off your numbers and determine the correct position of the decimal point by *approximation.*

HERE'S AN EXAMPLE: 2.47 × 34.2 = x

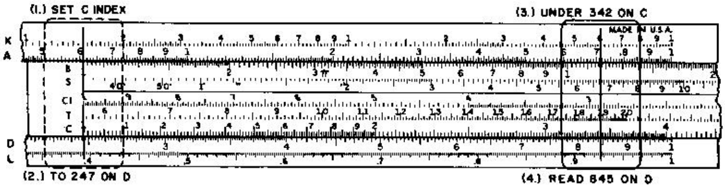

Fig. 12

1. Set the C index to 247 on D.
2. Move indicator to 342 on C. Directly below, on the D scale, will be your answer (845).

. . . *but,* is the answer 845, 84.5 or 8.45. To find out, round off 2.47 to 2 and round off 34.2 to 30. Mentally, you can easily determine that 2 × 30 = 60. Thus, your answer *must* be 84.5, which is nearer to 60 than 845 or 8.45.

With practice, you will learn to make these approximations in quick time.

PRACTICE EXERCISES: First, determine the *approximate* answers to the following problems, for the purpose of finding the position of the decimal point. Then proceed to solve with the slide rule.

(1) 38.6 × 5	(3) 0.95 × 6.2	(5) 0.08 × 2.1
(2) 40 × 5.9	(4) 3.8 × 10.5	(6) 99.5 × 0.4

(Answers on page 21)

Multiplying Three or More Factors...

Multiplying three or more factors is just as simple as multiplying two.

EXAMPLE: 642 × 3.5 × .0164 = x

First step:

Multiply the first two factors (642 × 3.5) as described on page 6.

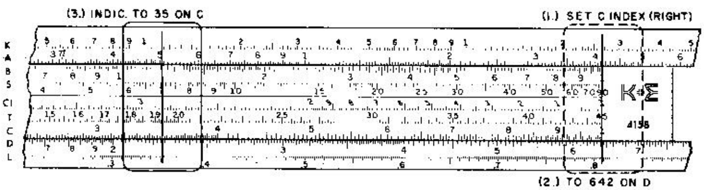

Fig. 13

1. Set the C index above 642 on D.
2. Move indicator to 35 on C. Directly below will be your product (225) on the D scale.

It's not important that you note the intermediate product (225), since you are interested only in the final product.

Your next step:

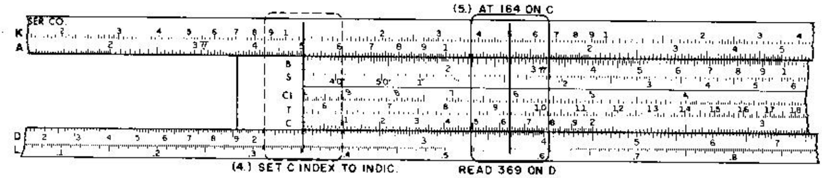

Fig. 14

1. Move the C index to the indicator (at 225 on D).
2. Move the indicator to the third factor (164) on C. Your final product (369) will be directly below on the D scale.

By rounding off your factors to 600 × 4 × .01 (24) it's certain that your answer must be 36.9, not 3.69 or 369.

You can multiply any number of factors in this manner. The position of the decimal point is easy to determine by approximation.

PRACTICE EXERCISES: Solve the following problems . . .

(1) 308 × 11 × 5	(3) 35.9 × 5 × 0.02	(5) 55 × 0.0092 × 15
(2) 495 × 3.5 × 0.4	(4) 7.15 × 1.5 × 0.08	(6) 75 × 3.12 × 0.25

(Answers on page 21)

Division . . .

Division is the exact reverse of multiplication. Refer to figure 9 on page 6, showing 2 × 3 = 6. The same setting shows 6 ÷ 3 = 2.

RULE: *To divide one number by another, set the divisor on the C scale directly over the dividend on the D scale. Read your quotient on the D scale, directly below the C index.*

EXAMPLE: 875 ÷ 35 = x

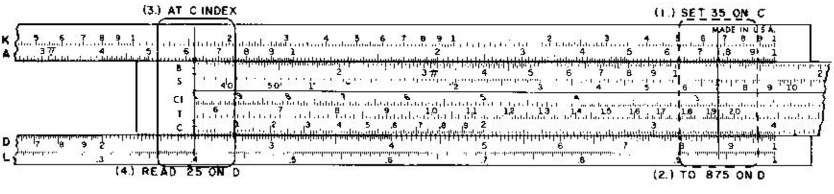

Fig. 15

1. Set 35 (your divisor) on C directly above 875 (your dividend) on D.
2. Move indicator to the C index. Directly below, on the D scale, is your quotient (25).

Determine the position of the decimal point by approximation, just as you did in multiplication. Substituting round numbers in the last problem, we see that 900 divided by 30 equals 30. Therefore, the answer must be 25 since this is closer to 30 than 250 or 2.5.

PRACTICE EXERCISES: Solve the following problems in division:

(1) 1.7 ÷ 0.85 (3) 0.5 ÷ 0.04 (5) 738 ÷ 6.15

(2) 945 ÷ 25 (4) 37.4 ÷ 6.8 (6) 71.5 ÷ 2.2

(Answers on page 21)

Solving Problems Involving Both Multiplication and Division...

With the slide rule, you can solve problems involving both multiplication and division much faster than by the standard arithmetic method. In solving problems of this type, it is not necessary to read the answer for each step. Only the *final* answer is important. Let's try one:

$$\frac{840 \times 648 \times 426}{790 \times 611} = x$$

The best way to solve problems like these is to perform one division first; then one multiplication; and to continue alternating until you've come to the end of the problem.

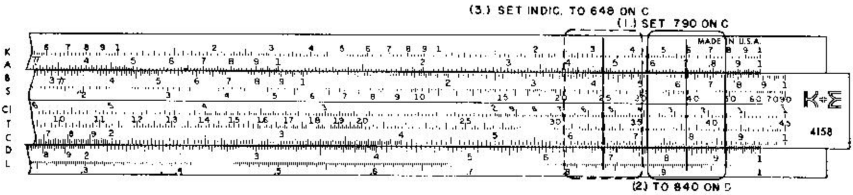

Fig. 16

1. Division: Set 790 on C above 840 on D.
2. Multiplication: Move indicator to 648 on C.

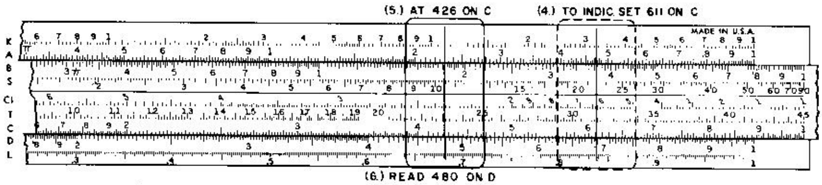

Fig. 17

3. Division: Move 611 on C to the indicator.

4. Multiplication: Move indicator to 426 on C.

5. Read your answer (480) on D.

PRACTICE EXERCISES:

(1) $\frac{7 \times 8}{5}$ (3) $\frac{45.2 \times 11.24}{336}$ (5) $\frac{47.3 \times 3.14}{32.5 \times 16.4}$

(2) $\frac{1375 \times 0.0642}{76400}$ (4) $\frac{218}{4.23 \times 50.8}$ (6) $\frac{3.82 \times 6.95 \times 7.85 \times 436}{79.6 \times 0.0317 \times 870}$

(Answers on page 21)

Proportion...

Problems in proportion are encountered daily in virtually all professions. Among problems of this type are those which call for —

(1) Converting:

- yards to meters
- kilograms to pounds
- knots to miles
- meters to feet, etc.

(2) Determining the weight of one quantity of material when the weight of another quantity of the same material is known, and their respective sizes or volumes are also known.

Use the C and D scales for proportion problems. You will find, for example, that when 2 on C is set above 4 on D, all readings on the C scale will bear a ratio of 1:2 or 2:4 with coinciding readings on D.

RULE: *With any slide setting, all coinciding readings on C and D are in the same ratio to each other.*

For your convenience, a table of Conversion Factors is shown on the back cover of this Manual.

EXAMPLE: 2.7 quarts of liquid weigh 4 lbs. What does 1.4 quarts of that liquid weigh?

Writing this in the form of a proportion, 2.7:4 = 1.4:x

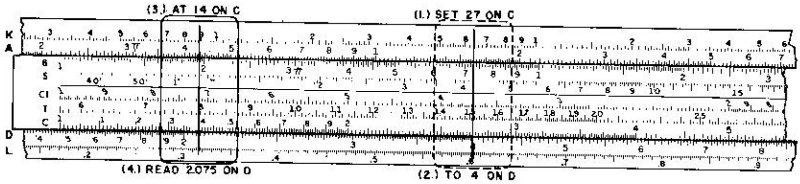

Fig. 18

1. Set 27 on C directly above 4 on D.
2. Find 14 on C and read the answer (2.075) directly below on D.

An easy method of remembering this is:

C D C D
2.7 : 4 = 1.4 : 2.075

PRACTICE EXERCISES: In the following equations find the value of the unknowns.

(1) $7 : 8 = 249 : x$ (4) $8.51 : 1.5 = 9 : x = 235 : y$

(2) $x : 5 = 78 : 9$ (5) $x : 0.429 = y : 0.789 = 2.43 : 0.0276$

(3) $2 : 3 = x : 7.83$ (6) $x : y = y : 7.34 = 3.75 : 29.7$

(Answers on page 21)

Dividing and Multiplying with the CI Scale...

Like the C and D scales, the CI scale is a single unit logarithmic scale. But the CI scale is an inverted C scale, and the numbers increase from right to left, instead of from left to right, as they do on the C and D scales.

Because of this arrangement, the values of CI and C are the *reciprocals** of each other, provided you give proper consideration to the decimal point. Note, on your rule, that 2 is opposite 5. Thus 0.5 is the reciprocal of 2 and 0.2 is the reciprocal of 5.

Dividing by the reciprocal of a number is the same as multiplying by the number itself. So any number on the CI scale may be used in multiplication in the same way that the corresponding number on the C scale is used in division.

THREE PRIMARY ADVANTAGES OF THE CI SCALE:

(1) To multiply two numbers using the CI and D scale, set one number on the CI scale opposite the other number on the D scale. Directly below the index of the C scale read the answer on the D scale. This procedure saves time, compared with using the C and D scales, since you never have to shift indices to bring the answer on the scale.

EXAMPLE: $19 \times 6 = x$

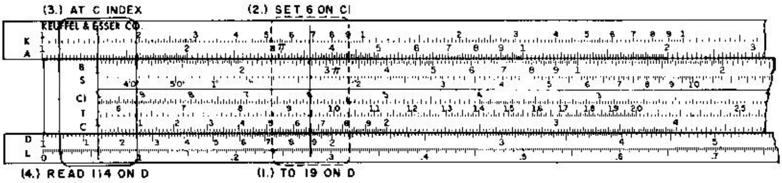

Fig. 19

1. Move 6 on CI directly over 19 on D.
2. At C index read your answer (114) on D.

(2) Another advantage of the CI scale is that it allows you to multiply three factors with a single setting of your slide.

*DEFINITION: Two numbers are reciprocals if their product is equal to 1, or we may say that the reciprocal of a number is 1 divided by that number. For example: The reciprocal of 5 is 0.2 ($5 \times 0.2 = 1$), the reciprocal of 2 is 0.5 ($2 \times 0.5 = 1$). Another example: The reciprocal of 8 is .125 ($8 \times 0.125 = 1$), the reciprocal of 125 is .008 ($125 \times .008 = 1$).

Referring back to the last problem (19 × 6), you are in position to multiply by a third factor without changing the setting of the slide. You merely move the indicator to the third factor on the C scale and read the answer on D.

EXAMPLE: 19 × 6 × 1.71 = x

First, multiply 19 × 6 as you just did. Then, move the indicator to 171 on C, directly below read your answer (195) on D.

(3) A third advantage of the CI scale is its ability to give you a series of quotients where the dividend remains constant and you have a series of different divisors.

EXAMPLE: Divide 732, in turn, by 14, 23, 32, 41 and 50.

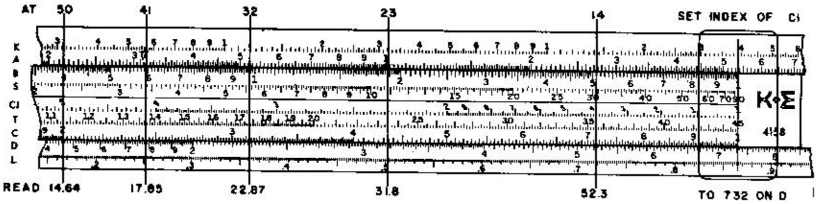

Fig. 20

Set the index of the CI scale to 732 on D. Move indicator to 14 (your first divisor) on the CI scale. Directly below, on D, is your quotient (52.3). Below the other divisors on your CI scale (23, 32, 41 and 50) read the respective quotients on the D scale (31.8, 22.87, 17.85 and 14.64).

PRACTICE EXERCISES: Using the CI scale, solve the following problems.

(1) 75 × 12	(3) 47 × 3 × 5	(5) 844 ÷ 8, 16, 2.5
(2) 47 × 3	(4) 24 × 4 × 13	(6) 19.5 ÷ 12, 15, 1.25

(Answers on page 21)

Squares and Square Roots...

Squares and square roots are probably the simplest of all problems to solve with the slide rule. And the time saved, compared to determining these values arithmetically, is considerable.

For problems of this type, you use the A and D scales. You won't need the slide of the rule at all.

SQUARES

RULE: *To find the square of a number, set the indicator over that number on the D scale. Its square will be found on the A scale under the indicator.*

EXAMPLE: Find the square of 43.8.

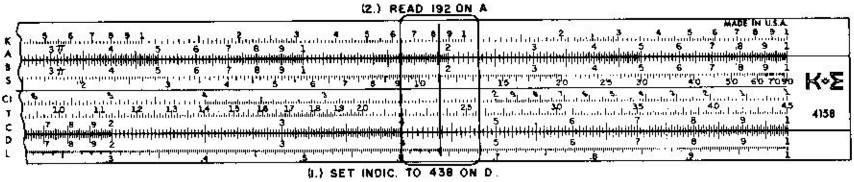

Fig. 21

1. Set indicator to 438 on D.
2. Read square (192) on A.

Determine the position of the decimal point the same way as you do in multiplication and division problems. Round off 43.8 to 40. Square it mentally and your answer is 1600. Thus the answer must be 1920, not 19200 or 192.

PRACTICE EXERCISES: Find the square, accurate to three digits, of the following numbers:

(1) 25 (2) 32 (3) 89 (4) 733 (5) 2.08 (6) 0.00356

(Answers on page 21)

SQUARE ROOTS

Square roots are found by the exact opposite method used in finding squares.

RULE: *To find the square root of a number, set the indicator over that number on the A scale. Read the square root on the D scale, under the indicator.*

At this point, locating a number on the A scale may pose a problem, because the A scale is a two section scale, with *two* sets of numbers 1 through 10.

To determine which half of the A scale to use to find the square root of a number and to locate the decimal point, here's what to do:

(1) *If your number is 1 or larger:* Space off groups of two digits, starting at the decimal point, working to your *left*. If the last group to the left has one digit, use the left half of A. If the last group to the left has two digits, use the right half of A.

(2) *If your number is less than 1:* Space off groups of two digits, starting at the decimal point, working to your *right*. If the first group with significant figures to the right of the decimal point is a one place number, use the left half of A. If a two place number, use the right half of A.

(3) *To locate the decimal point:* Working from left to right, place the first digit of your answer under the first group containing a significant figure. The second digit of your answer is placed under the next group to the right, and so on.

NOTE: Your answer must contain a digit for each group of digits in your original number. It may be necessary to add a zero to fill out the spaces before or after the decimal point.

HERE ARE SOME EXAMPLES:

a. To find the square root of	625				
Space off in groups of two	6	25			
Use left half of A. Answer on D	2	5			

b. To find the square root of	4,719,000				
Space off in groups of two	4	71	90	00	
Use left half of A. Answer on D	2	1	7	0	

A zero was added to fill out the last group before the decimal point.

c. To find the square root of	.00003721				
Space off in groups of two	.00	00	37	21	
Use right half of A. Answer on D	.0	0	6	1	

Two zeros were added to fill out the two groups after the decimal point.

PRACTICE EXERCISES: Find the square root of the following numbers:

(1) 8 (2) 12 (3) 89 (4) 8.90 (5) 890 (6) 0.0635

(Answers on page 21)

NOTE: The B and C scales on the slide of your rule may also be used to determine squares and square roots. For squares, locate your number on C and read its square on B. For square roots, locate the number on B and read its square root on C.

Cubes and Cube Roots...

The K and D scales are used to find cubes and cube roots.

CUBES

RULE: *To find the cube of a number, set the indicator to that number on the D scale. Read its cube under the indicator on the K scale.*

EXAMPLE: Find the cube of 4.38

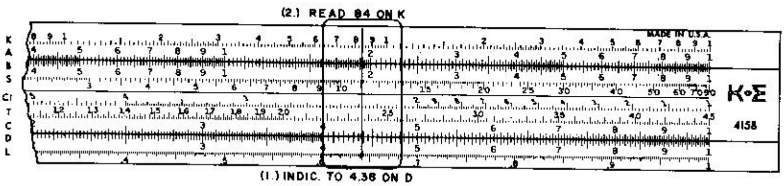

Fig. 22

1. Set your indicator to 438 on D.
2. Under the indicator on K, read your answer (84).

Cubing 4 (the round number nearest to 4.38) is $4 \times 4 \times 4 = 64$. Thus, your answer must be 84, not 8.4 or 840.

PRACTICE EXERCISES: Cube each of the following numbers, using the K scale.

(1) 2.1 (2) 3.2 (3) 62 (4) 0.452 (5) 3.08 (6) 0.0334

(Answers on page 21)

CUBE ROOTS

RULE: *To find the cube root of a number, set the indicator to that number on the K scale. Read its cube root on D, under the indicator.*

IMPORTANT: The K scale is a three section scale. To determine which section of the K scale to use, and to determine how to locate the decimal point, proceed as follows:

1. *If your number is 1 or larger:* Space off groups of three digits, starting at the decimal point, working to your *left*. If the last group to the left has one digit, use the left hand section of the K scale. If it has two digits, use the middle section; three digits, use the right hand section.

2. *If your number is less than 1:* Space off groups of three digits starting at the decimal point, working to your *right*. If the first group with significant figures to right of the decimal point is a one place number, use the left hand section of the K scale. If a two place number, use the middle section; if a three place number, use the right hand section.

3. *To locate the decimal point:* Working from left to right, place the first digit of your answer under the first group containing a significant figure. The second digit of your answer is placed under the next group to the right, and so on.

NOTE: Your answer must contain a digit for each group of digits in your original number. It may be necessary to add a zero to fill out the spaces before or after the decimal point.

EXAMPLE:

a. To find the cube root of	125
Space off in groups of three	125
Use right hand section of K. Answer on D	5

b. To find the cube root of	23,400,000		
Space off in groups of three	23	400	000
Use middle section of K. Answer on D	2	8	6

c. To find the cube root of	.000001728		
Space off in groups of three	.000	001	728
Use the left hand section of K. Answer on D	.0	1	2

A zero was added to fill out the first group after the decimal point.

PRACTICE EXERCISES: Find the cube root of the following numbers:

(1) 8.72 (2) 30 (3) 729 (4) 7630 (5) 0.0763 (6) .763

(Answers on page 21)

Trigonometry . . .

The slide rule can be used to actually solve problems involving triangles, but it is more often used to check answers obtained by other methods.

Problems of multiplication, division and proportion, in which one factor is the sine or tangent of an angle, can be quickly solved. You follow the same method as used when both factors are numbers, except now you will use the S scale in conjunction with the A and B scales, and the T scale with the C and D scales.

SINES

RULE: *To find the sine of an angle appearing on the S scale, read from S to B (See fig. 23).*

IMPORTANT: The natural sines read on the left half of the B scale have one zero between the first significant figure and the decimal point. The natural sines read on the right half of the B scale have the decimal point just before the first significant figure.

TANGENTS

RULE: *To find the tangent of an angle appearing on the T scale, read from T to C (See fig. 23).*

IMPORTANT: The natural tangents read on the C scale have the decimal point just before the first significant figure.

In problems making use of the sine or tangent scale, it's very important to take into consideration the location of the decimal point in the natural value of the sine or tangent, as this affects the position of the decimal point in the final answer.

Angles below 5° 43′, as you will note, cannot be read on the T scale. However, since the natural tangents of angles below 5° 43′, for all practical purposes, are the same as the natural sines of like angles, the left half of the S scale can be used for tangents as well as for sines, by reading from S to B.

The natural tangents of angles greater than 45° should be found by using the formula:

$$\tan x = \frac{1}{\tan(90^\circ - x)}$$

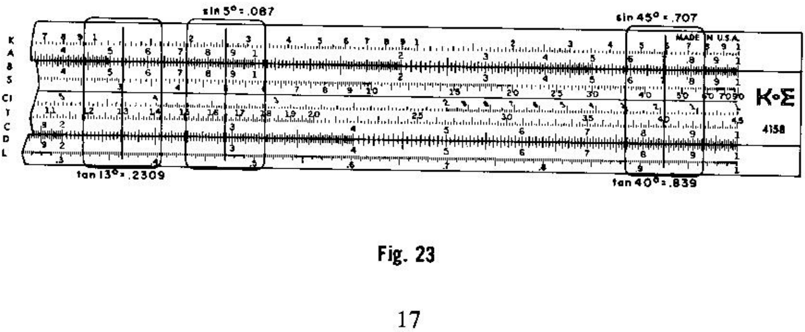

Fig. 23

Simple Problems
Making Use of the S and T Scales...

MULTIPLICATION

EXAMPLES: $4 \times \sin 11° = x$

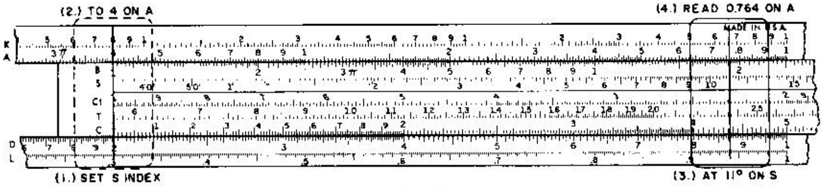

Fig. 24

1. Set the S index to 4 on A (left section).
2. Move indicator to 11° on S. Read your answer (0.764) on A.

DIVISION

EXAMPLE: $\dfrac{3}{\tan 11°} = x$

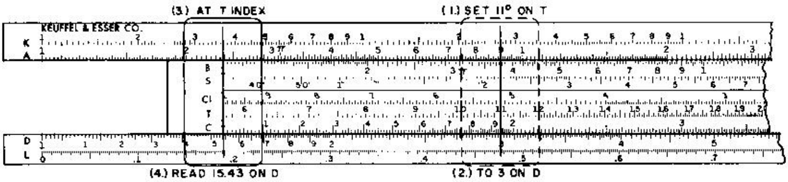

Fig. 25

1. Set 11° on T to 3 on D.
2. At T index, read your answer (15.43) on D.

PROPORTION

EXAMPLE: $\dfrac{\sin 9°}{3} = \dfrac{\sin 30°}{x}$

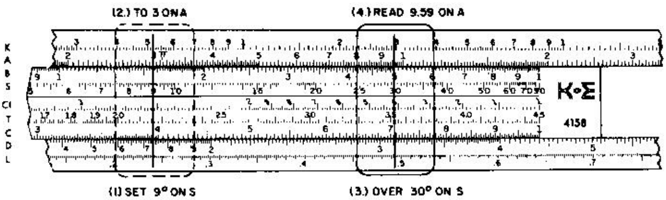

Fig. 26

1. Set 9° on S to 3 on A (left section).
2. Locate 30° on S and read your answer (9.59), above, on A.

PRACTICE EXERCISES: Solve the following problems using the S and T scales.

(1) $5 \times \sin 30°$

(2) $12 \times \tan 60°$

(3) $22 \div \sin 30°$

(4) $15 \div \tan 20°$

(5) $\dfrac{\sin 40°}{8} = \dfrac{\sin 60°}{x}$

(6) $\dfrac{\tan 25°}{15} = \dfrac{\tan x}{23.8}$

(Answers on page 21)

Solving and Checking Problems Involving Triangles...

Here is a typical right angle triangle problem, with one side and adjacent angle known:

Given $A = 32° \, 30'$
$c = 14.7$

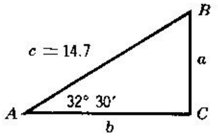

Fig. 27

Find sides a and b.

The solution using logarithms, is as follows:

$$a = 7.898 \qquad b = 12.398$$

These answers are generally checked as follows:

$$a^2 = c^2 - b^2 = (c + b)\ (c - b)$$
$$2 \log a = \log (c + b) + \log (c - b)$$
$$1.79507 = \log 27.098 + \log 2.302$$
$$= 1.43293 + .36214$$
$$= 1.79507$$

Checking this answer, as done above, takes about 10 minutes. With the slide rule it takes only a few seconds.

The sine formula, or sine law, is a proportion which expresses the relation between the known and unknown quantities, and is very convenient for slide rule use:

$$\frac{\sin A}{a} = \frac{\sin B}{b} = \frac{\sin C}{c}$$

$$B = 180° - (90° + 32° \, 30') = 57° \, 30'$$

$$\frac{\sin 90°}{14.7} = \frac{\sin 32° \, 30'}{a} = \frac{\sin 57° \, 30'}{b}$$

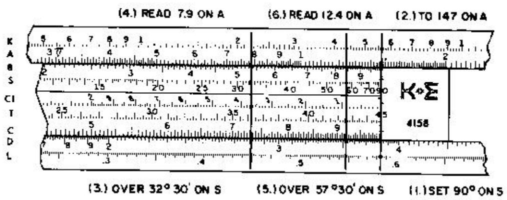

Fig. 28

1. Set 90° on S to 14.7 on A
2. Locate 32° 30′ (A) on S and read your answer on A ($a = 7.9$)
3. Locate 57° 30′ (B) on S and read your answer on A ($b = 12.4$)

We could have used the slide rule to speedily solve this problem in the first place. But it is a good general practice, for students especially, to use the logarithmic method first in order to insure complete understanding of the mathematical process involved.

When functions other than the sine or tangent are encountered make use of the following formulae to express them in terms of sine or tangent.

$$\cos x = \sin(90° - x) \qquad \sec x = \frac{1}{\sin(90° - x)}$$

$$\cot x = \frac{1}{\tan x} \qquad \csc x = \frac{1}{\sin x}$$

Thus, if we have: $3.4 \times \csc 14° = y$

make the problem read: $y = \dfrac{3.4}{\sin 14°}$

. . . and solve as follows:

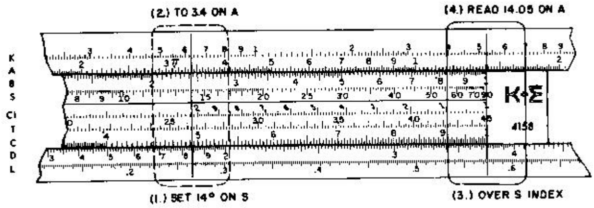

Fig. 29

1. Set 14° on S to 3.4 on A
2. Over the S index, read your answer (14.05) on A

Logarithms . . .

RULE: *To find the mantissa (fractional part) of the common logarithm of any number, set the indicator to the number on D and read the mantissa on L.*

EXAMPLE: Find the logarithm of 40

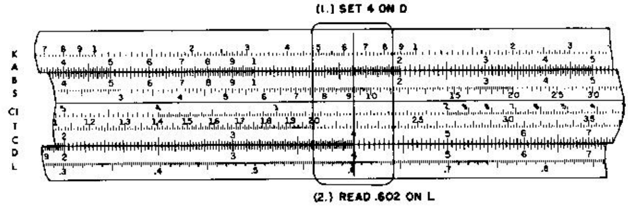

Fig. 30

1. Move the hairline to 4 on D.
2. On L, read .602, prefixing the characteristic as usual: log 40 = 1.602

PRACTICE EXERCISES: Find the logarithm of the following numbers:

(1) 32.7 (2) 6.51 (3) 980,000 (4) 72.6 (5) .432 (6) 1.6

(Answers on page 21)

Answers

Page	(1)	(2)	(3)	(4)	(5)	(6)
7	595	972	595	2380	1750	1953
8	193	236	5.89	39.9	0.168	39.8
9	16940	693	3.59	0.858	7.59	58.5
10	2	37.8	12.5	5.5	120	32.5
11	11.2	0.001156	1.512	1.015	0.279	41.3
12	x = 284.5	x = 43.3	x = 5.22	x = 1.586 y = 41.4	x = 37.8 y = 69.5	x = 0.1170 y = 0.927
13	900	141	705	1248	105.5 52.75 337.6	1.625 1.3 15.6
14	625	1024	7920	537000	4.33	0.00001267
15	2.83	3.46	9.43	2.98	29.8	0.252
16	9.25	32.8	238,000	0.0925	29.2	0.0000373
16	2.06	3.11	9.00	19.69	0.424	0.914
19	2.5	20.8	44	41.2	10.78	36° 30′
21	1.515	0.814	5.991	1.861	9.635 − 10	0.204

How to Convert Measurements Easily

The following tables show a simplified Slide Rule method of conversion from various units of measurement to others.

For instance: 1 inch = 2.54 centimeters. To convert inches to centimeters, set the Index of the C scale to 2.54 on the D scale. Then, all readings on the C scale will represent inches, and the corresponding readings on the D scale will show the equivalents in centimeters (with proper attention to decimal points).

Conversion Factors

	Set index of C scale to D scale at:	*On C scale read measurement in:*	*On D scale read equivalent in:*
LINEAR MEASURE			
1 inch = 2.54 cm	2.54	in.	cm
1 foot = 0.3048 m	0.3048	ft.	m
1 yard = 0.9144 m	0.9144	yds.	m
1 mile = 1.609 km	1.609	mi.	km
1 mile = 5280 ft.	5280.	mi.	ft.
1 naut. mile = 1.152 mi.	1.152	naut. mi.	mi.
AREA MEASURE			
1 sq. inch = 6.452 cm^2	6.452	sq. in.	cm^2
1 sq. foot = 0.0929 m^2	0.0929	sq. ft.	m^2
1 sq. yard = 0.8361 m^2	0.8361	sq. yds.	m^2
1 sq. mile = 2.59 km^2	2.59	sq. mi.	km^2
1 sq. mile = 640 acres	640.	sq. mi.	acres
1 acre = 43,560 sq. ft.	43560.	acres	sq. ft.
VOLUME MEASURE			
1 cu. inch = 16.39 cm^3	16.39	cu. in.	cm^3
1 cu. foot = 0.0283 m^3	0.0283	cu. ft.	m^3
1 cu. yard = 0.7646 m^3	0.7646	cu. yds.	m^3
MEASURE OF CAPACITY			
1 U.S. gallon = 3.785 liters	3.785	U.S. gal.	liters
1 U.S. gallon = 231 cu. in.	231.	U.S. gal.	cu. in.
1 cubic foot = 28.32 liters	28.32	cu. ft.	liters
WEIGHT			
1 pound = 0.4536 kg	0.4536	lbs.	kg
1 grain = 0.0648 g	0.0648	grains	grams
1 U.S. gallon = 8.345 lbs.	8.345*	U.S. gal.	lbs.
1 cu. ft. of water = 62.43 lbs.	62.43*	cu. ft.	lbs.

** Pure water at maximum density, 39.1° F.*

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