LEARN BASIC SLIDE RULE ON YOUR OWN

A Modern Programed Instruction Manual: Prepared and tested by Cybern-Education, Inc., for Frederick Post Company

This program was developed and produced for Frederick Post Company by

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2nd Edition

This programed manual has been refined as a result of extensive validation testing. Increased cueing via color highlights, more detailed analysis of step-by-step procedures for multiple number problems and added emphasis on estimating procedures have been introduced without changing the original format or numbering.

Edition 2 retains the original continuity as well as most problem statements and solutions. For classroom use, both editions one and two are compatible.

TABLE OF CONTENTS

When you finish this program, you will be able to use your slide rule to multiply and divide, find squares and square roots, cubes and cube roots, reciprocals, ratios and proportions. You may also learn, if you wish, sines, tangents and logarithms.

Of course, before you begin, you should be able to handle such kinds of problems using the longer arithmetic methods. In other words, your slide rule will save you time, but it will not teach you mathematics.

Does this notation form look familiar to you: $235 = 2 \cdot 10^2 + 3 \cdot 10 + 5$

How about this: $235 = 2.35 \cdot 100 = 2.35 \cdot 10^2$

Factoring numbers into groups with exponents of 10 is called Scientific Notation, and it is the key to a new easy way to learn about slide rules. You'll find an optional brief review of Scientific Notation starting on page 19.

No attempt has been made in this programed manual to go beyond fundamental slide rule operation, nor to discuss or teach the theory on which the slide rule is based. For a more detailed treatment of the subject, you will find a great deal of helpful material in the Instruction Manual accompanying the POST Versalog. This manual can be obtained through your Post dealer.

Go on to p. 3.

This program looks like a book, but don't read it like a book!
If you will think of this as a map in the form of a book, you'll get the purpose much more quickly. You see, from any one point on a map, you follow the possible roads (or direction) toward your destination and you don't worry about the other directions (or roads). This program is made up in the same way--as long as you are on the right road, you need not worry at all about the "side roads" you might be passing. If you make a "wrong" turn, be sure to read all the instructions which tell you how to go back to the right track. We all make a mistake now and then, but we don't want to repeat the same mistake. OK?

Just follow the directions at the bottom of each page you **do** read--no matter how it seems to make you skip about. Do **not** read the pages in order. In fact, the program has been planned to help you concentrate on the pages you need, saving your time by skipping the pages you don't need. When you stop, mark your place.

So, get ready with your Post 1447 Slide Rule. Work at your own rate, think about what you are doing and write your problems on separate pieces of paper, not in this program.

TURN TO PAGE 6 and begin.

If you are reading this from page 10, OK. Otherwise, you were told to begin on page 6.

The graduations on the Post 1447 Slide Rule are highly accurate, but the accuracy of the slide rule is limited to your ability to set and read the desired numbers. These are the skills you will develop as you proceed through this lesson.

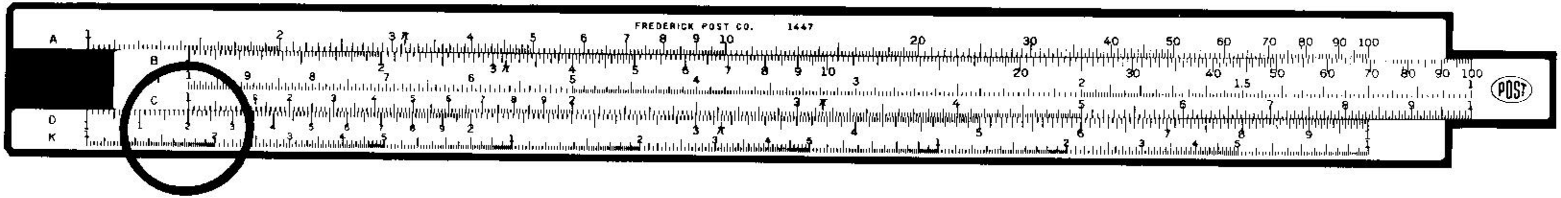
Generally, the scales should only be read to an accuracy of three significant digits. Settings as accurate as four significant digits can be made on the C and D scales for numbers having 1 as the **first digit.** Three-digit accuracy is all that is required of ordinary slide rule calculations; if just one factor in a computation contains an error larger than one part in one thousand, that determines the accuracy as a whole. So, even with three-significant-digit accuracy, your slide rule is a very practical tool. Start the lesson on how to read the C and D scales at the top of the next page. **Go to p. 5.**

When you compare your answers to the solutions in this manual, you're usually all right if the third significant digit varies by about 1, perhaps more if you have multiplied and/or divided several numbers in one problem.

Start the lesson on how to read the C and D scales at the top of the next page. **Go to p. 5.**

From p. 4.

Now let's learn how to read the scales on the slide rule. **First**, look at the left of your slide rule. You'll see there are six (6) scales on the front of the Post 1447, the A, B, CI, C, D, and K scales. The C and D scales are commonly used for multiplication and division. Look at the C and D scales in the picture below; then answer the question at the bottom of the page.



QUESTION: The **Left Index** of the C scale is at:

- The number 1.2 on the D scale .... **Go to p. 14**
- The number 2 on the D scale .... **Go to p. 12**
- Wait, I don't know what you mean by the Left Index .... **Go to p. 8**

From p. 3.

Okay. It's time to find out just **what** this program will teach you.

Upon completion of this program, you will be able to use your Post 1447 Slide Rule to:

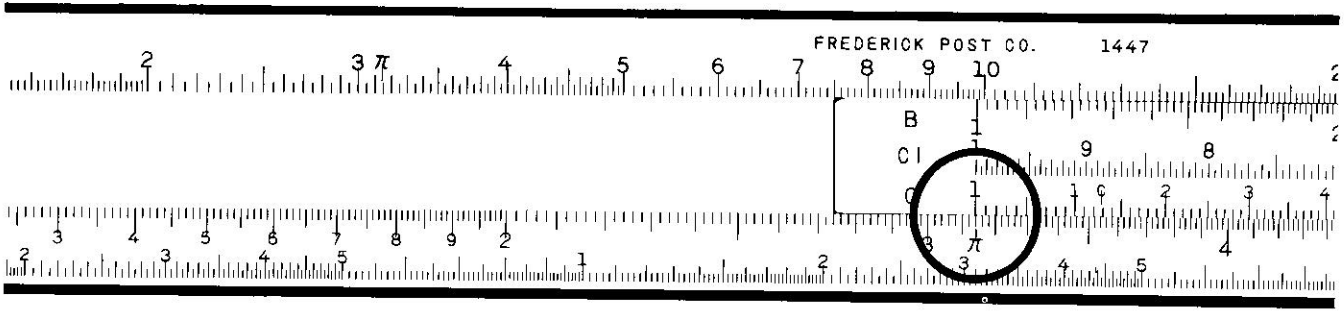
1. Multiply and divide three-digit numbers using the C and D scales.
2. Multiply and divide multiple factors (X·Y·Z) using the C, D, and CI scales (with minimum movement of the slide).
3. Find reciprocals of numbers.
4. Find ratios and proportions.
5. Determine squares and square roots using the A and D scales.
6. Determine cubes and cube roots using the D and K scales.

And, if you want to use the back of your slide, study the last three units to learn how to:

Find common logarithms using the CI and L scales.
Find sines and tangents for angle-measures and vice versa.

Now go to p. 10 and continue.

From p. 8. Your answer: Your slide rule setting is the same as this.

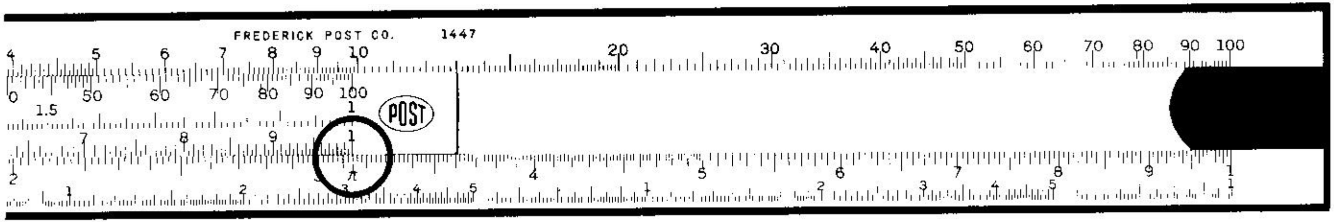


You were to set the **Right Index** of the C scale over π on the D scale. You've set the **Left Index** of the C scale at π. If you concentrate as you read, and think as you use your slide rule, you won't make mistakes like this again. Go back to page 8 and set your slide again. Return to p. 8.

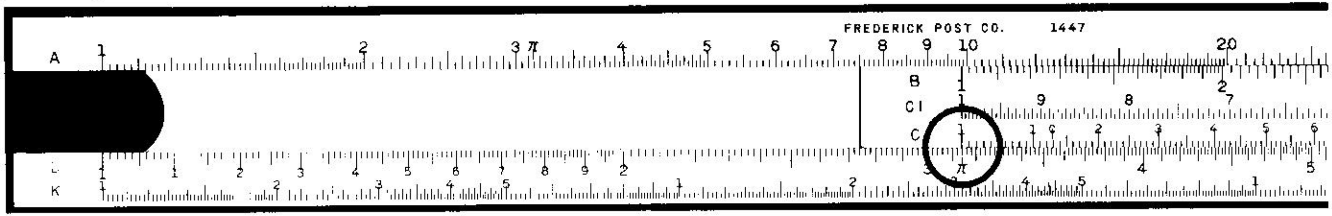
From p. 5. Your answer. Wait, I don't know what you mean by the Left Index.

All right. The number 1 on the extreme left of the C is called the left Index. Generally, each scale also has a Right Index.

PROBLEM: Set the C scale Right Index of your slide rule over the π symbol on the D scale (near the middle of your rule). Compare your slide rule setting with the pictures and then go to the appropriate page.

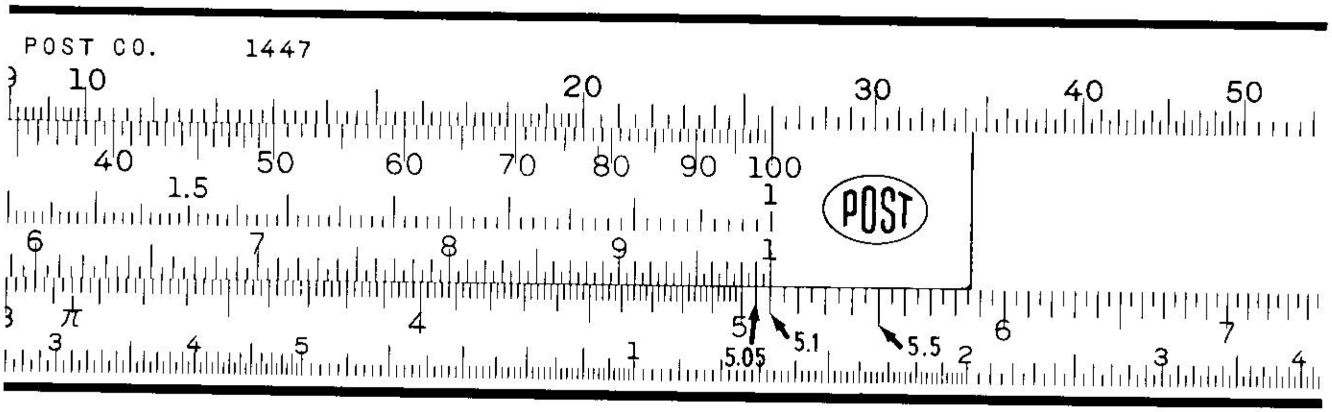


Go to p. 5



Go to p. 7

From p. 14. Your answer: Your slide rule setting for 5.2 is the same as this.



Notice that half way between the numbers 5 and 6 on your slide rule is a mark that is longer than all the rest. That much stands for 5.5. Then notice the medium length (or secondary) marks which stand for tenths, 5.1, 5.2, etc. Finally notice the short marks (tertiary) which divide the tenths in two; they stand for 5.05, 5.15, etc. When using a slide rule, you must accurately determine the value represented by each mark between the major graduations (like the ones between 5 and 6). Return to page 14 and set your slide rule correctly to 5.2. Go back to p. 14.

From p. 6.

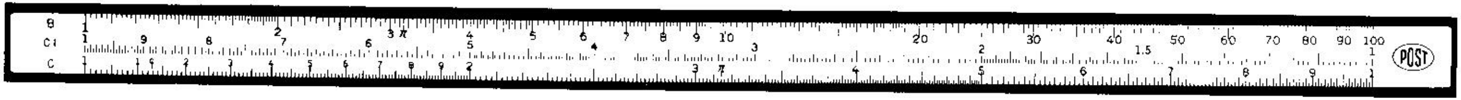
Now that you know what you are going to learn, it's time to find out how your Post 1447 Slide Rule is put together. Pick up your slide rule and perform each of the following tasks.

1. The center portion is called the **slide.** (See the top of page 11.) Push the slide to the **left** and remove it from the **body.** Place your slide over the picture of the slide on page 11.

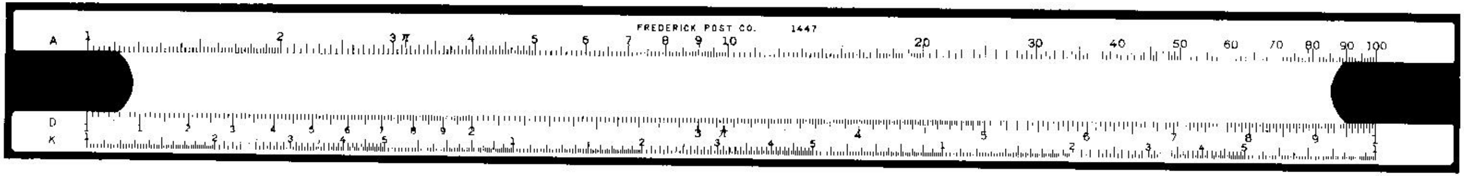
2. The **hairline** on the **indicator** helps you to read from one scale to another. The indicator can be removed from the body for cleaning whenever necessary. To remove: Push **down** on the top and pull **out** on the bottom. Place your indicator over the appropriate picture on page 11.

3. Reassemble your slide rule. Make sure that the C and D scales are matched adjoining each other. For our first look at reading the scales, we'll work without the indicator. Set it aside. . .

Turn to p. 4.

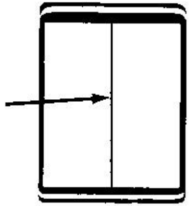


Slide



Body

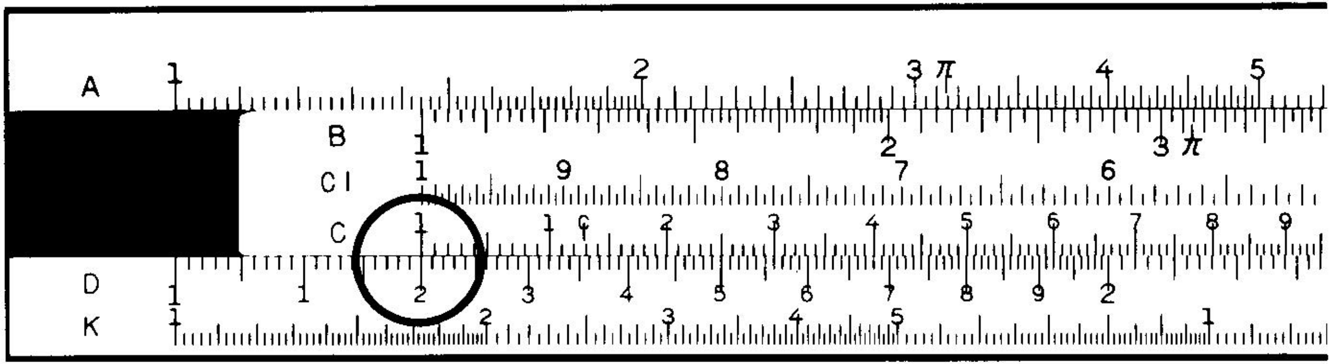
Push down to remove Indicator



Hairline

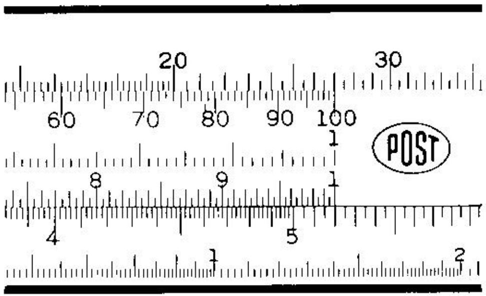
Turn to p. 4.

From p. 5. Your answer. The Left Index on the C scale is over the numeral 2 on the D scale.



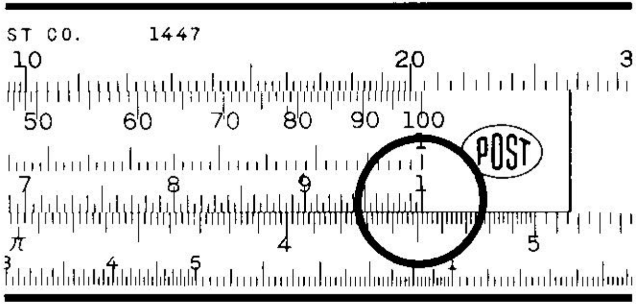
All right, you've made an honest mistake. Take a look at the entire D scale. You can see that it provides a special kind of number line which represents numerals between 1 and 10. On this number line, the spacing gets smaller as you go to the right, but you can see the difference between 2 and 1.2, can't you? Now I think you can turn to page 5 and select the correct answer. Return to p. 5.

From p. 14. Your answer: On your rule, 5.2 looks like this:

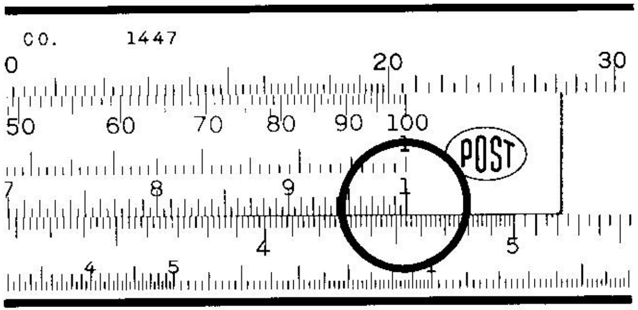


Right you are. You've just learned a very important point. Namely, when using any slide rule you must **accurately determine** the value of the marks between the major graduations. The secondary marks stand for tenths and the tertiary marks divide the tenths in two for the C-D scales between 5 and 10.

PROBLEM: Place the Right Index (C scale) of your slide rule at 4.52 on the D scale. Take your time and then compare your setting with the pictures.



Go to p. 18.

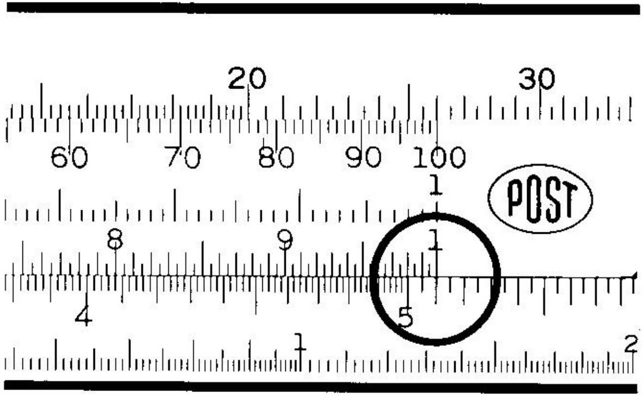


Go to p. 20.

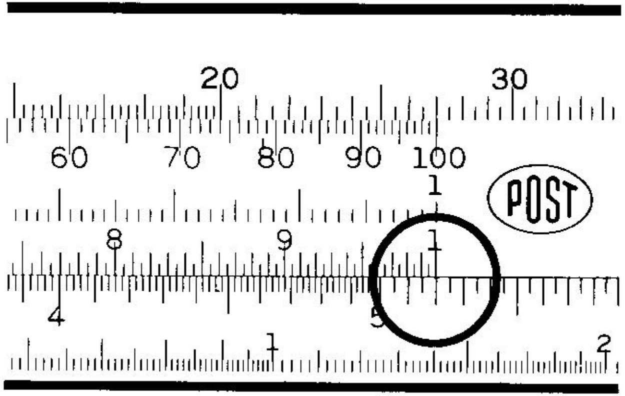
From p. 5. Your answer: The Left Index of the C scale is over 1.2 on the D scale.

Excellent! You can see that the C and D scales are special kinds of number lines which represent numerals between 1 and 10, with the spacing smaller to the right. You located the marks which stand for tenths between 1 and 2.

PROBLEM: Set the Right Index (C scale) of your slide rule at 5.2 on the D scale. Then compare your slide rule setting with the pictures and go to the appropriate page.

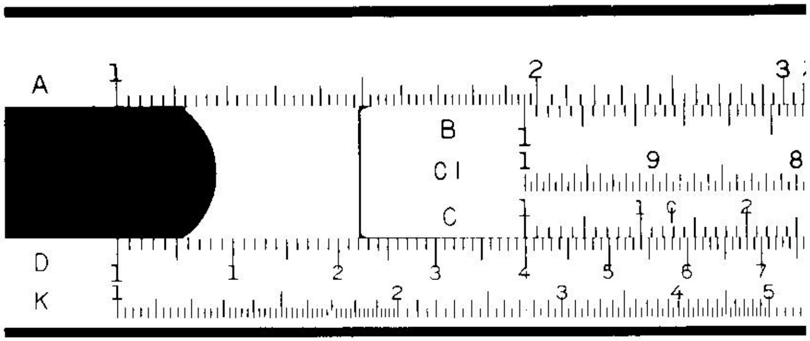


Go to p. 9



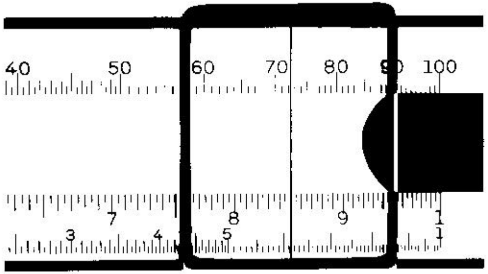
Go to p. 13

From p. 18. Your answer: Your slide rule setting for 1.4 looks like this:

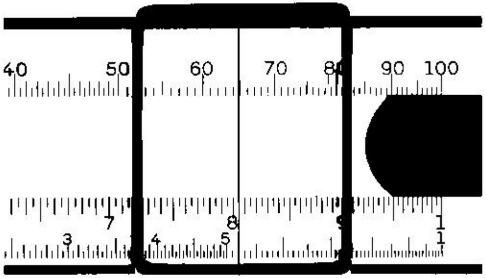


Excellent. You've remembered that there are numbered **minor** graduations between 1 and 2 on your slide rule. Now replace the Indicator (the little metal spring goes at the top of your rule, push **down** on the **top** and **in** on the bottom of the Indicator). Place the **Right Index** of the C scale over the **Left Index** of the D scale — just to get it out of the way.

PROBLEM: Place the hairline at 8.05 on the D scale. Then compare your setting with the pictures.

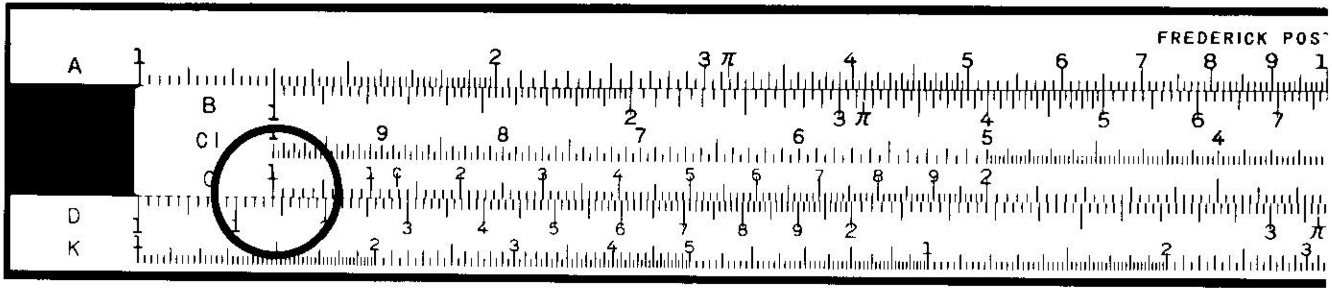


Go to p. 17.

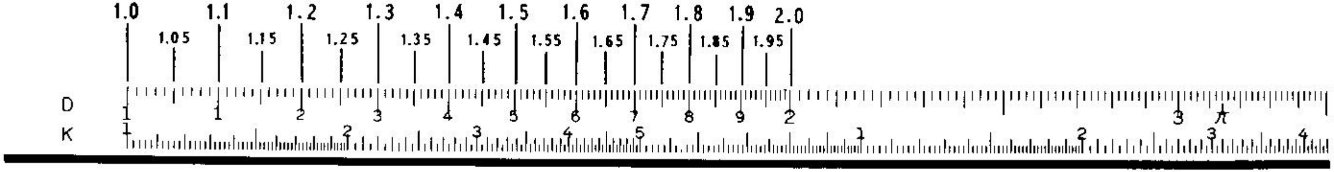


Go to p. 22.

From p. 18. Your answer: Your slide rule setting for 1.4 is the same as this.

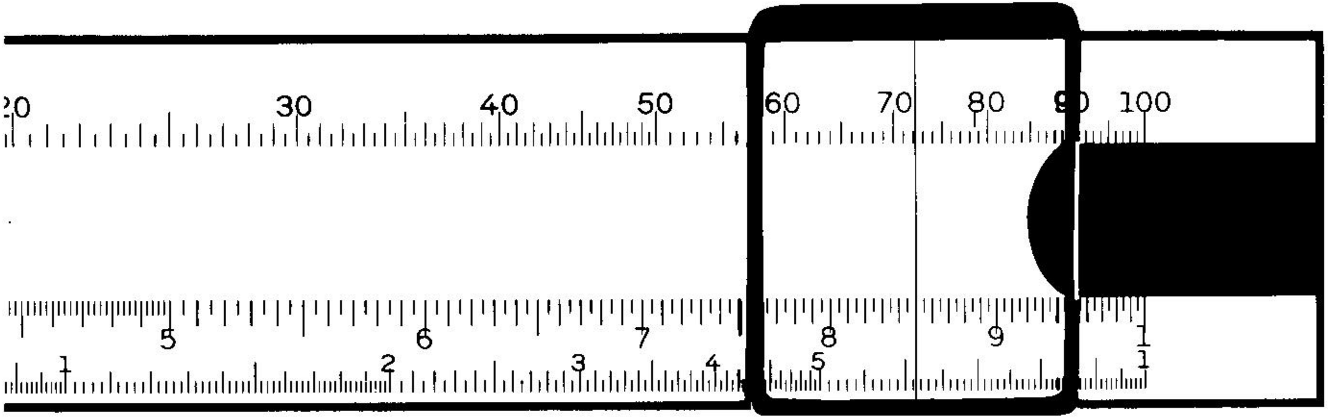


Have you forgotten that there are minor graduations between 1 and 2? You have your slide rule set on 1.14 not on 1.4. Study the following picture.



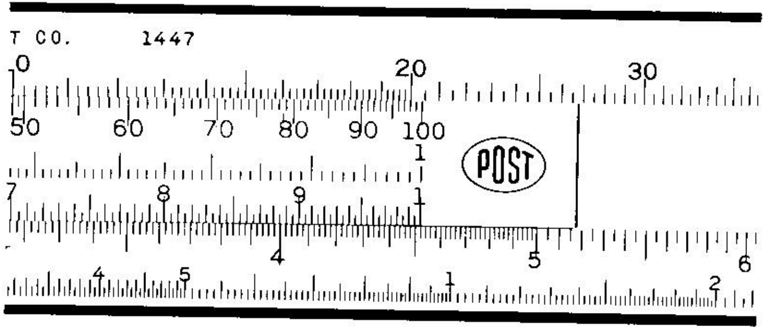
I think you can return to page 18 and correctly set your slide rule to 1.4. Go back to p. 18.

From p. 15. Your answer: Your slide rule setting for 8.05 is the same as this.



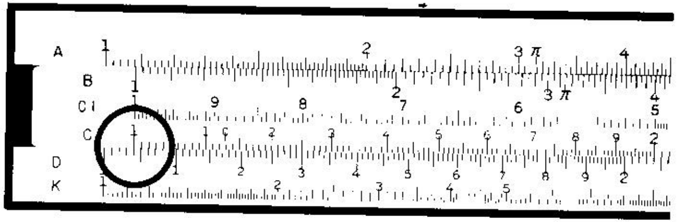
Look at your rule again. 8.05 is close to 8, but your hairline is about midway between 8 and 9. What does it indicate? 8.5, but you were looking for 8.<u>0</u>5. Turn to page 15 and correctly set your hairline to 8.05. Return to p. 15.

From p. 13. Your answer: Your slide rule setting for 4.52 looks like this:

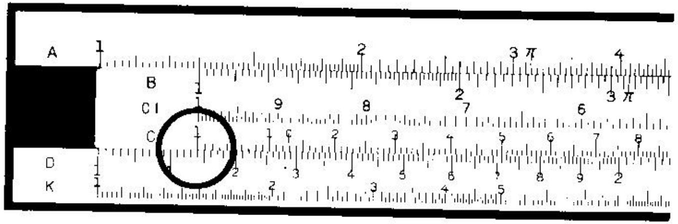


Right again. If you always remember to accurately determine the value of the scale markings you'll never have any trouble locating a numeral between 1 and 10. Let's try another problem.

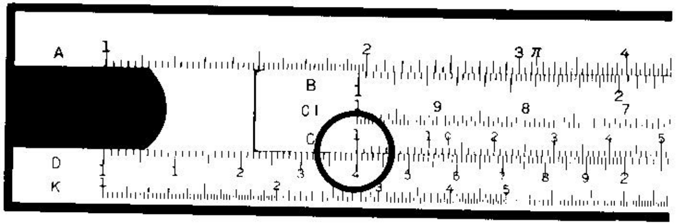
PROBLEM: Set the Left Index (C scale) of your slide rule at 1.4 on the D scale. Then compare your slide rule setting with the pictures.



Go to p. 21



Go to p. 16



Go to p. 15

From p. 23.

As you have probably noticed, all of the numbers in the problems have been between 1 and 10. This does not mean that you cannot use the Post 1447 Slide Rule to solve problems with numbers larger than 10 or smaller than 1. To do this you must first think of each number as a value between 1 and 10 times some power of ten. This is called Scientific Notation.

Problem example:

$$284 \times 692$$
$$2.84 \cdot 10^2 \times 6.92 \cdot 10^2$$
$$2.84 \times 6.92 \cdot 10^4$$

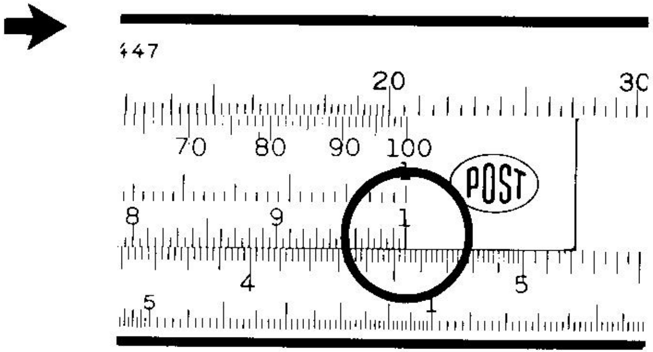
NOTE: We'll use the centered dot to mean "multiply" only when we are multiplying by a power of 10.

Decision time. Select the statement you feel is true.

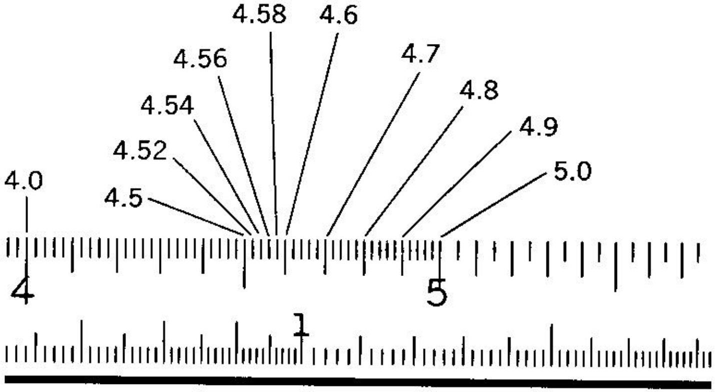
I know how to express numbers by the Scientific Notation method. **Go to p. 43.**

I would like to have a review of Scientific Notation and exponents. **Go to p. 24.**

From p. 13. Your answer: Your slide rule setting for 4.52:

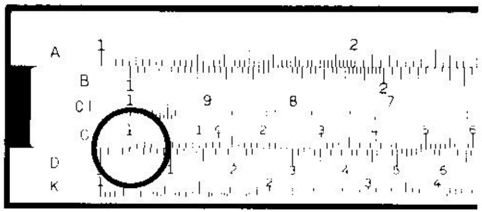


You have your slide rule set on 4.54, not on 4.52. There are five spaces between 4.5 and 4.6; therefore each space equals .02.

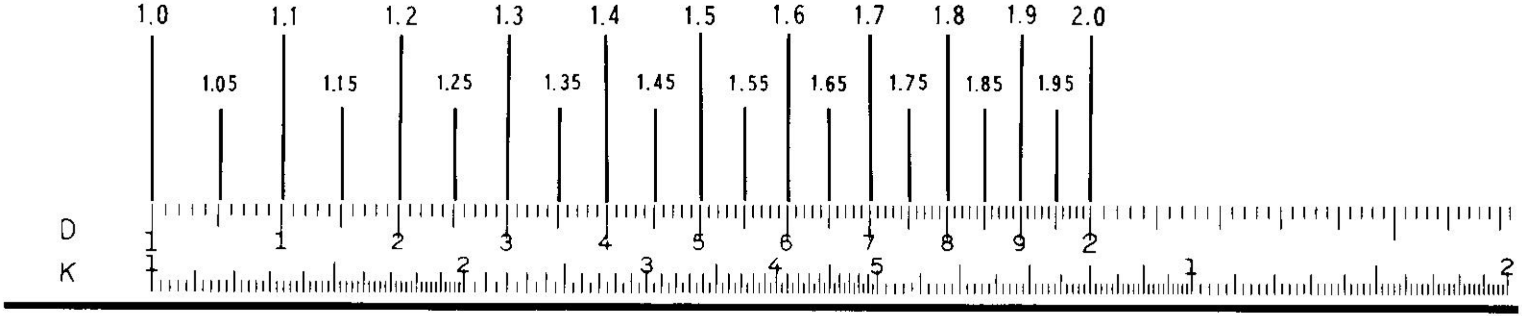


You see that you must first look at all of the markings between the major graduations (here we are using 4 and 5). Then accurately determine the value of each. Return to page 13 and set your slide rule correctly at 4.52. Go back to p. 13.

From p. 18. Your answer: Your slide rule setting for 1.4:

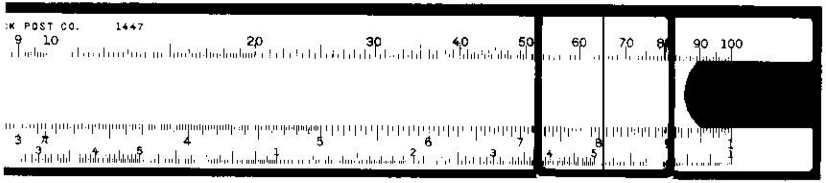


Have you forgotten that there are minor graduations between 1 and 2? You have your slide rule set on 1.04 not on 1.4. Study the following picture.



I think you can turn to page 18 and correctly set your slide rule to 1.4. Return to p. 18.

From p. 15. Your answer: Your slide rule setting is the same as this.



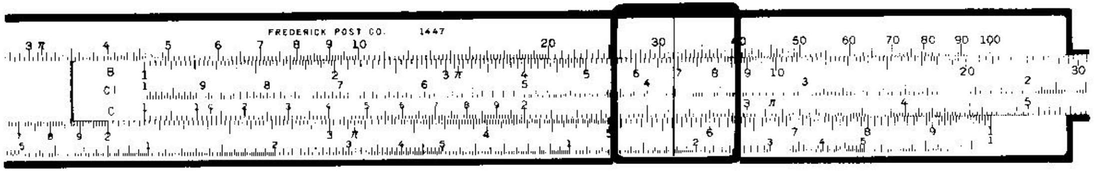
Correct. Cover all of the pictures on page 23 with a piece of paper. Solve each of the following problems. Check your settings (one at a time) by sliding down the paper covering the pictures.

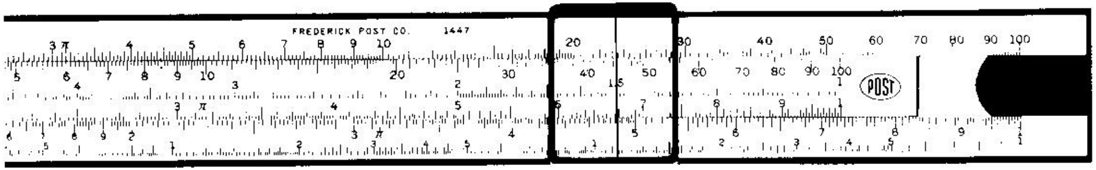
PROBLEM #1. Place the Left Index (C scale) at 2.14 on the D scale and place the hairline at 2.62 on the C scale. After you have your slide rule properly set uncover the **top** picture on page 23.

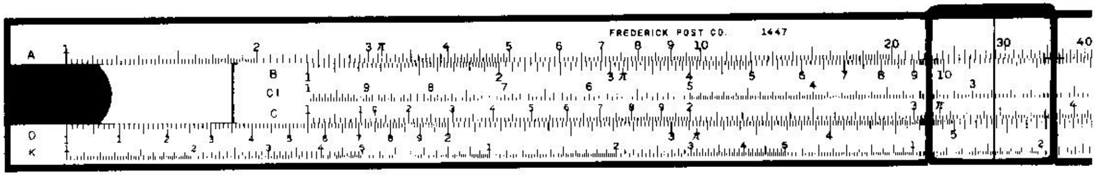
PROBLEM #2. Place the Right Index (C scale) at 7.25 on the D scale and place the hairline at 6.67 on the C scale (this one is a little hard to do). Uncover the second picture.

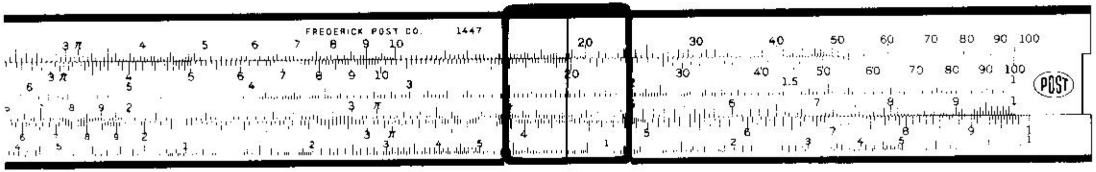
PROBLEM #3. Place the Left Index (C scale) at 1.55 on the D scale (be careful) and place the hairline at 3.46 on the C scale. Uncover the third picture and check your setting.

PROBLEM #4. Place the Right Index (C scale) at 9.73 on the D scale (think and be careful) place the hairline at 4.44 on the C scale. Remove the paper from page 23, check your answer and then read the material at the right of page 23.









Now it's time for you to make a decision. Read **each** statement and select the one that you feel is true.

1. I really need to have more practice reading the C and D scales. I would like to repeat the material covering the C and D scales.

All right. Return to p. 5.

2. I honestly feel that I can accurately locate numbers on the C and D scales.

Fine. **Go to p. 19.**

From p. 19. Your answer: I would like to have a review of Scientific Notation and exponents.

All right. Any number can be expressed as a product of some number between 1 and 10 times some integral power of 10. In other words, $a \cdot 10^x$, where $1 < a < 10$, and x is a whole number.* This expression is called Scientific Notation.

For example:

$556 =$	$5{,}560 =$	$55{,}600 =$
$5.56 \cdot 10^2 =$	$5.56 \cdot 10^3 =$	$5.56 \cdot 10^4 =$
$5.56 \cdot 100 = 556$	$5.56 \cdot 1{,}000 = 5{,}560$	$5.56 \cdot 10{,}000 = 55{,}600$

QUESTION: How would you express a number in Scientific Notation?

a. Place a decimal point so that your number is between 1 and 10; $1 < N < 10$; determine the exponent of base 10 by counting the total number of digits . . . . **go to p. 27.**

b. Place a decimal pount so that $1 < N < 10$; determine the exponent of base 10 by counting the number of places the decimal point has been moved . . . . **go to p. 29.**

c. I don't know . . . . **go to p. 31.**

* This can be read "a is greater than 1 and less than 10," or "a is between 1 and 10." To help you remember, the smaller part of the symbol ($<$) points to the smaller number.

From p. 29. Your answer: To express 4,560 x 12,600 in scientific notation it should be written as $45.6 \times 12.6 \cdot 10^5$.

Is $45.6 < 10$? Is $12.6 < 10$?

Your slide rule number lines on the C-D scales are generally read from 1 to 10. Scientific notation always has factors between 1 and 10 times an integral power of 10. Think about this for a moment. Return to page 29 and select the correct answer. Go back to p. 29.

From p. 32 or p. 35. Your answer: To express number **less than one** in scientific notation, move the decimal so that $1 < N < 10$; determine the value of the negative exponent by counting the number of places the decimal point has been moved.

Very good. You are absolutely right. Now suppose you have a multiplication problem like this: .00854 x 2,560

QUESTION: How should this problem be written?

$8.54 \cdot 10^{-3} \times 2.56 \cdot 10^{3}$. . . . . **Go to p. 33**

$8.54 \times 2.56 \cdot 10^{6}$. . . . . **Go to p. 28**

$8.54 \times 2.56 \cdot 10^{0}$. . . . . **Go to p. 30**

From p. 24. Your answer: Place a decimal point so that $1 < N < 10$; determine the exponent of the appropriate power of 10 by counting the total number of digits.

Let's see what you've said in equation form:

$$556 = 5.56 \cdot 10^3$$
$$556 = 5.56 \times 1{,}000$$
$$556 = 5{,}560$$
$$\text{But } 556 \neq 5{,}560$$

The decimal point locates the ones place so you can find your number on the slide rule C or D scale. Turn to page 24 and select the correct answer. Return to p. 24.

$\neq$ "does not equal"

From p. 26. Your answer 10^{-3} plus 10^{3} equals 10^{6}

Remember, you must add the exponents.

What is $^{-}3 + 3$? What is the sum of a number and its opposite? Right! It is zero. Now return to page 26 and select the correct answer. Go back to p. 26.

From p. 24. Your answer: Place a decimal point so that $1 < N < 10$; determine the exponent of 10 by counting the number of places the decimal point has been moved.

Excellent! That will express a number as the product of $1 < N < 10$ (a number between 1 and 10) and an integral power of 10 every time. Here's another point that will help you when expressing more than one number in scientific notation: The exponents of 10 can be added and written as a single power of 10.

For example: $255 \times 4{,}850 = 2.55 \cdot 10^2 \times 4.85 \cdot 10^3$
$= 2.55 \times 4.85 \cdot 10^5$

PROBLEM: $4{,}560 \times 12{,}600$ should be written as

$45.6 \times 12.6 \cdot 10^5$ . . . . **Go to p. 25**

$4.56 \cdot 10^3 \times 1.26 \cdot 10^4$. . . . . **Go to p. 34**

$4.56 \times 1.26 \cdot 10^7$. . . . . **Go to p. 32**

From p. 26. Your answer: $.00854 \times 2{,}560$ should be written as $8.54 \times 2.56 \cdot 10^0$

Yes, very good. You will recall that $10^0 = 1$, so $8.54 \times 2.56 \cdot 10^0$ is the same as $8.54 \times 2.56 \times 1$ or 8.54×2.56.

Here are some more examples of positive and negative exponent problems.

$.0462 \times 2850 =$	$.00642 \times 78.4 =$	$.0428 \times 5.68 =$
$4.62 \cdot 10^{-2} \times 2.85 \cdot 10^3 =$	$6.42 \cdot 10^{-3} \times 7.84 \cdot 10^1 =$	$4.28 \cdot 10^{-2} \times 5.68 \cdot 10^0 =$
$4.62 \times 2.85 \cdot 10^1 =$	$6.42 \times 7.84 \cdot 10^{-2} =$	$4.28 \times 5.68 \cdot 10^{-2} =$

Note: Setting up problems with paper and pencil helps to assure correct solutions.

QUESTION: What is the product of $5.0 \times 6.0 \cdot 10^2$?

30 . . . . **Go to p. 38**

300 . . . . **Go to p. 40**

3,000 . . . . **Go to p. 37**

From p. 24. Your answer: I don't know.

Okay. To express any number greater than 10 in scientific notation (between 1 and 10), you must first locate the decimal point.

Here's an example: 7,850 is the same as

a. 785×10 or $785 \cdot 10^1 = 7{,}850$
b. 78.5×100 or $78.5 \cdot 10^2 = 7{,}850$
c. $7.85 \times 1{,}000$ or $7.85 \cdot 10^3 = 7{,}850$

In the example above, a and b are not what we want, because we do **not** have our number **expressed** as a **value** between 1 and 10. Remember, we want to locate the decimal point so the number is between 1 and 10, written $1 < N < 10$. Return to p. 24.

From p. 29 or p. 34. Your answer: $4{,}560 \times 12{,}600$ should be written as $4.56 \times 1.26 \cdot 10^{7}$

You are right. Sometimes, you will want to express numbers less than 1 in scientific notation. This requires the use of negative exponents.

For example: $.00156 = 1.56 \cdot 10^{-3}$* $.0184 = 1.84 \cdot 10^{-2}$ $.568 = 5.68 \cdot 10^{-1}$

QUESTION: What would be a good rule to follow when expressing numbers less than 1 in scientific notation?

a. Move the decimal to the right so that $1 < N < 10$; determine the value of the negative exponent by counting the number of places the decimal point has been moved . . . . **go to p. 26**

b. Move a decimal point so that $1 < N < 10$; determine the negative exponent by counting the number of digits to the right of this decimal point . . . . **go to p. 35**

* Notice that we write the minus sign near the top of the number to show that it is part of the number, not an operating sign.

From p. 26. Your answer: $.00854 \times 2{,}560 = 8.54 \cdot 10^{-3} \times 2.56 \cdot 10^{3}$

Okay. But you are supposed to add the two exponents. As you know, $^{-}5$ plus 5 is zero. I think you can turn to page 26 and select a better answer. Return to p. 26.

From p. 29. Your answer: $4{,}560 \times 12{,}600 = 4.56 \cdot 10^3 \times 1.26 \cdot 10^4$

You are right, but if you will add the exponents of 10, you can write the problem in its simplest form. Remember that $A \cdot 10^2 \times B \cdot 10^3$ is expressed in its simplest form by adding the exponents of 10; that is, it should be written as $A \times B \cdot 10^5$ Write your answer in its simplest form and **go directly to p. 32**

From p. 32. Your answer: Move the decimal point so that $1 < N < 10$; determine the negative exponent by counting the number of digits to the right of this decimal point.

Here's something you should consider. Look at the following examples and see if your answer is correct.

2 places

$556. = 5.56 \cdot 10^2$

3 places

$.00556 = 5.56 \cdot 10^{-3}$

Move the decimal point so that $1 < N < 10$ -- until it is to the right of the first non-zero digit.

- The number of places that the decimal point is moved to the **right** gives you the value of the **negative** power of 10.
- The number of places that the decimal point is moved to the **left** gives you the value of the **positive** power of 10.

Go directly to p. 26

From p. 39. Your answer: $4 \times 5 \cdot 10^{-3} = 20{,}000$

Remember (—) means move the decimal point to the LEFT. In this problem the exponent is negative and **not** positive. It's true that $4 \times 5 \cdot 10^{3} = 20{,}000$ but our problem is $4 \times 5 \cdot 10^{-3} = ?$ I think you can correctly solve this problem now. Return to p. 39.

From p. 30 or p. 38 or p. 40. Your answer: $5.0 \times 6.0 \cdot 10^2 = 3{,}000$

Right. As you know, $10^2 = 10 \times 10 = 100$

$$\therefore \quad 5.0 \times 6.0 \cdot 10^2 = 30 \cdot 10^2 = 30 \cdot 100 = 3{,}000$$

QUESTION: What is the product of $2.0 \times 6.0 \cdot 10^{-4}$?

.0012 . . . . **go to p. 39**
.00012 . . . **go to p. 41**
.000012 . . **go to p. 42**

From p. 30. Your answer: $5.0 \times 6.0 \cdot 100 = 30$

It is true that $5 \times 6 = 30$, but you need to apply the results of the 10^2 ($10^2 = 100$).

Try it again and **go directly to p. 37**

From p. 37 or p. 41 or p. 42 Your answer: $2.0 \times 6.0 \cdot 10^{-4} = .0012$

Correct! You have observed an important point, namely, that the negative exponent tells you how many places to the **left** you must move the decimal point.

As in our example, $2.0 \times 6.0 \cdot 10^{-4} = 12.0 \cdot 10^{-4} = .0012$

QUESTION: What is the product of $4.0 \times 5.0 \cdot 10^{-3}$?

.020 . . . . **go to p. 43**
20,000 . . . . . **go to p. 36**

From p. 30. Your answer: $5 \times 6 \cdot 10^2 = 300$

Your answer suggests that either you did not apply the proper factor of 10, or you did not multiply properly.

Try it again and go directly to p. 37.

From p. 37. Your answer: $2 \times 6 \cdot 10^{-4} = .00012$

Perhaps you've written $2 \times 6 = 1.2$ and then multiplied 1.2×10^{-4} to get .00012. But is that correct? You must correctly place the decimal after the product of 2×6, which is: $2 \times 6 = 12$. Then move the decimal a total of four places. The problem is solved by multiplying $2 \times 6 = 12.$ and $12 \cdot 10^{-4} = .0012$

Think about that; then go directly to p. 39

From p. 37. Your answer: $2.0 \times 6.0 \cdot 10^{-4} = .000012$

If you're using paper and pencil to set up your work, you may have done this: 2 x 6 = 12 (that's true) then you placed the decimal in front of the first digit to read .12 (is that correct?) and then you counted four places to the left (that's okay). You should have correctly placed the decimal after the entire product of 2 x 6 to be read as 12., THEN moved the decimal a TOTAL of four places to the left. Think it over; then go directly to p. 39

From p. 19. Fine, try out your knowledge of scientific notation on the 20 problems below.

From p. 39. Your answer: $4.0 \times 5.0 \cdot 10^{-3} = .020$

Right again. $4.0 \times 5.0 \cdot 10^{-3} = 20 \times .001 = .020$

Use a separate sheet of paper to answer the following questions. Your scientific notation should look like this:

1. 256 x 4850 = *2.56* X *4.85* *·10⁵*
2. 46 x 580 = ______ X ______ ·10?
3. .00456 x 54 = ______ X ______ ·10?
4. .00275 x .0434 = ______ X ______ ·10?
5. .000184 x 46400 = ______ X ______ ·10?
6. 598 x 2.5 = ______ X ______ ·10?
7. 2.66 x 7.82 = ______ X ______ ·10?
8. 4.15 x 255 = ______ X ______ ·10?
9. 12.1 x 24.5 = ______ X ______ ·10?
10. 30600 x 4850 = ______ X ______ ·10?
11. $2.0 \times 4.0 \cdot 10^{4}$ = *80,000*
12. $1.0 \times 7.0 \cdot 10^{-3}$ = ______
13. $3.0 \times 6 \cdot 10^{-2}$ = ______
14. $5.0 \times 5.0 \cdot 10^{3}$ = ______
15. $2.0 \times 7.0 \cdot 10^{0}$ = ______
16. $3.0 \times 2.0 \cdot 10^{1}$ = ______
17. $7.0 \times 7.0 \cdot 10^{2}$ = ______
18. $4.0 \times 5.0 \cdot 10^{-3}$ = ______
19. $2.0 \times 2.0 \cdot 10^{4}$ = ______
20. $1.0 \times 1.0 \cdot 10^{0}$ = ______

Check your answers. **Go to p. 44**

Answers to Problems on p. 43

1. $2.56 \times 4.85 \cdot 10^5$	11. 80,000
2. $4.6 \times 5.8 \cdot 10^3$	12. 0.007
3. $4.56 \times 5.4 \cdot 10^{-2}$	13. 0.18
4. $2.75 \times 4.34 \cdot 10^{-5}$	14. 25,000
5. $1.84 \times 4.64 \cdot 10^0$	15. 14
6. $5.98 \times 2.5 \cdot 10^2$	16. 60
7. $2.66 \times 7.82 \cdot 10^0$	17. 4,900
8. $4.15 \times 2.55 \cdot 10^2$	18. 0.020
9. $1.21 \times 2.45 \cdot 10^2$	19. 40,000
10. $3.06 \times 4.85 \cdot 10^7$	20. 1

Decision time.

1. If you missed more than two answers, you probably need more practice on exponents and powers of 10. If you repeat the material covering exponents and powers of 10, you'll have a better understanding to use your slide rule. **Return to p. 24**

2. If you missed two or less, and if you honestly feel that you can accurately use factors and powers of 10 to express any number in scientific notation, **Go to p. 45** and continue.

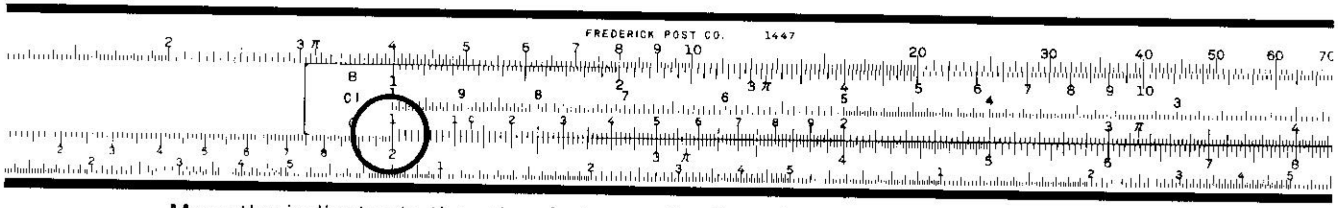
From p. 44

I think that you are ready to use your slide rule for multiplication. Start with the C & D scales.

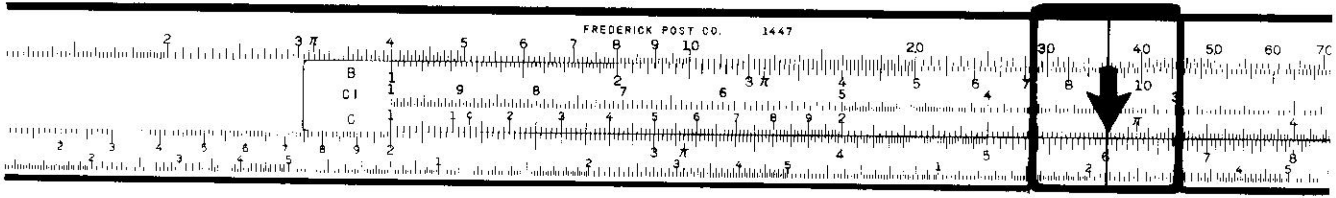
PROBLEM: Find 2 x 3 = ?

Set the C scale index to one factor on the D scale.

> **NOTE:** As you know, multiplication is commutative -- that is, 2 x 3 gives the same answer as 3 x 2. If your slide rule does not always match the pictures, you may have started the other way. If your answer is OK, don't worry about it.



Move the indicator to the other factor on the C scale.

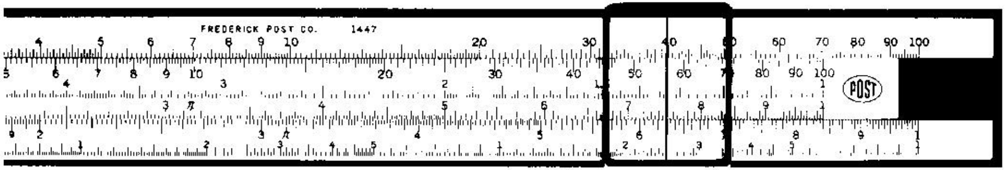


Read the answer at the hairline on the D scale, 2 x 3 = 6 Wasn't that easy?

All right, try another on your rule. Find 2 x 4 = ?

If your answer is 8, **turn to p. 48**   If your answer is 2, **turn to p. 52**

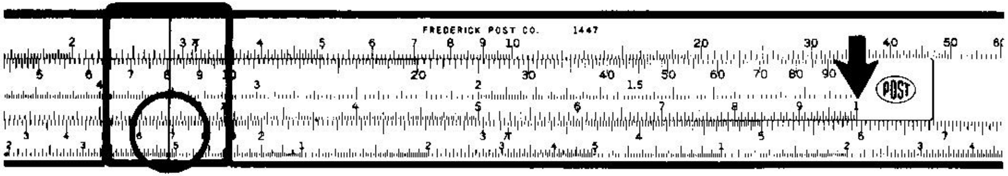
From p. 48. Your answer:
$8.4 \times 7.5 = 63.0$
Check by estimating:
[$\sim 8 \times 8 = 64$]



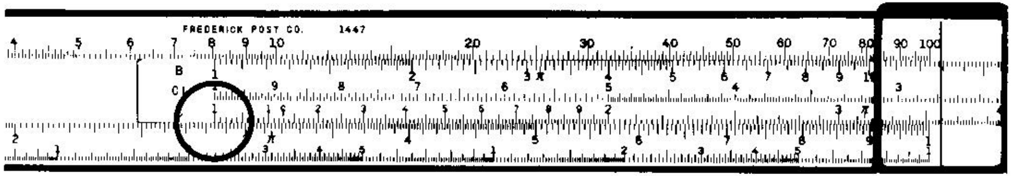
QUESTION: Which picture does your slide rule match?

Very good. Now here's another problem: Find $284 \times 595 = ?$

1. Express in scientific notation:
   $2.84 \cdot 10^2 \times 5.95 \cdot 10^2$
2. Estimate the slide rule product:
   [$\sim 3 \times 6 = 18$]
3. Calculate $2.84 \times 5.95 \cdot 10^4 =$
   (Remember the index factor)
   Check your slide rule setting with the pictures; then answer the question.



The product is 16,900 . . **Go to p. 49.** The product is 169,000 . . **Go to p. 50.**



I've got trouble . . . **Go to p. 54.**

From p. 50 Your answer: $.00865 \times 71.5 = .0618$

Let me show you what you might have done to get such a result.

a. $.00865 \times 71.5 = 8.65 \cdot 10^{-3} \times 7.15 \cdot 10^{1} = 8.65 \times 7.15 \cdot 10^{-2}$ (correct).

b. Estimate the slide rule product: [$\sim 9 \times 7 = 63$]

c. You multiplied using the Right C index. If you placed the decimal point after the **first** digit, this lead you to . . .

d. $6.18 \cdot 10^{-2} = .0618$. Is that correct? You should have found . . .
e. $61.8 \cdot 10^{-2} = .618$ Do you know why? Because 8.65 (at Right C index) x 10 x 7.15 = 61.8
And that checks with your estimate, 63.

Go directly to p. 55

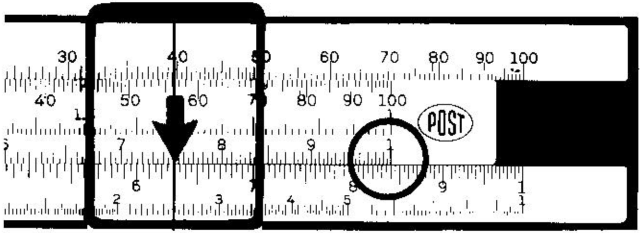
From p. 45 Your answer: 2 x 4 = 8. You knew that was correct, but you found it properly on your rule. Good.

For some problems, you will use the **right** index of the C scale instead of the **left** index. How do you decide?

Some people try* the left C index first; if it doesn't work, they use the right C index, the one that stands for 10 on your special number line. When you use the right C index, you will read the 10 into your problem: A x 10 x B. Your product: $10 < P < 100$.

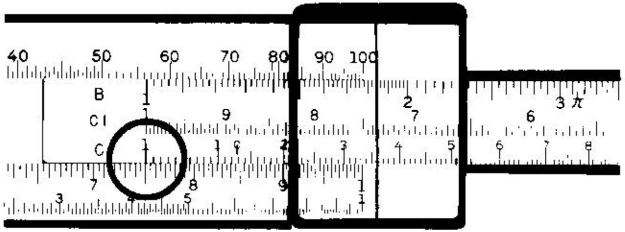
PROBLEM: Find 8.4 x 7.5 = ?
Write estimate [~ 8 x 8 = 64]
(~ indicates a rounded-off problem)

You should estimate your product, then calculate, remembering the index factor. With your estimate, check the decimal placement.



If your rule looks like this, and your answer is 63.0,
Go to p. 46

If your answer is 6.3,
Go to p. 51

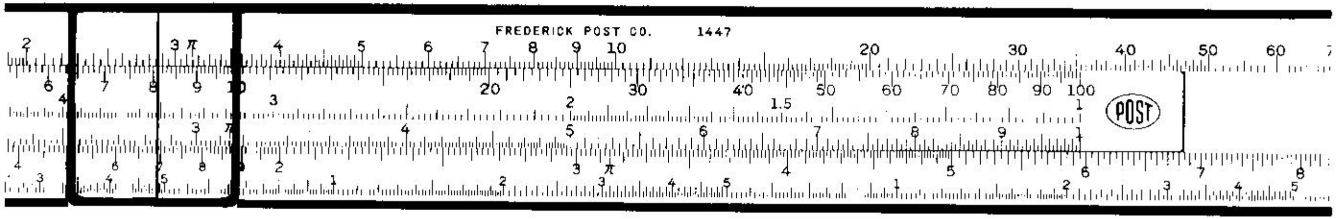


If your rule looks like this, you've got troubles.
Go to p. 53

*NOTE: If you want a procedure, go to page 53.

From p. 46. Your answer: 284 x 595, the rule looks like this, and the product is 16,900

Consider Right C Index as "x10"



10< Product <100

CHECK BY ESTIMATING
$2.84 \times 5.95 \cdot 10^4 =$
$[\sim 3 \times 6 = 18]$
$= 16.9 \cdot 10^4$

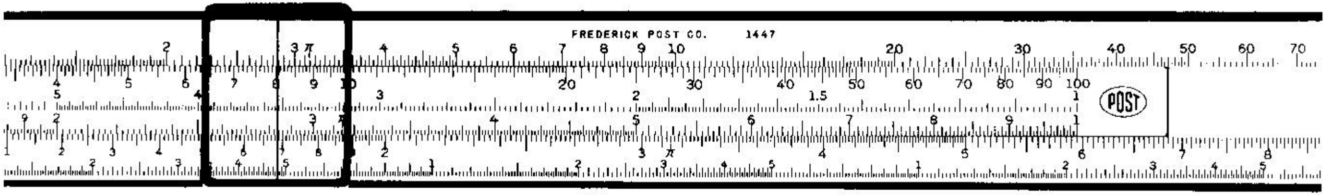
That is good handling of your rule, but perhaps you have read the product, 2.84 x 5.95 = 1.69. You may be thinking of the D scale as a number line between 1 and 10, but when you multiply, you must consider the Right C Index as "x10." So your product should be read x10.

Read 16.9, not 1.69 or 169. Your product is between 10 and 100, checked by your estimate, 18.

Now, apply your exponent, $16.9 \cdot 10^4 = 169{,}000$.

Consider this as you look again at your problem on the rule and go directly to p. 50.

From p. 46 or p. 49. Your answer: 284 x 595 = 169,000



Correct. $2.84 \times 5.95 \cdot 10^4 = 16.9 \cdot 10^4 = 169{,}000$
[$\sim$ 3 x 6 = 18]

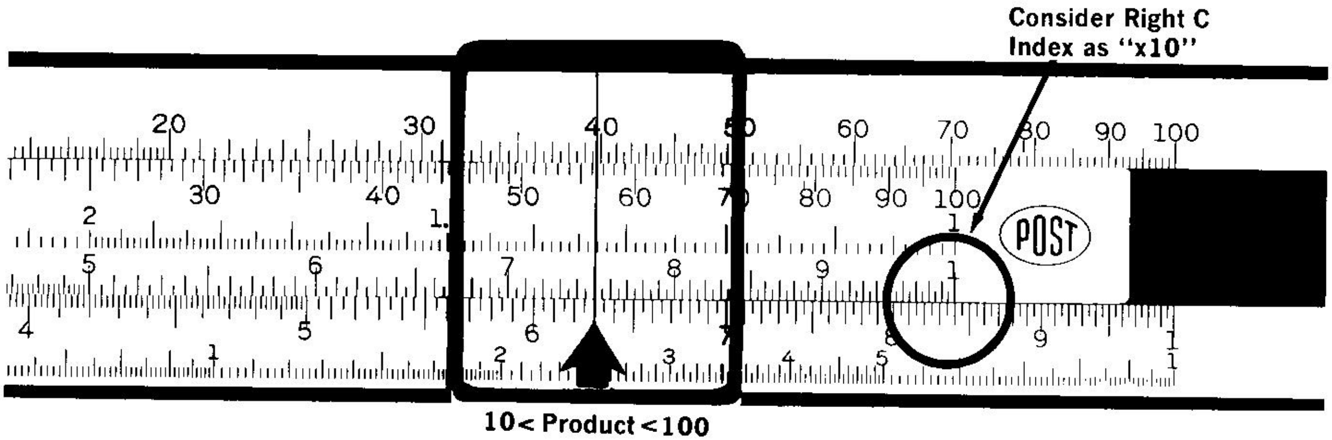
Now let's try a problem with negative and positive exponents.

PROBLEM: Multiply .00865 x 71.5 = ?

Steps 1. Express each factor as a value $1 < N < 10$, times 10^x
2. Estimate the slide rule product.
3. Calculate the answer, remembering to use the index factor.
4. Apply the exponent and place the decimal in the final product.

QUESTION: If you think .00865 x 71.5 = .618, **go to p. 55**
If you think .00865 x 71.5 = .0618, **go to p. 47**

From p. 48. Your answer. 8.4 x 7.5 = 6.30



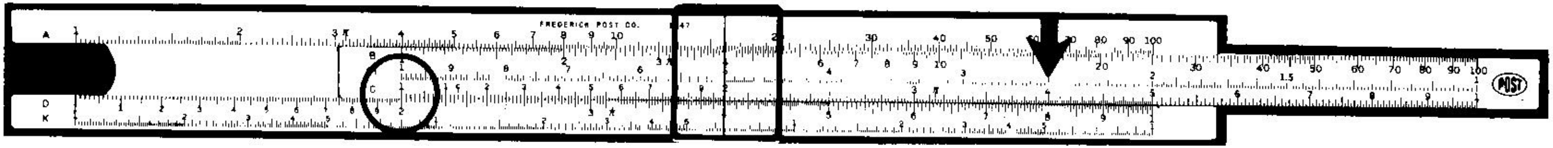
You did use the Right Index (correct). But remember the Right Index stands for 10, so you should read the 10 into your problem. In this case, you can think of it as "8.4 x 10 x 7.5"

You can check yourself by remembering: Using the Right C scale index makes product: 10<p<100.

Your estimate [~ 8 x 8 = 64] confirms your slide rule as 63, not 6.3

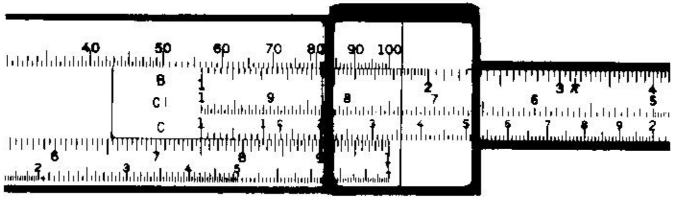
Return to p. 48

From p. 45. Your answer: Your rule looks like this and 2 x 4 = 2



Let's see if we can straighten you out. You have the Left C Index on 2 (that's a good start). But your indicator should be at **4** on the C scale. And you will read your answer on the D scale. I think you will do well to review the multiplication procedure, so return to p. 45.

From p. 48- Your answer: Like this, and you've got troubles.



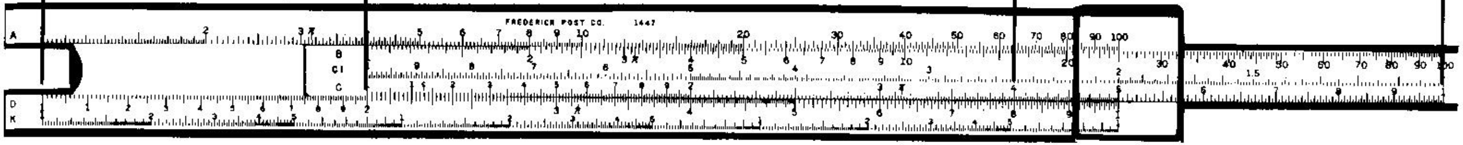
Okay. Your troubles are easy to correct. You can't move the hairline to the second factor. So try the **Right** C Index.

If you want a procedure, try this:
Compare the two factors, each in relation to its index.

smaller factor is closer

Find 2 x 4 = ?

larger factor is farther



Use **Left** C Index.
It stands for 1.
Read the product:
1< P <10.
2 x 4 = 8

smaller factor is farther

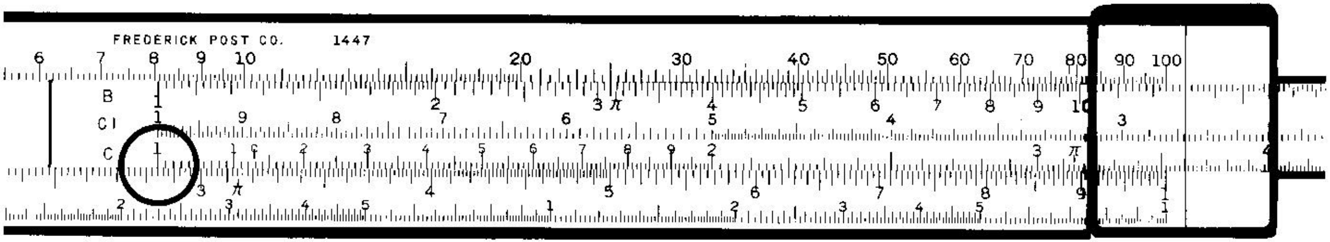
Find 2 x 6 = ?

larger factor is closer

Use **Right** C Index.
It stands for 10.
Read the product:
10< P <100.
2 x 6 = 12

Return to page 48 and use the correct index of the C scale to solve the problem. Return to p. 48.

From p. 46. Your answer: 284 x 595 = ? Slide rule looks like this and I've got trouble.



Yes indeed. Your trouble is that you are not using the correct C index.

Return to page 46 and solve the problem by using the correct C index. Go back to p. 46.

From p. 50 or p. 47. Your answer: The product of .00865 x 71.5 = .618

Excellent. You have followed the steps as outlined:

1. $.00865 \times 71.5 = 8.65 \cdot 10^{-3} \times 7.15 \cdot 10^{1}$
   $= 8.65 \times 7.15 \cdot 10^{-2}$
2. [~ 9 x 7 = 63]
3. $= 61.8 \cdot 10^{-2}$
4. = .618

Remember, if you can use your slide rule to multiply 2 x 4 = 8 and 2 x 6 = 12, you can use the same procedures to multiply any of these numbers.

Solve each of the following problems. On a separate sheet of paper, record your scientific notation and your slide rule estimate, as well as your answer.

1. 945 x 360 = $9.45 \times 3.60 \cdot 10^{4}$ = $34.0 \cdot 10^{4}$ = 340,000
   [~9 x 4 = 36]
2. .72 x .695 = ________
3. 145 x 40 = ________
4. 8.35 x 3.50 = ________
5. .21 x .25 = ________
6. 185,000 x 33,000 = ________
7. 7650 x 392 = ________
8. 2 x 2 = ________
9. 95 x 59 = ________
10. 8,250 x 182 = ________

Turn to p. 56 when finished.

From p. 55 Here are answers to the problems, written so you can check your steps

1. $945 \times 360 = \underline{340,000}$

2. $.72 \times .695$

   $7.2 \times 6.95 \cdot 10^{-2} =$
   $[\sim 7 \times 7 = 49]$
   $50.0 \cdot 10^{-2} = \underline{.50}$

3. 145×40

   $1.45 \times 4.0 \cdot 10^{3} =$
   $[\sim 1 \times 4 = 4]$
   $5.8 \cdot 10^{3} = \underline{5800}$

4. $8.35 \times 3.50 = \underline{29.2}$

   $[\sim 8 \times 4 = 32]$

5. $.21 \times .25$

   $2.1 \times 2.5 \cdot 10^{-2} =$
   $[\sim 2 \times 3 = 6]$
   $5.25 \cdot 10^{-2} = \underline{.0525}$

6. $185,000 \times 33,000$

   $1.85 \times 3.3 \cdot 10^{9} =$
   $[\sim 2 \times 3 = 6]$
   $6.1 \cdot 10^{9} = \underline{6,100,000,000}$

7. 7650×392

   $7.65 \times 3.92 \cdot 10^{5} =$
   $[\sim 8 \times 4 = 32]$
   $30.0 \cdot 10^{5} = \underline{3,000,000}$

8. $2 \times 2 = 4$ (Not 3.99! Estimate so your answers make sense.)

9. 95×59

   $9.5 \times 5.9 \cdot 10^{2} =$
   $[\sim 10 \times 6 = 60]$
   $56.0 \cdot 10^{2} = \underline{5600}$

10. 8250×182

    $8.25 \times 1.82 \cdot 10^{5} =$
    $[\sim 8 \times 2 = 16]$
    $15.0 \cdot 10^{5} = \underline{1,500,000}$

Decision time

If you missed more than two answers, you probably need more practice on multiplication. You may want to repeat this unit. If so, return to p. 45

If you missed two or less and if you feel confident about multiplying with C and D scales, **Go to p. 57**

From p. 56.

Division procedures are the opposite of multiplication. Consider the following problem:

$$684 \div 34.2$$

The first step is to place the numerator (684) over the denominator (34.2)

$$\frac{684}{34.2}$$

Then express in scientific notation.

$$\frac{6.84 \cdot 10^2}{3.42 \cdot 10^1}$$

Next, and this is important, **subtract** the value of the **denominator's** exponent from the numerator's exponent ($10^{2-1} = 10^1$).

$$\frac{6.84}{3.42} \cdot 10^1$$

QUESTION:

How should the problem $\frac{4.95 \cdot 10^5}{3.84 \cdot 10^2}$ be written?

$\frac{4.95}{3.84} \cdot 10^3$ **Go to p. 62.**

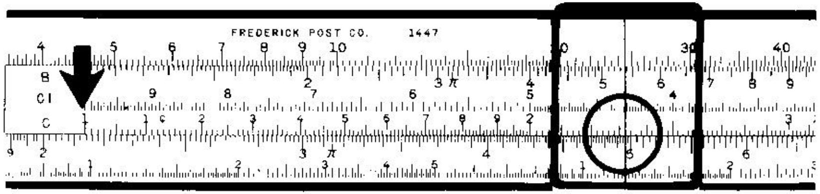
$\frac{4.95 \cdot 10^3}{3.84}$ **Go to p. 59.**

From p. 62 or p. 60. Your answer: Estimate $\left[\frac{8.95}{7.58} \quad Q<1\right]$

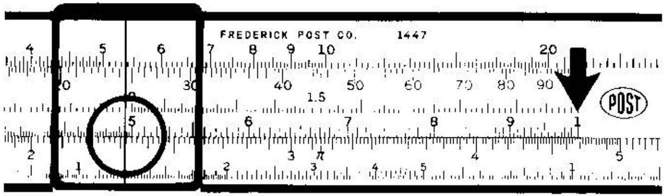
Correct. Now let's put all of the procedures together and solve a division problem using the C and D scales.

PROCEDURES:
1. Express each number in scientific notation.
2. Subtract the denominator's exponent from the numerator's exponent and write $\frac{x}{y} \cdot 10$
3. Estimate quotient; is $Q>1$ or $Q<1$?
4. Move the hairline **to** the value of the **numerator** on the **D** scale.
5. Slide the value of the **denominator** on the **C** scale to the hairline.
6. Determine the location of the decimal by estimation or by the C Index used.
7. Read the answer on the **D scale** at the **C index.**
8. Properly place the decimal in the answer and multiply by the appropriate power of 10.

PROBLEM: Find $\frac{496}{232} = ?$



And the answer is 2.14, **Go to p. 63.**



And the answer is 4.68, **Go to p. 61.**

From p. 57. Your answer: $\frac{4.95 \cdot 10^3}{3.84}$

You are right, of course, but for the purposes of this lesson we'll write it: $\frac{4.95}{3.84} \cdot 10^3$

Go directly to p. 62

From p. 62. Your answer: Estimate $\left[\frac{8.95}{7.58} \quad Q<1\right]$

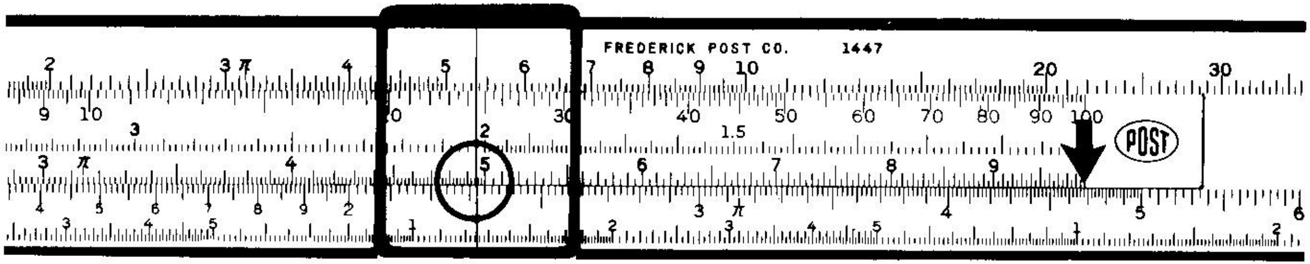
Which is larger, the numerator? or the denominator?

If $8.95 > 7.58$, can $Q < 1$? No.

You may wish to review p. 62 again.

Or you may **Go to p. 58**

From p. 58. Your answer: $\frac{496}{232} = 4.68$



Did you invert the problem, as if it were $\frac{232}{496}$? If so, you also lost track of the decimal point.

How can we help you avoid this mistake? Well, your estimate $\left[\frac{4.96}{2.32}; Q > 1\right]$ indicates a quotient greater than 1.

496 is the numerator; begin by placing the hairline on 4.96. You can review the procedures on p. 58, then practice solving the problem.

Return to p. 58

From p. 57 or p. 59. Your answer: $\frac{4.95 \cdot 10^5}{3.84 \cdot 10^2}$ should be written $\frac{4.95}{3.84} \cdot 10^3$

Yes, you are right. After the problem is properly written, you must determine where the decimal will be placed in the slide rule quotient.

Because you have converted your numbers to $1 < N < 10$, there are just two possibilities for your estimate:

If numerator > denominator, your quotient >1; in fact, $1 < Q < 10$.

If numerator < denominator, your quotient <1; in fact, $.1 < Q < 1$.

Try estimating each of these as decimals. Is $Q < 1$ or >1?

$\frac{5.8}{3.2}$, $\frac{3.1}{4.9}$, $\frac{7.3}{9.2}$, $\frac{9.1}{4.3}$

PROBLEM: Estimate $\frac{8.95}{7.58}$

If you estimate: . . . $Q > 1$ . . **go to p. 58**
If you estimate: . . . $Q < 1$ . . **go to p. 60**

If you prefer a system related to the Index used . . . . **go to p. 66**

From p. 58 Your answer: ➡ $\frac{496}{232} = \frac{4.96 \cdot 10^2}{2.32 \cdot 10^2} = \frac{4.96}{2.32}$ Estimate $\left[\frac{4.96}{2.32}; Q > 1\right]$ Calculate $\frac{4.96}{2.32} = \underline{2.14}$

Very good. Here's a problem that will involve one negative exponent and one positive exponent.

Example: $\frac{244}{.00122} =$

$\frac{2.44 \cdot 10^2}{1.22 \cdot 10^{-3}} =$

$\frac{2.44}{1.22} \cdot 10^5 =$

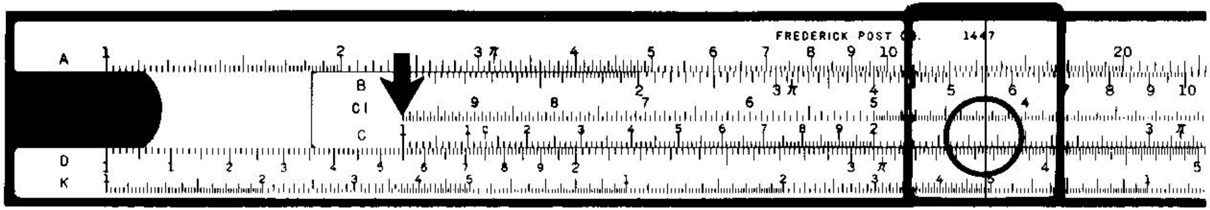
Estimate $\left[\frac{2.44}{1.22}; Q > 1\right]$

$2 \cdot 10^5 = \underline{200{,}000}$

Remember to express your numbers in scientific notation; locate the decimal; combine the exponents.

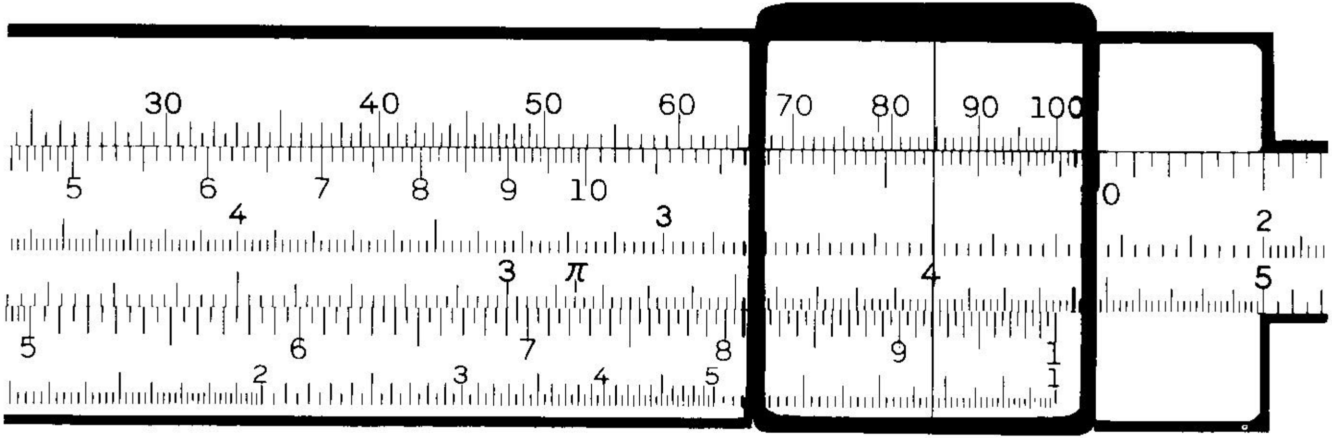
Notice that the exponent ($^-3$) of the numerator becomes $^+3$ when combining with the exponent (2) of the denominator. Why? Because dividing by 10^{-3} is the same as multiplying by 10^3.

PROBLEM: Find $\frac{366}{.0236}$



The answer is 1.55, **Go to p. 65** The answer is 15,500 **Go to p. 67**

From p. 77. Your answer: Your slide rule is the same as this picture for 920 x 35



Look at your slide rule again; what is on the CI scale at the hairline? Is that 3.5 you were looking for? Or is it 2.5? Remember, the CI scale is a "C-Inverted scale" and is therefore read from right to left. Remember, too, it is "red" from **right** to left. Go back to p. 77 and correctly set 3.5 on the CI scale at the hairline. Return to p. 77

From p. 63. Your answer: $\frac{366}{.0236} = 1.55$

You must have made a mistake in the combination of the exponents. Look at this:

$$\frac{3.66 \cdot 10^{2}}{2.36 \cdot 10^{-2}} =$$

$$\frac{3.66}{2.36} \cdot 10^{4} =$$

$$1.55 \cdot 10^{4} = 15{,}500$$

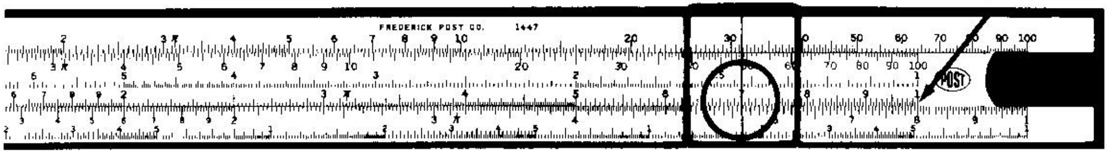
Think it over and go directly to p. 67.

From p. 62

Your answer: You prefer to locate decimal points using a system based on the index.

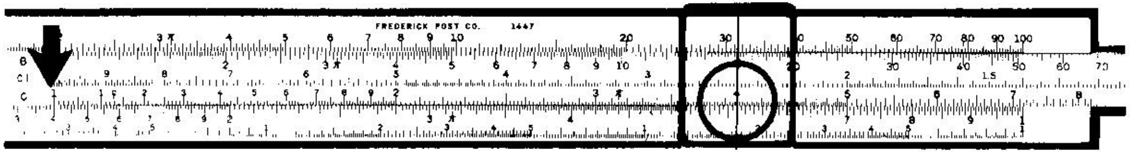
OK. Try this. Set up this division on your slide rule: $\frac{5.6}{7}$

Read Right C Index as "divide by 10"



You read the answer at the right C index, which stands for 10. So you think, "5.6 over 7 equals 8, divided by 10, or .8." Do you follow that? Your slide rule quotient at the right C index will be: $.1 < Q < 1$.

Try this: $\frac{5.6}{4} = ?$ Set it up on your slide rule.



You read the answer at the **left** C index, which stands for 1. So your decimal does not change. Your slide rule quotient will be: $1 < Q < 10$.

Got it? Then go directly to p. 58.

From p. 63 or p. 65

Your answer: $\frac{366}{.0236} = \frac{3.66 \cdot 10^2}{2.36 \cdot 10^{-2}} = 1.55 \cdot 10^4 = 15{,}500$. Excellent!

Estimate $\left[\frac{3.66}{2.36}; Q > 1\right]$

Solve each of the following problems with your slide rule. Remember, express your number in scientific notation; combine the exponents; locate your decimal.

If you can divide $\frac{8}{4} = 2$, and $\frac{30}{5} = 6$, you can use the same procedures to solve any of these:

1. $\frac{420}{52.5} =$ $\frac{4.20 \cdot 10^2}{5.25 \cdot 10^1} = .8 \cdot 10^1 = 8$ ______ $\left[\frac{4.2}{5.25}; Q<1\right]$
2. $\frac{635}{27.6} =$ ______
3. $\frac{42}{35} =$ ______
4. $\frac{362}{48} =$ ______
5. $\frac{515}{2200} =$ ______
6. $\frac{52{,}000}{226} =$ ______
7. $\frac{85}{264} =$ ______
8. $\frac{2}{1} =$ ______

Turn to p. 68

From p. 67 Solutions to division problems.

1. $\frac{420}{525} = \underline{.8}$

2. $\frac{635}{27.6} = \frac{6.35 \cdot 10^2}{2.76 \cdot 10^1} = 2.3 \cdot 10^1$

   $\left[\frac{6.35}{2.76}; Q>1\right] \qquad = \underline{23}$

3. $\frac{42}{35} = \frac{4.2 \cdot 10}{3.5 \cdot 10} = \underline{1.2}$

   $\left[\frac{4.2}{3.5}; Q>1\right]$

4. $\frac{362}{48.0} = \frac{3.62 \cdot 10^2}{4.80 \cdot 10} = .755 \cdot 10$

   $\left[\frac{3.62}{4.80}; Q<1\right] \qquad = \underline{7.55}$

5. $\frac{515}{2200} = \frac{5.15 \cdot 10^2}{2.20 \cdot 10^3} = 2.34 \cdot 10^{-1}$

   $\left[\frac{5.15}{2.20}; Q>1\right] \qquad = \underline{.234}$

6. $\frac{52{,}000}{226} = \frac{5.20 \cdot 10^4}{2.26 \cdot 10^2} = 2.30 \cdot 10^2$

   $\left[\frac{5.20}{2.26}; Q>1\right] \qquad = \underline{230}$

7. $\frac{85}{264} = \frac{8.5 \cdot 10}{2.64 \cdot 10^2} = 3.22 \cdot 10^{-1}$

   $\left[\frac{8.5}{2.64}; Q>1\right] \qquad = \underline{.322}$

8. $\frac{2}{1} = \underline{2}$ (See how easy?)

Decision time

If you missed more than 2, you may need more practice on C and D scale division. Return to p. 57.

If you missed 2 or less, and if you feel that you understand C and D scale division, **Go on to p. 69.**

From p. 68.

Finding the reciprocal of a number is one of the easier jobs with the Post 1447 Slide Rule. The C and CI scales are so designed that the reciprocal of a number on the C scale is immediately opposite it on the CI scale, and vice versa. "CI" stands for "C, Inverted"; and so it is read from right to left. It is also **red**, so you can remember "red for reversed" and **read** the **red** from the **right**. The procedure that will be taught in this sequence will be that of locating a number on the C scale and reading its reciprocal on the CI scale. As you know, a number multiplied by its reciprocal equals 1 ($N \times \frac{1}{N} = 1$). Therefore, the reciprocal of a number greater than 1 is **always less than** 1.

Line up the **Left** C scale index with the **Left** D scale index.

PROBLEM: Move the hairline to 2 on the C scale. Read the reciprocal of 2 on the CI scale at the hairline.

QUESTION: What is the reciprocal of 2. ?

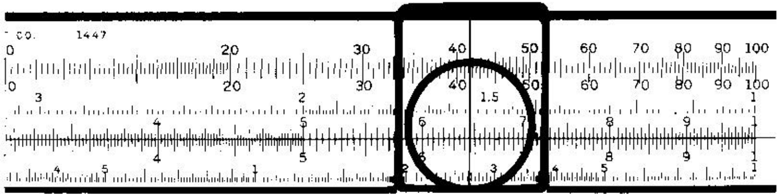
5........**go to p. 71.**
.5.......**go to p. 74.**

RECIPROCALS

From p. 74. Your answer: The reciprocal of 500 is .002

Very good. Now let's try another problem. Remember, express your number in scientific notation, change the sign of the exponent and subtract 1; record this on paper. Locate your basic number on the C scale and read the reciprocal of your number on the CI scale at the hairline. Apply the changed exponent, $x' = -x-1$.

PROBLEM: Find the reciprocal of .0645 Compare your setting with the picture.



The reciprocal of .0645 is 155 ....**go to p. 72**

The reciprocal of .0645 is 15.5...........**go to p. 75**

From p. 69. Your answer: The reciprocal of 2 is 5

By definition, the reciprocal of a number multiplied by the number equals 1. Now, you've said $2 \times 5 = 1$ and you have to agree that is not true. If $N > 1$, then $\frac{1}{N} < 1$. So, the exponent of a reciprocal will be of the opposite sign. Because the C scale and the CI scale are both numbered 1.0 to 10, you must change the sign and subtract 1. If that is clear, return to p. 69 and select the correct answer.

If you want to think further about exponents of reciprocals, study these:

$N = 2$ $= 2 \cdot 10^0$ Exponent $x = 0$	$\frac{1}{N} = .5$ $= 5 \cdot 10^{-1}$ Exponent of reciprocal $x' = {}^-1$	$N = 20$ $= 2 \cdot 10^1$ $x = 1$	$\frac{1}{N} = .05$ $= 5 \cdot 10^{-2}$ $x' = {}^-2$
$N = .2$ $= 2 \cdot 10^{-1}$ $x = {}^-1$	$\frac{1}{N} = 5$ $= 5 \cdot 10^0$ $x' = 0$	$N = .02$ $= 2 \cdot 10^{-2}$ $x = {}^-2$	$\frac{1}{N} = 50$ $= 5 \cdot 10^1$ $x' = 1$

In each case, you change the sign of the exponent and subtract one; $x' = -x - 1$. **Go directly to p. 74**

From p. 70. Your answer: The reciprocal of .0645 is 155

Well, you're reading the slide rule properly, but you need to check your decimal point.

$$N = .0645 \qquad \therefore x = {}^-2 \qquad \frac{1}{N} = 1.55 \cdot 10^{x'}$$
$$= 6.45 \cdot 10^{-2} \qquad x' = -X - 1 \qquad = 1.55 \cdot 10^{1}$$
$$= -({}^-2) - 1 \qquad = 15.5$$
$$= +1$$

Think about that and **go directly to p. 75.**

From p. 74. Your answer: The reciprocal of 500 is .02

Let's see what you might have done to get an answer like that:

a. Found $5.0 \cdot 10^2$ (Right) and changed the sign of the exponent.
b. Found 2 on the CI (Right).
c. Multiplied $2.0 \cdot 10^{-2} = .02$. But did you subtract 1 from the exponent?
d. You should have multiplied $2 \cdot 10^{-3} = .002$

Turn to page 74; reread the instructions; study the example; then solve the problem correctly.

Return to p. 74.

From p. 69 or p. 71. Your answer: The reciprocal of 2 is .5

Of course. You know that $2 > 1$, so the reciprocal, or $\frac{1}{2} < 1$.

If you can find the reciprocal of 2 to be .5, you can use the same procedure to find any reciprocal.

1. Express the given number in scientific notation. Record your exponent. **CHANGE** the sign of the exponent and subtract 1. Record this on paper.
2. Move the hairline to the number on the **C scale.**
3. Read the **reciprocal** at the hairline on **the CI scale.**
4. Multiply the reciprocal by the new exponent $x' = -x-1$.

EXAMPLE: $20 = 2.0 \cdot 10^{1}$ (Change the sign to 10^{-1-1} or 10^{-2}). The reciprocal on the CI scale is 5; this is to be multiplied by 10^{-2}; therefore we have $5 \cdot 10^{-2} = .05$. The reciprocal of 20 = .05

PROBLEM: Find the reciprocal of 500

The reciprocal is .02 . . . . go to p. 73.

The reciprocal is .002 . . . . go to p. 70.

From p. 70 or p. 72. Your answer: The reciprocal of .0645 is 15.5

Correct. Now solve each of the following problems. Write your answers on a separate sheet of paper. When you finish all of the problems check your answers on page 76. Remember that the CI scale is numbered from **RIGHT** to **LEFT.** And, if we start with $a \cdot 10^x$, then $\frac{1}{a \cdot 10^x}$ on the reciprocal scale has an exponent of $x' = -x - 1$.

1. $\frac{1}{565} = \frac{1}{5.65 \cdot 10^2} = 1.77 \cdot 10^{-3} = .00177$
2. $\frac{1}{.0041} =$
3. $\frac{1}{164} =$
4. $\frac{1}{236} =$
5. $\frac{1}{.25} =$
6. $\frac{1}{49} =$
7. $\frac{1}{7{,}250} =$
8. $\frac{1}{.0212} =$
9. $\frac{1}{40} =$
10. $\frac{1}{1} =$

Go to p. 76.

From p. 75. Solutions to reciprocal problems

1. $\frac{1}{565} = \underline{.00177}$

2. $\frac{1}{.0041} = \frac{1}{4.1 \cdot 10^{-3}} = 2.44 \cdot 10^{2} = \underline{244}$

3. $\frac{1}{164} = \frac{1}{1.64 \cdot 10^{2}} = 6.1 \cdot 10^{-3} = \underline{.0061}$

4. $\frac{1}{236} = \frac{1}{2.36 \cdot 10^{2}} = 4.24 \cdot 10^{-3} = \underline{.00424}$

5. $\frac{1}{.25} = \frac{1}{2.5 \cdot 10^{-1}} = 4 \cdot 10^{0} = \underline{4}$

6. $\frac{1}{49} = \frac{1}{4.9 \cdot 10} = 2.04 \cdot 10^{-2} = \underline{.0204}$

7. $\frac{1}{7{,}250} = \frac{1}{7.25 \cdot 10^{3}} = 1.38 \cdot 10^{-4} = \underline{.000138}$

8. $\frac{1}{.0212} = \frac{1}{2.12 \cdot 10^{-2}} = 4.72 \cdot 10^{1} = \underline{47.2}$

9. $\frac{1}{40} = \frac{1}{4.0 \cdot 10} = 2.5 \cdot 10^{-2} = \underline{.025}$

10. $\frac{1}{1} = 1$ (and that's a fact)

After you have checked your answers, **go on to p. 77.**

From p. 76.

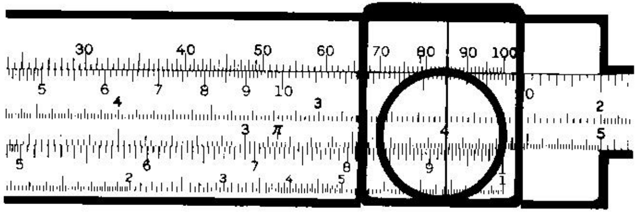
Multiplication with the C, CI, and D scales is based on the fact that division by the reciprocal of a number is the same as multiplication by the number. For two-factor multiplication problems the CI and D scales are often easier to use than the C and D scales.

PROCEDURES:

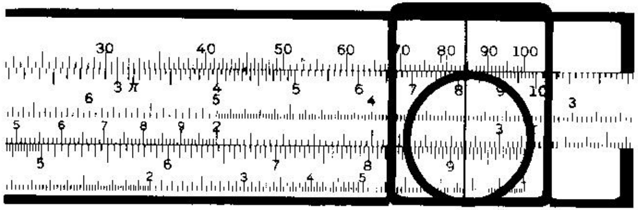
1. Express each factor in scientific notation, and locate the decimal point.
2. Estimate product.
3. Move the hairline to the first factor on the **D scale.**
4. Move the **CI scale** until the second factor is at the hairline.
5. Read the product on the **D scale** at the C scale index.

NOTE: Just as in division if you read the answer at the Right C Index (10) you divide your product by 10; products at the Left C Index are read directly between 1 and 10.

PROBLEM: Use the CI and D scales and set up 920 x 35.



go to p. 64.



go to p. 81.

From p. 85. Your answer: Move the hairline to 9.4 on the C scale.

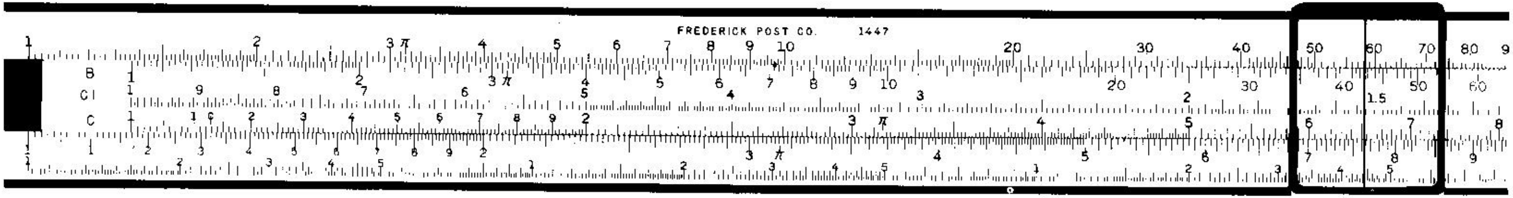
In the problem 5.45 x 85 x 9.4 the following procedures should be used. Use your slide rule and:

1. Set the hairline to 5.45 on the D scale.
2. Move 8.5 on the CI scale to the hairline.

After these two steps, you'll notice that 9.4 is "off scale." Therefore, you cannot "move the hairline to 9.4 on the C scale."

You still want to multiply by 9.4. How can you do that? You have an **intermediate** product at the Left C Index. Move your hairline to the Left C Index; **then** move 9.4 on the CI scale to the hairline. That's multiplication, isn't it? Turn to p. 85 and select the correct answer. Return to p. 85

From p. 81. Your answer: 7650 x 153 = $11.7 \cdot 10^5$ = 1,170,000



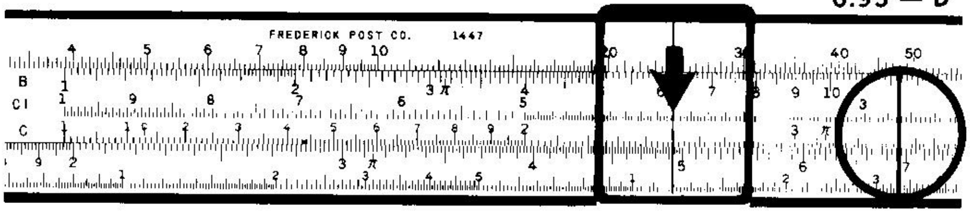
Very good. Now to solve a three-factor multiplication problem (with minimum slide movement) use the C, CI, and D scales. Before calculating, write the problem with exponents and estimate the product.

1. Move the hairline to the first factor on the D scale.
2. Slide the CI scale until the second factor is at the hairline.
3. Move the hairline to the third factor on the C scale (if possible).
4. Read the product on the D scale at the hairline.

Note: You have an intermediate answer at left C index, but you can ignore the value of it.

PROBLEM: Solve 695 x 284 x 25 = ?

2.84 — CI
6.95 — D



And the product is $49.4 \cdot 10^5$ . . **go to p. 84.**

And the product is $4.94 \cdot 10^5$ . . **go to p. 80.**

From p. 79. Your answer: $695 \times 284 \times 25 = 4.94 \cdot 10^5$

Not quite. After expressing your factors in scientific notation you should have determined:
$6.95 \times 2.84 \times 2.5 \cdot 10^5$

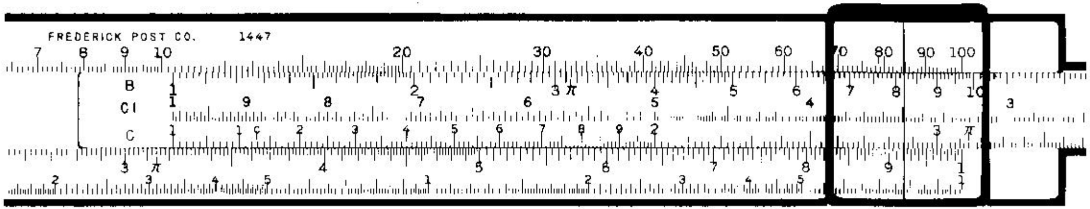
Estimate [$\sim 7 \times 3 \times 2 = 42$]

therefore you should determine that your product will be about:
$42 \cdot 10^5$

Return to page 79 and select the correct answer. Go back to p. 79.

From p. 77. Your answer: 920 x 35 = $32.2 \cdot 10^3$ = 32,200 and your slide rule is the same as this:

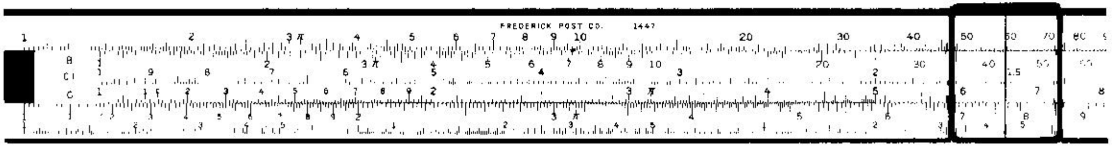
Yes, that is correct. Remember, move the hairline to the first factor on the D scale. Slide the CI scale until the second factor is at the hairline. Read the product on the D scale at the C index.



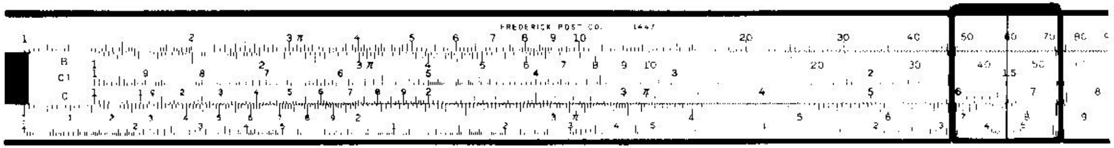
Let's solve another two-factor problem with the CI and D scales. Use scientific notation.

PROBLEM:

Solve: 7,650 x 153 = ?



Go to p. 79.



Go to p. 86.

From p. 88. Your estimated answer: $\frac{9 \times 4 \times 2}{2 \times 2 \times 6} = 3$

If your estimated answer does not agree with the one above, return to page 88 and study the procedure again.

If you understand this procedure, you are ready to solve for a calculated answer on your slide rule.
Turn to p. 83

From p. 82.

Study the steps in this simple problem, following through on your slide rule.

Example:

$$\frac{2 \times 3 \times 4}{5 \times 6 \times 7}$$

Estimate

$$\left[\frac{24}{210} \approx .1\right]$$

1. Scientific notation, if needed. Estimate.
2. (x2) Set hairline to 2 on D scale
3. (x3) Move 3 on CI scale to hairline
4. (x4) Set hairline to 4 on C scale
5. (÷5) Move 5 on C scale to hairline
6. (÷6) Set hairline to RC Index. Move 6 to hairline
7. (÷7) Set hairline to 7 on CI scale
8. Set decimal from estimate: **.1141**

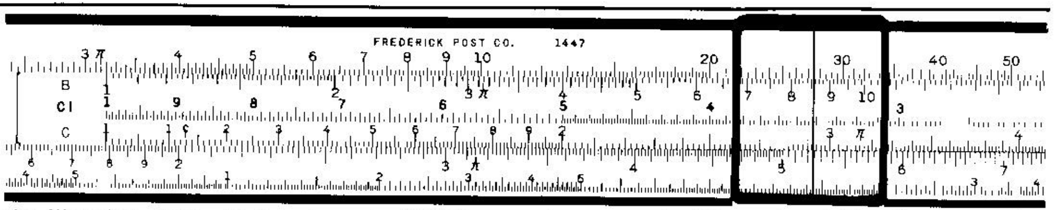
Step	CHECK SETTINGS
3.	Right C Index — 6
4.	Hairline 2.4 — D
5.	Right C Index — 4.8
6.	Right C Index — 8
7.	Hairline 1.141 — D

Fine, now you are ready to work a practice problem.

(≈ indicates an approximate answer)

PRACTICE PROBLEM:

$$\frac{356 \times 490 \times 19.5}{.042 \times 15.5 \times 2920}$$



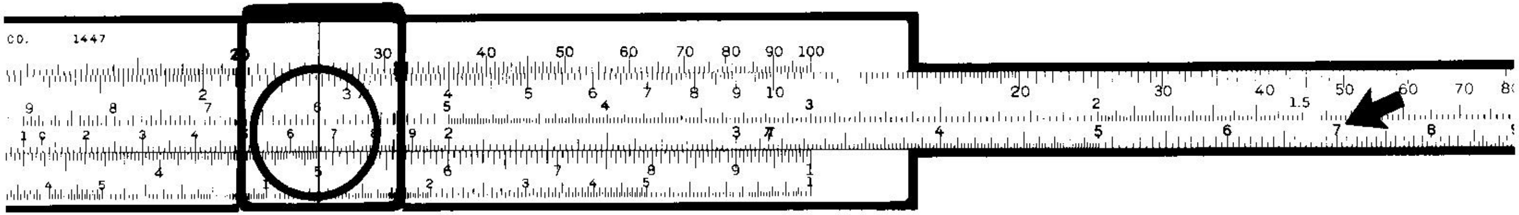
If your rule looks like this, and your answer is 1790, you have good slide rule skills. **Go to p. 90**
If you need the steps to the answer, **Go to p. 87**
If you want to see the slide rule steps, **Go to p. 89**

From p. 79. Your answer: $695 \times 284 \times 25 = 49.4 \cdot 10^5 = 4{,}940{,}000$

Correct. But suppose it is not possible to move the hairline to the third factor on the C scale.

Example: $5 \times 6 \times 7$

It is not possible to set the hairline to the third factor (7)



PROCEDURES: Study these procedures; then use them to solve the problems on page 85.

1. Move the hairline to the first factor on the D scale.
2. Slide the CI scale until the second factor is at the hairline. (Of course you are multiplying by 10).

AND DECIDE:

IF THE HAIRLINE **CANNOT** BE MOVED TO THE THIRD FACTOR ON THE C SCALE:

3. Move the hairline to the C index.
4. Slide **CI scale** so third factor is at hairline.
5. Read product on D scale at **C index.**

IF THE HAIRLINE **CAN BE MOVED** TO THE THIRD FACTOR ON THE C SCALE; DO SO:

Read the product on the D scale at the hairline.

Go to p. 85.

From p. 84.

These problems are designed to give you practice using the procedures on page 84. Be sure you use the correct set of procedures (listed on page 84) when solving a problem. Note: The number in parentheses after each problem is the minimum number of moves of slide.

PRACTICE PROBLEMS

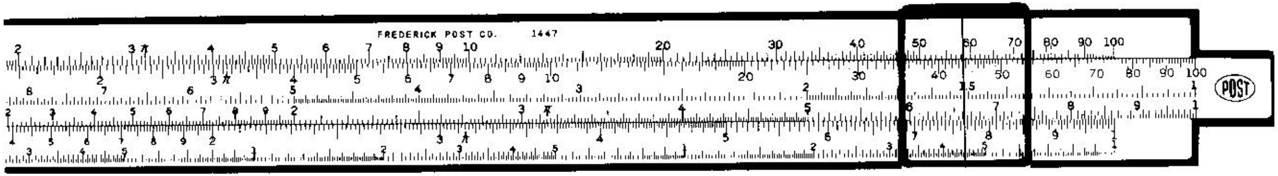
1. 2 x 3 x 4 = 24 (1)
2. 3 x 8 x 5 = 120 (2)
3. 2 x 2 x 2 = 8 (2)
4. 2 x 3 x 3 = 18 (1)
5. 5 x 2 x 5 = 50 (1)
6. 5 x 4 x 5 = 100 (1)
7. 15 x 2 x 3 = 90 (2)
8. π x 3 x 6 = 56.5 (1)

QUESTION:

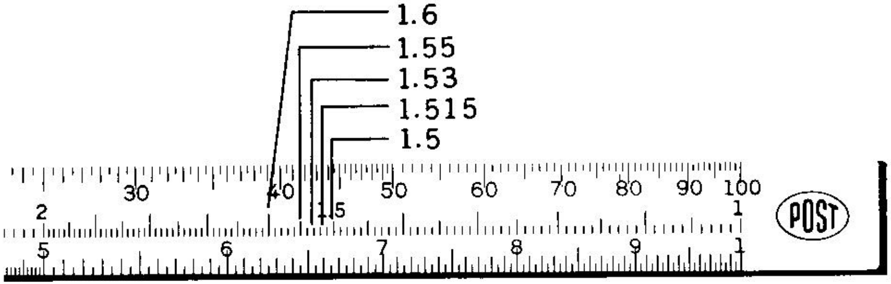
In the problem 5.45 x 85 x 9.4, after you move the hairline to 5.45 on the D scale and slide the CI scale until 8.5 is at the hairline, you should:

a. Move the hairline to 9.4 on the C scale .... **Go to p. 78.**
b. Move hairline to Left C Index.
   Slide 9.4 on CI scale to hairline.
   Read 4.35 at Left C Index... **Go to p. 88.**

From p. 81. Your answer: Your slide rule setting is the same as this for 7650 x 153.



Let's have a fast review of the scale markings between 1 and 2. Study the following picture.



I think you can see that you have 1.515 set at the hairline. Return to page 81 and correctly position 1.53 on the CI scale at the hairline. Go back to p. 81.

From p. 83

Let's review what you should be doing:

$$\frac{356 \times 490 \times 19.5}{.042 \times 15.5 \times 2920} =$$

1. Scientific Notation

$$\frac{3.56 \cdot 10^2 \times 4.90 \cdot 10^2 \times 1.95 \cdot 10^1}{4.2 \cdot 10^{-2} \times 1.55 \cdot 10^1 \times 2.92 \cdot 10^3} =$$

2. Combine exponents

$$\frac{3.56 \times 4.90 \times 1.95}{4.2 \times 1.55 \times 2.92} \cdot 10^3 =$$

3. Estimate

$$\left[\frac{4 \times 5 \times 2}{4 \times 2 \times 3} = \frac{40}{24} \approx 2\right]$$

4. Calculate and apply exponent $= 1.790 \cdot 10^3$

$= \underline{1790}$

If you follow that on your slide rule, **go to p. 90**
You may see the steps which lead to this answer **on p. 89**

From p. 85. Your answer: Move hairline to Left C Index. Slide 9.4 on CI scale to hairline. Read 4.35. Correct!

Study the following procedures; then use them to solve the practice problem.

$$\text{Example: } \frac{26 \times 79{,}800 \times .00633}{.0081 \times 7{,}800{,}000} =$$

1. Express in scientific notation .... $\dfrac{2.6 \cdot 10^{1} \times 7.98 \cdot 10^{4} \times 6.33 \cdot 10^{-3}}{8.1 \cdot 10^{-3} \times 7.8 \cdot 10^{6}} =$
2. Simplify exponents and combine (numerator–denominator)...... $\dfrac{2.6 \times 7.98 \times 6.33}{8.1 \times 7.8} \cdot 10^{-1} =$
3. Estimate .... $\left[\dfrac{3 \times 8 \times 6}{8 \times 8} = \dfrac{144}{64} \approx 2\right] \cdot 10^{-1}$
4. Calculate and apply exponent .... $2.08 \cdot 10^{-1} = \underline{.208}$

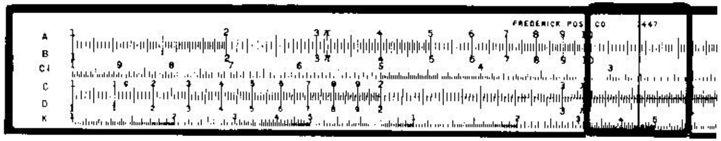
PRACTICE PROBLEM: $\dfrac{90 \times 390 \times .20}{.17 \times 22 \times 6.3}$

Solve for the **estimated** answer before you apply the exponent.
Go to p. 82

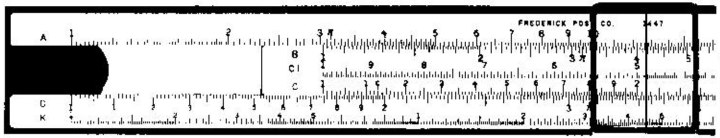
From p. 87 or p. 83 $\dfrac{3.56 \times 4.90 \times 1.95}{4.2 \times 1.55 \times 2.92} \cdot 10^3 = ?$

MULTIPLY

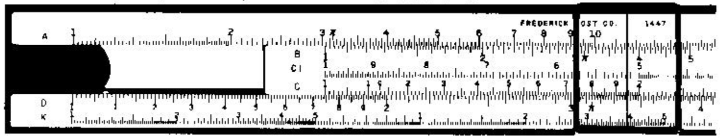
Step 1. Hairline to 3.56-D



2. (x4.90) Slide 4.90–CI to hairline

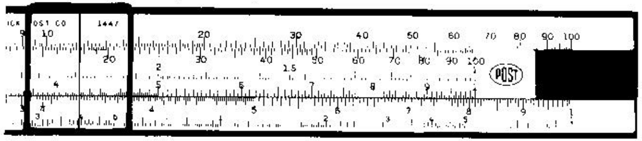


3. (x1.95) Hairline to 1.95-C

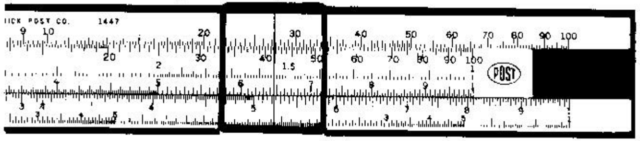


THEN DIVIDE

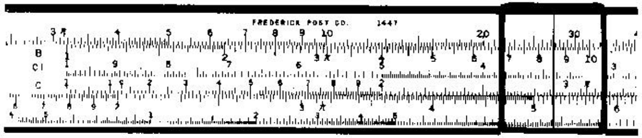
4. (÷4.2) Slide 4.2–C to hairline



5. (÷1.55) Hairline to 1.55-CI



6. (÷2.92) Slide 2.92–C to hairline



Read: 1.790. Apply exponent $1.790 \cdot 10^3 = \underline{1790}$

Check your rule settings with those above. Then **go to p. 90**

From p. 89 or p. 87 or p. 83

All right, here's one more problem involving the C, CI, and D scales. After solving this problem, if you wish, you may return to page 88 and repeat the practice sequence on multiplication and division with the C, CI and D scales.

Example: $\dfrac{4 \times 4}{3 \times 3 \times 3}$

$\left[\dfrac{16}{27} \approx .5\right]$

1. Scientific notation; estimate for decimal — **Check settings**
2. Set hairline to 4 on D scale
3. (x4) Move 4 on CI scale to hairline .... $4 \times 4 = 1.6$
4. (÷3) Set hairline to 3 on CI scale .... $1.6/3 = 5.33$
5. (÷3) Move 3 on C scale to hairline .... $5.33/3 = 1.777$
6. (÷3) Set hairline to 3 on CI scale .... $1.777/3 = 5.93$
7. Set decimal from estimate: .593

PRACTICE PROBLEM:

$$\frac{100 \times 60{,}500}{480 \times 300 \times 655} = 0.0642$$

Follow the procedures outlined above and prove for yourself that the answer is 0.0642. When you are finished (and if you feel you are ready) **Go to page 91** and start the next lesson.

From p. 90.

Now let's learn to **square** numbers using the A and D scales. Look at the **A** scale. On the Post 1447 rule, you will notice values between 1 and 100. This is very helpful in solving **squares** of numbers.

PROCEDURE:

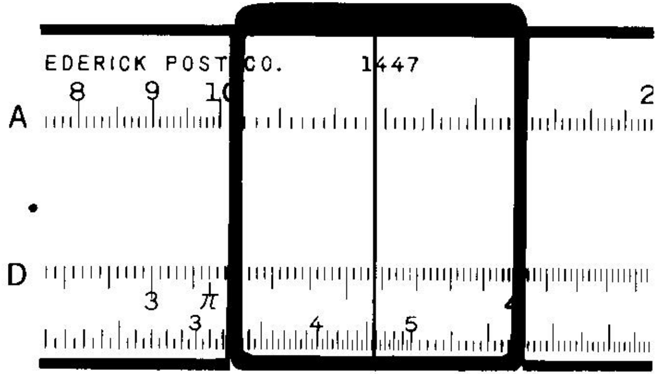
Place the right index of the C scale at the left index of the D scale (just to get the slide out of the way).

1. Express the number to be **squared** in scientific notation, then **DOUBLE** the exponent. Record this on paper.
2. Set the hairline at the number to be squared on the **D** scale.
3. Read the **square** on the **A** scale at the hairline; THEN apply the correct exponent.

EXAMPLE: $40^2 = (4.0 \cdot 10^1)^2 = 16 \cdot 10^2 = 1{,}600$

PROBLEM: $358^2 = ?$

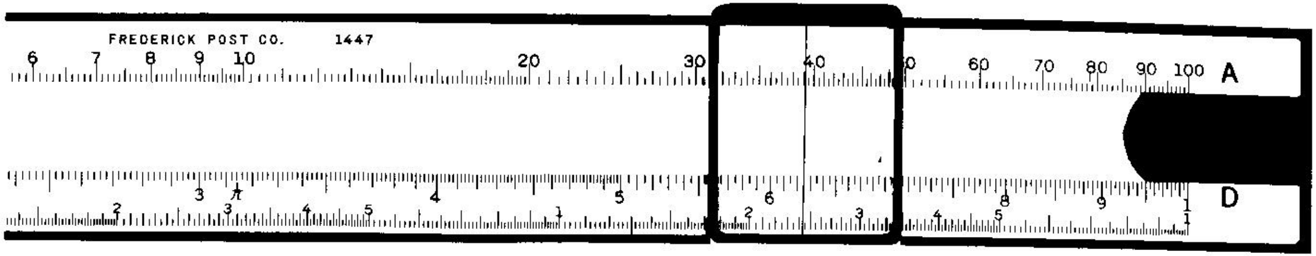
(Compare your setting with the illustration).



$358^2 = 128{,}000$ **Go to p. 100.**

$358^2 = 1{,}280$ **Go to p. 93.**

From p. 98. Your answer $\sqrt{625} = 39.2$



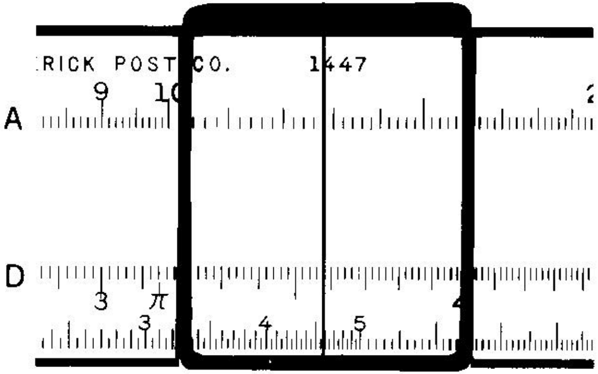
There is an error here. You were instructed to set the hairline at the converted number on **A** scale. But if you will study your rule, you will see that you have really done this: $6.25^2 = 39.2$

Is that what you were asked to do?

NOTE: If you ever wonder which side is up, use your A and D scales to find $\sqrt{4} = 2$. If you can do that, you can use the proper scales for any square or square root problem.

Return to p. 98.

From p. 91. Your answer: $358^2 = 1{,}280$



Your thinking is right but let's see how you have placed the decimal.

1. Did you express the number to be squared in scientific notation?
2. Did you **DOUBLE** the exponent?

Is this what you did?

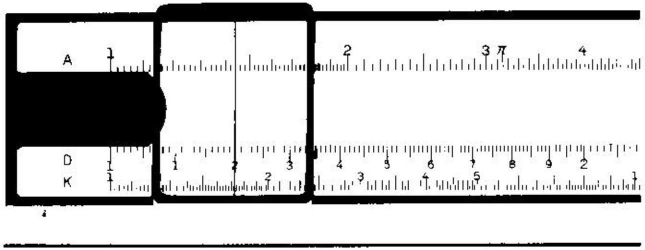
$$358^2 = (3.58 \cdot 10^2)^2 = 12.8 \cdot 10^2 = 1{,}280$$

Here is what you should have done:

$$358^2 = (3.58 \cdot 10^2)^2 = 12.8 \cdot 10^4 = 128{,}000$$

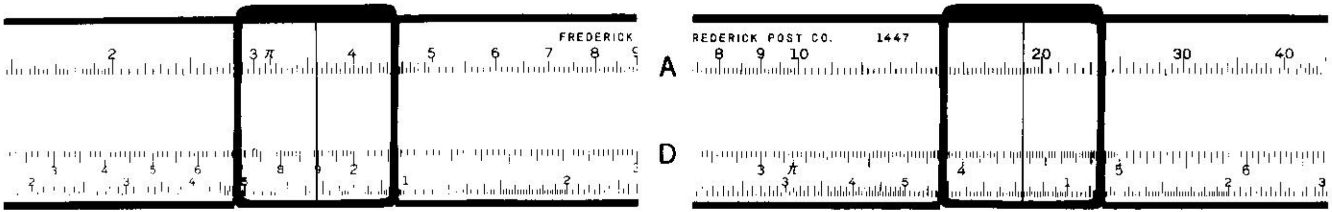
If you are clear on that, go directly to p. 100. Or, you can check it again; return to p. 91.

From p. 96. Your answer $\sqrt{0.000144} = .012$



Right. Now solve another problem. Remember the number must be expressed as $b \cdot 10^{2x}$ where b is between 1 and 100 and 2x is an even number. Then the exponent must be divided by 2.

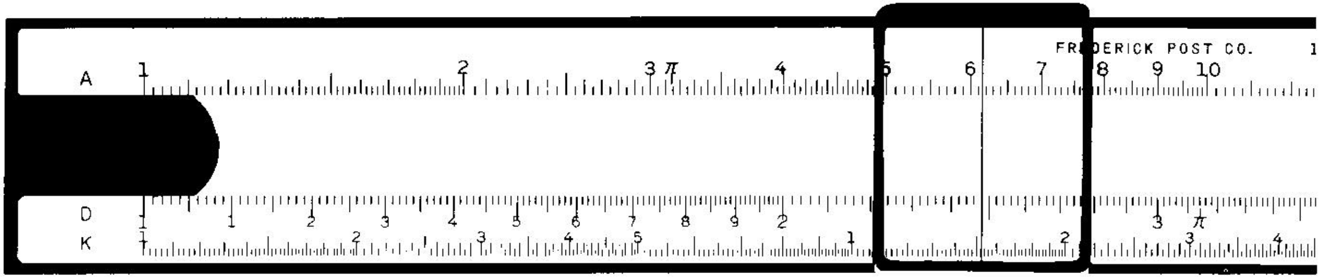
PROBLEM: $\sqrt{1900} = ?$



$\sqrt{1900} = 36.0$
Go to p. 97

$\sqrt{1900} = 43.6$
Go to p. 103

From p. 100. Your answer $24.8^2 = 61.6$



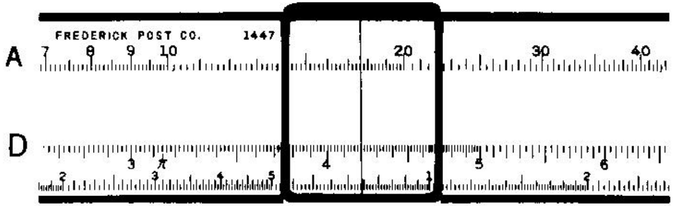
Almost, but not good enough. It appears that you failed to **DOUBLE** the exponent **after** you expressed the number in scientific notation. If you had recorded the problem correctly it would have looked like this:

$$24.8^2 = (2.48 \cdot 10^1)^2 = 6.16 \cdot 10^2 = 616$$

You may go directly to p. 98

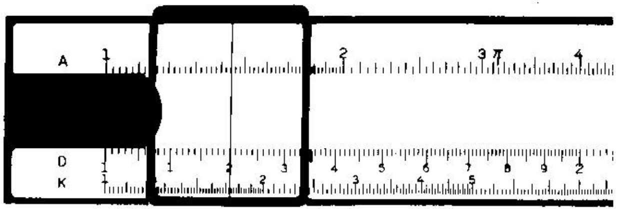
From p. 101 or p. 99. Your answer

$$\sqrt{0.00176} = .042$$

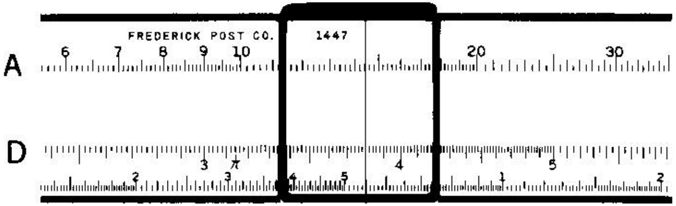


Excellent. You can find the square root of a number less than 1 with no trouble:

PROBLEM: $\sqrt{0.000144} = ?$

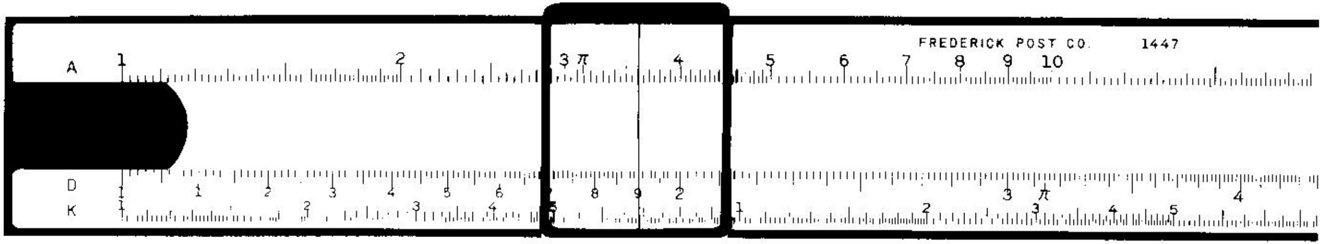


$\sqrt{0.000144} = .012$
Go to p. 94



$\sqrt{0.000144} = .0379$
Go to p. 102

From p. 94 Your answer: $\sqrt{1900} = 36$



To find square roots, set the hairline at the converted number on the A scale.

Did you find $\sqrt{19}$ or did you find 19^2?

Try the problem again and see if it doesn't look like this:

$$\sqrt{1900} =$$

$$\sqrt{19} \cdot 10^2 =$$

$$4.36 \cdot 10 = 43.6$$

Got that? If you ever wonder which side is up, use your rule to find $\sqrt{4} = 2$. If you can do that, you can solve square and square root problems, keeping your scales in order. OK, go directly to p. 103.

From p. 100 or p. 95. You said that $24.8^2 = 616$

Fine. Now we can move into **square roots.** Here again we will use the A and D scales. Remember that on your Post 1447 rule, the **A** scale ranges from 1 to 100.

PROCEDURE:

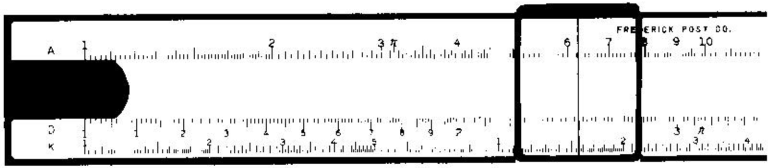
1. Express the number as $b \cdot 10^{2x}$, where b is between 1 and 100 and ^{2x} is an even number.
2. Find: $\sqrt{10^{2x}} = 10^x$
3. Set hairline at converted number on **A** scale.
4. Read square root on **D** scale at hairline; THEN multiply it by the correct power of 10.

EXAMPLES:

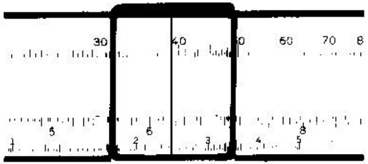
$$\sqrt{1440} = \sqrt{14.4 \cdot 10^2} = 10\sqrt{14.4} = 3.79 \cdot 10 = 37.9$$

$$\sqrt{300} = \sqrt{3.0 \cdot 10^2} = 10\sqrt{3} = 1.731 \cdot 10 = 17.31$$

PROBLEM: $\sqrt{625} = ?$

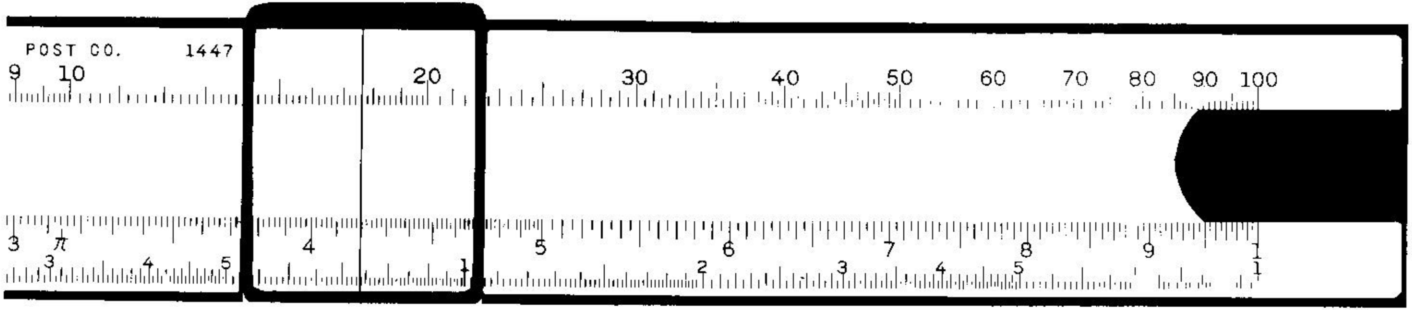


$\sqrt{625} = 25$ **Go to p. 101.**



$\sqrt{625} = 39.2$ Go to p. 92.

From p. 101. Your answer $\sqrt{0.00176} = 420$

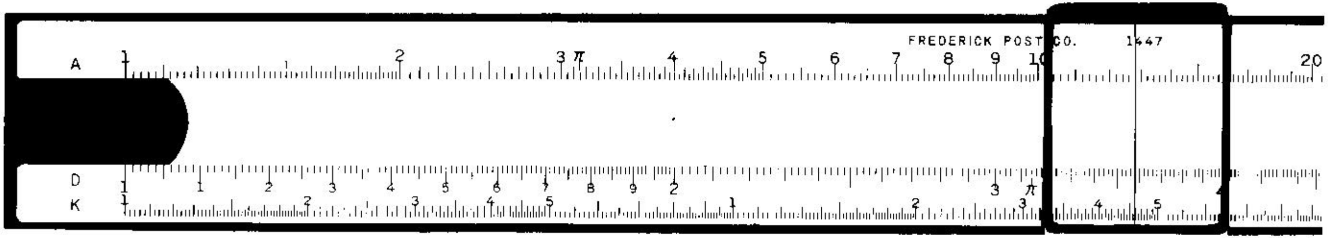


There is an error here in your decimal placement; although a common error, it is one which makes a **big** difference in our answer. You arrived at your answer through the use of **POSITIVE** exponents rather than **NEGATIVE** exponents.

SOLUTION: $\sqrt{0.00176} = \sqrt{17.6 \cdot 10^{-4}} = 4.2 \cdot 10^{-2} = .042$

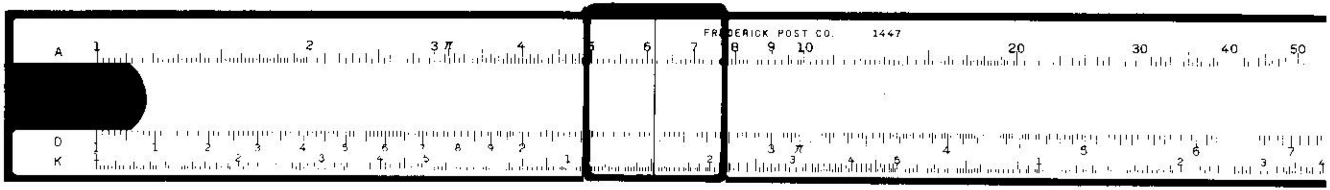
You may go directly to p. 96

From p. 91. Your answer: $358^2 = 3.58^2 \cdot 10^{2\times2} = 12.8 \cdot 10^4 = 128{,}000$



Very fine. Now solve this problem.

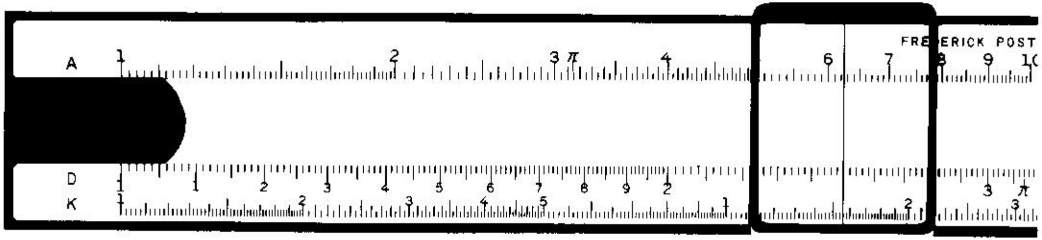
PROBLEM: $24.8^2 = ?$ **NOTE:** You may check the procedures on **page 91**, if necessary.



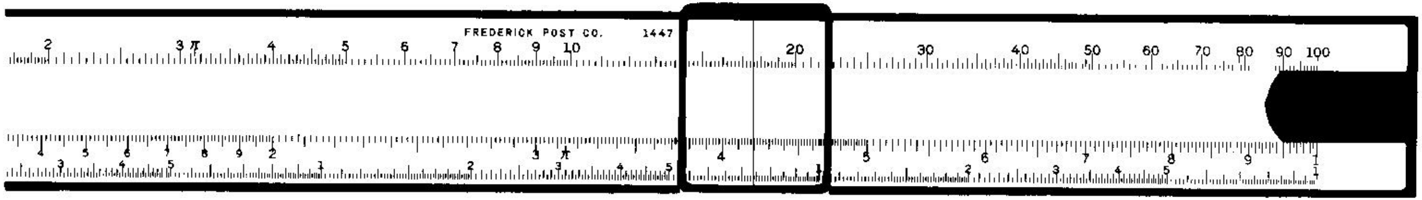
$24.8^2 = 61.6$ **Go to p. 95.** $24.8^2 = 616$ **Go to p. 98.**

From p. 98. Your answer $\sqrt{625} = 25$

Good choice. Square roots of numbers **less** than **1** can also be determined with the Post 1447. In doing so, however, you must remember that the exponent will be **negative.** Following the square root procedures and then observing negative exponent procedure, solve this problem.



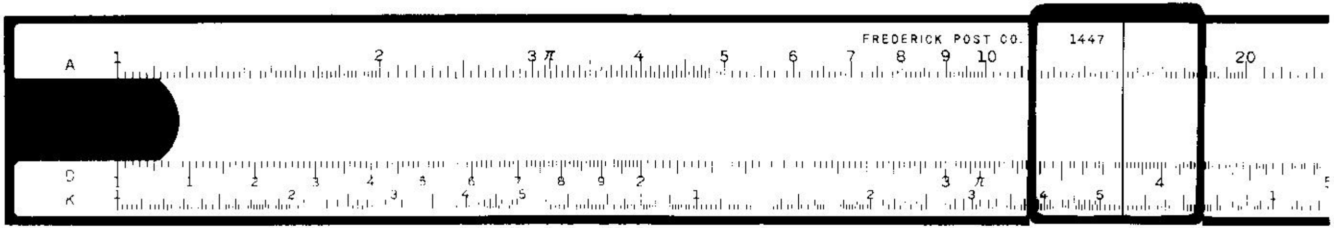
PROBLEM: $\sqrt{0.00176} = ?$



$\sqrt{0.00176} = .042$ **Go to p. 96.**

$\sqrt{0.00176} = 420.$ **Go to p. 99.**

From p. 96 Your answer: $\sqrt{0.000144} = .0379$



Well, such an answer could come from a slide rule set for 14.4. When you factored to place the decimal did you do it: $b \cdot 10^{2x}$, such that 2x is an even number? Unless 2x is **even**, how can you divide by 2 to find the exponent of the square root, x? If you factor such that 2x is even, what is b? Is it 14.4 or 1.44?

Go back to page 96, reread and try it again. **Return to p. 96.**

From p. 94 or p. 97. Your answer: $\sqrt{1900} = 4.36 \cdot 10^1 = 43.6$

Right. Now solve each of the following problems. Record your answer on a separate sheet of paper. After you have solved the problems check your answers on page 104.

1. $\sqrt{840}$ = $2.9 \cdot 10^1 = 29$ ______
2. 42^2 = ______
3. 158^2 = ______
4. $\sqrt{32.5}$ = ______
5. 62^2 = ______
6. $\sqrt{7500}$ = ______
7. $\sqrt{530}$ = ______
8. 2^2 = ______
9. 163^2 = ______
10. $\sqrt{2.25}$ = ______

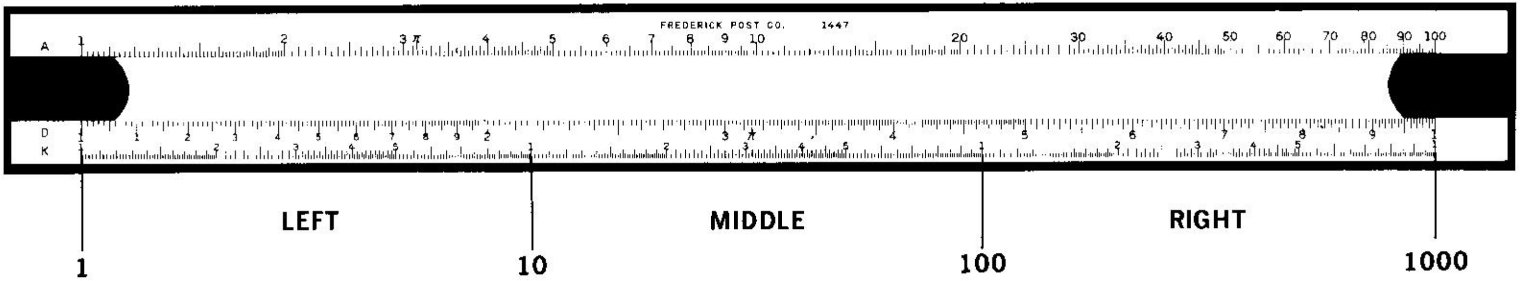
From p. 103. Answers to Square and Square Root Problems.

1. $\sqrt{840} = 2.9 \cdot 10^1 = 29$	6. $\sqrt{7500} = 8.66 \cdot 10^1 = 86.6$
2. $42^2 = 17.6 \cdot 10^2 = 1760$	7. $\sqrt{530} = 2.3 \cdot 10^1 = 23$
3. $158^2 = 2.5 \cdot 10^4 = 25{,}000$	8. $2^2 = 4$
4. $\sqrt{32.5} = 5.7$ (Read directly)	9. $163^2 = 2.65 \cdot 10^4 = 26500$
5. $62^2 = 38.4 \cdot 10^2 = 3840$	10. $\sqrt{2.25} = 1.5$

Go to p. 105.

From p. 104.

The D and K scales are used to find the cubes and cube roots of numbers. The K scale is the only portion of the front of the Post 1447 that is new to you. The K scale is used directly to locate any number between **1 and 1000.** Study the illustration of the K scale and then answer the question.



QUESTION: Which section of the K scale would directly contain the number 2700?

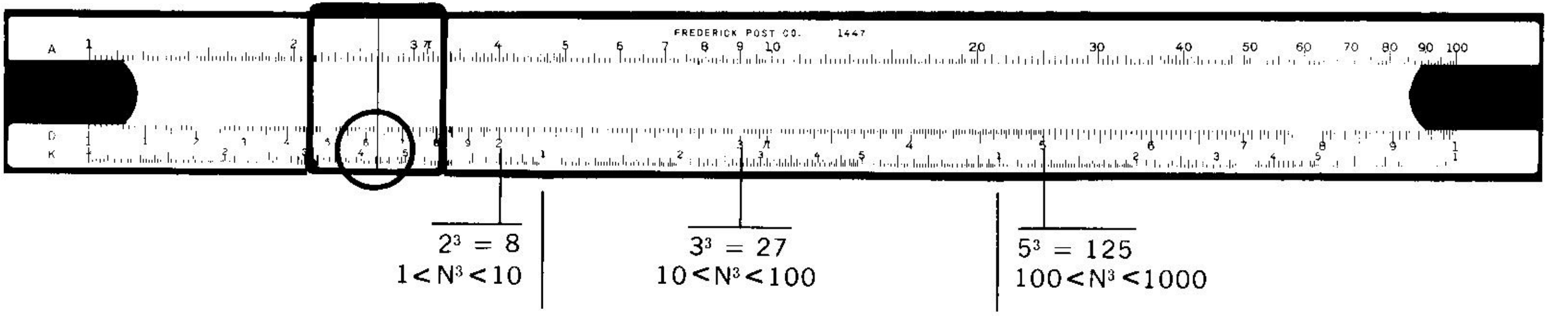
The middle section of the K scale........................... **Go to p. 111.**

The right section of the K scale.............................. **Go to p. 107.**

None of them.. **Go to p. 112.**

From p. 112. Your answer: The cube root of 430 is 1.63

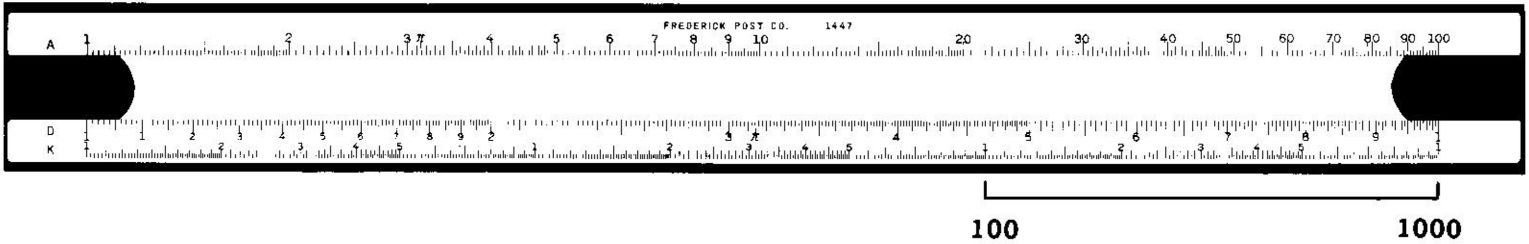
Are you using the correct section of the K scale? Study the picture below until you understand the proper sections of the K scale and their relations to the D scale.



For this problem, $N^3 = 430$

Return to page 112 and use the correct section of the K scale to find the cube root of 430. Go back to p. 112.

From p. 105. Your answer: 2700 is found directly on the right section of the K scale.



The right section of the K scale directly contains numbers that range from 100 to 1000. Turn to page 105 and select the correct answer. Return to p. 105.

From p. 112. Your answer. $\sqrt[3]{430}$ is 7.55

Correct. Now let's find the cube roots of some numbers that are LARGER than 1,000. Express the number as $a \cdot 10^{3x}$, where $1 < a < 1{,}000$.

EXAMPLES:

A. 2,700 converts to $2.7 \cdot 10^3$; use the left section of the K scale.
B. 27,000 converts to $27 \cdot 10^3$; use the middle section of the K scale.
C. 270,000 converts to $270 \cdot 10^3$; use the right section of the K scale.
D. .0027 converts to $2.7 \cdot 10^{-3}$; use the left section of the K scale.

Set the hairline at the number on the APPROPRIATE SECTION of the K scale.
Read the cube root at the hairline on the D scale.
Multiply the cube root on the D scale by 10 to ONE THIRD of the appropriate exponent.

EXAMPLE:

$$\sqrt[3]{27{,}000} =$$
$$\sqrt[3]{27 \cdot 10^3} =$$
$$3 \cdot 10 = 30$$

PROBLEM:

Find $\sqrt[3]{350{,}000}$. Take your time and solve the problem. When you are through compare your setting and answer on the top of the next page. DON'T LOOK AT THE ANSWER until you have solved the problem for yourself. Then look at p. 109.

From p. 108. Your answer should be: $\sqrt[3]{350,000} = 7.05 \cdot 10^1 = 70.5$

PROCEDURES FOR CUBING NUMBERS (N^3)

1. Express the number to be cubed in scientific notation, $a \cdot 10^x$
   Thus, $(a \cdot 10^x)^3 = a^3 \cdot 10^{3x}$
2. Set the hairline at the converted number on the D scale.
3. Read the cube of your number at the hairline on the K scale; **THEN DETERMINE** if your K scale is between 1 and 10 **OR** 10 and 100 **OR** 100 and 1000.
4. Multiply your written cubed number by your calculated 10^{3x}. Remember if you can find $\sqrt[3]{64} = 4$, you can solve cube and cube root problems.

PROBLEMS:

1. $60^3 =$ $216 \cdot 10^3 = 216,000$
2. $\sqrt[3]{85} =$ ______
3. $\sqrt[3]{8} =$ ______
4. $28^3 =$ ______
5. $\sqrt[3]{420} =$ ______
6. $1.4^3 =$ ______
7. $\sqrt[3]{.0035} =$ ______
8. $\sqrt[3]{.025} =$ ______
9. $\sqrt[3]{295,000} =$ ______
10. $\sqrt[3]{2,950} =$ ______
11. $\sqrt[3]{10} =$ ______
12. $\sqrt[3]{1} =$ ______

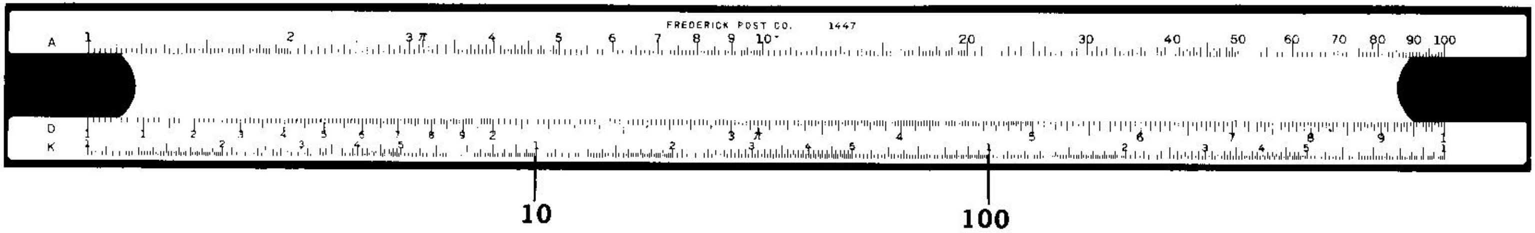
Finished? Check your answers on p. 110.

From p. 109. Answers to Cube and Cube Root Problems.

1. $60^3 = 216{,}000$
2. $\sqrt[3]{85} = 4.4$
3. $\sqrt[3]{8} = 2$
4. $28^3 = 22 \cdot 10^3 = 22{,}000$
5. $\sqrt[3]{420} = 7.5$
6. $1.4^3 = 2.75$
7. $\sqrt[3]{.0035} = 1.52 \cdot 10^{-1} = .152$
8. $\sqrt[3]{.025} = 2.93 \cdot 10^{-1} = .293$
9. $\sqrt[3]{295{,}000} = 6.66 \cdot 10^1 = 66.6$
10. $\sqrt[3]{2{,}950} = 1.43 \cdot 10^1 = 14.3$
11. $\sqrt[3]{10} = 2.16$
12. $\sqrt[3]{1} = 1$

When completed go to p. 113.

From p. 105. Your answer. 2,700 is found directly on the middle section of the K scale.



The only numbers that are directly found on the middle section of the K scale range from 10 to 100. Turn to page 105 and select the correct answer.

Return to p. 105.

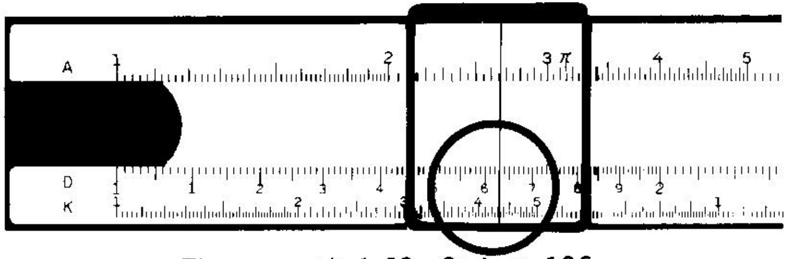
From p. 105. Your answer: None of the sections directly contains the number 2,700

That is true. Here's a quick exercise: Set the hairline at 2.7 on the left section of the K scale and read the cube root of 2.7 on the D scale at the hairline. THEN find the cube root of 27 on the middle section of the K scale. THEN find the cube root of 270 on the right section of the K scale.

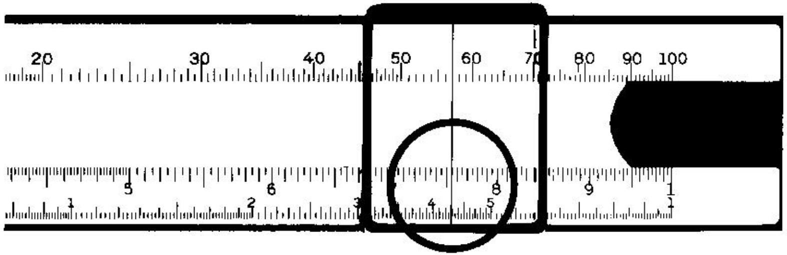
EXAMPLES:

1. $\sqrt[3]{2.7} = 1.39$ $(1.39 \times 1.39 \times 1.39 = 2.7)$
2. $\sqrt[3]{27} = 3$ $(3 \times 3 \times 3 = 27)$
3. $\sqrt[3]{270} = 6.46$ $(6.46 \times 6.46 \times 6.46 = 270)$
4. $\sqrt[3]{.000270} = (270 \cdot 10^{-6})^{1/3} = 6.46 \cdot 10^{-2} = .0646$
   (Notice that the exponent is divisible by 3.)
5. $\sqrt[3]{.0027} = (2.7 \cdot 10^{-3})^{1/3} = 1.393 \cdot 10^{-1} = .1393$
6. $\sqrt[3]{.027} = (27 \cdot 10^{-3})^{1/3} = 3.0 \cdot 10^{-1} = .3$

PROBLEM: Find $\sqrt[3]{430}$. Compare your setting with the pictures.



The answer is 1.63 **Go to p. 106.**



The answer is 7.55 **Go to p. 108.**

From p. 110.

A **ratio** is an indicated division -- that is, $\frac{a}{b}$

A **proportion** is a statement that two or more ratios are equal: $\frac{a}{b} = \frac{c}{d}$

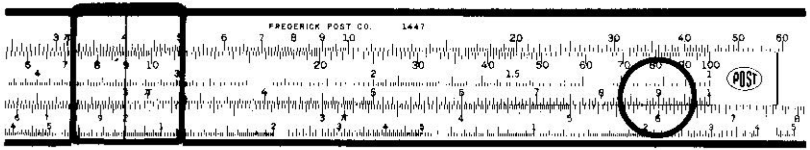
Your Post slide rule is a "natural" for determining proportions. No algebraic manipulation of terms is necessary. The procedures for finding ratios and proportions are exactly like those for division with the C and D scales.

EXAMPLE: $\frac{5}{8} = \frac{x}{17}$

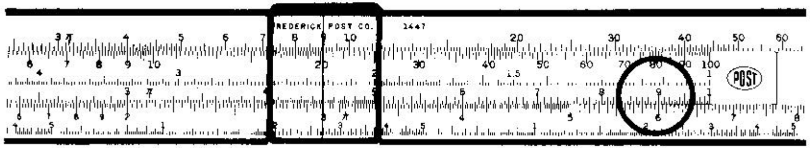
Do this with your slide rule:

1. Set hairline to 5 on D scale.
2. Move 8 on C scale at hairline.
3. Move hairline to 17 on C scale.
4. Read 10.62 (x) on D scale.

PROBLEM: $\frac{6}{9} = \frac{x}{3}$ Solve for x.



$x = 2$ **Go to p. 118.**



$x = 4.5$ **Go to p. 120.**

From p. 119. Your answer: 57 miles

Correct. Actually, this problem could have been solved by ratio and proportion procedures using a formula of $\frac{\text{time}}{\text{time}} = \frac{\text{distance}}{\text{distance}}$ or $\frac{\text{2.5 hrs.}}{\text{1 hr.}} = \frac{\text{95 miles}}{\text{x miles}}$ or $\frac{\text{2.5 hrs.}}{\text{95 mi.}} = \frac{\text{1 hr.}}{\text{x mi.}}$

On the back of your Post 1447 rule, you'll find common relationships that you can express as ratios.

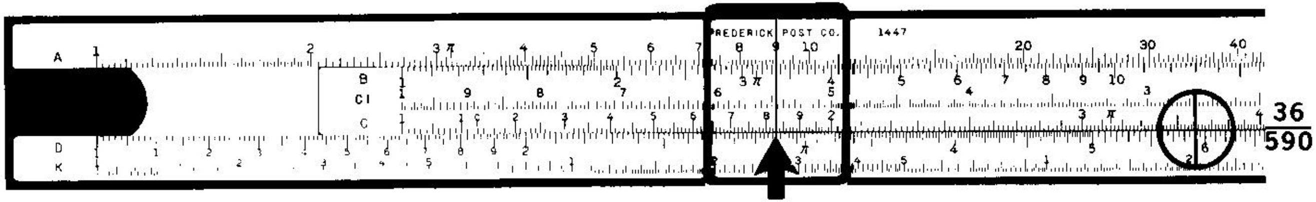
Example: You can translate cubic centimeters to cubic inches by using the ratio, $\frac{590.}{36}$

Scale C	Scale D	Scale C	Scale D
Sq. in	Sq. centimetre	31	200
" ft	" metre	140	13
" yd	" "	61	51
Cub. in	Cub. centimetre	36	590
" ft	" metres	106	3
" in	Imp. gallons	6100	22

PROBLEM: A motorcycle engine has 300 cubic centimeters(cc): Find the cubic inches(cu.in.)

$$\frac{\text{cc}}{\text{cu.in.}} = \frac{590}{36} = \frac{300}{X}$$

Express in scientific notation.



If your answer is 183 cu.in., **Go to p. 121.**

If your answer is 18.3 cu.in., **Go to p. 125.**

From p. 118. Your answer: $\frac{62.5}{10} = \frac{25}{4} = \frac{2}{0.32}$

Very good. Let's go on to an operation you used before in this program — the case where the C scale value you must use is off scale. $\frac{6}{3} = \frac{x}{7}$

PROCEDURE:
1. Set the hairline at 6 on the D scale.
2. Move 3 on the C scale at the hairline, forming the ratio $\frac{6}{3}$.
3. Note that you cannot solve the proportional ratio for $\frac{x.}{7}$ Why? Because 7 on the C scale is off scale.
4. Set the hairline at the left index of the C scale and move the right index of the C scale to the hairline.
5. Now read the ratio $\frac{14}{7}$ which is proportional to $\frac{6}{3}$

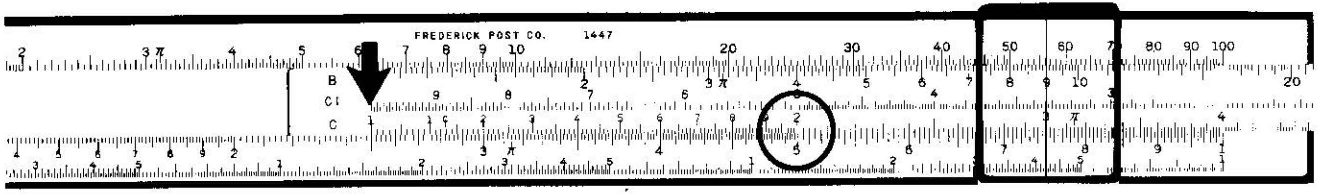
PROBLEM: $\frac{5}{2} = \frac{7.5}{x} = \frac{y}{6}$

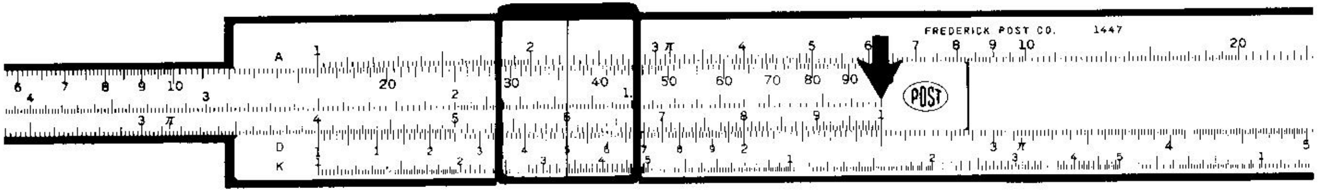
Your answer is: $\frac{5}{2} = \frac{7.5}{1.875} = \frac{15}{6}$ **Go to p. 116.** $\frac{5}{2} = \frac{7.5}{3} = \frac{15}{6}$ **Go to p. 124.**

From p. 115. Your answer: $\frac{5}{2} = \frac{7.5}{1.875} = \frac{15}{6}$

You are half right. Did you make a mistake when you moved the slide to the right index on the C scale? Did you change the indexes too soon?

Study the illustrations below for the proper location of hairline and slide to locate the proportional ratios for $\frac{5}{2} = \frac{7.5}{x} = \frac{y}{6}$





You may review on page 115; or, if you have this clear, go to p. 124.

From p. 124. Your answer: 175 cu. ft.

You can get an answer like that if you invert one set of numbers. But it is not the answer you want. The formula is $\frac{\text{volume}}{\text{depth}} = \frac{\text{volume}}{\text{depth}}$ or $\frac{40}{2} = \frac{x}{3.5}$. Setting the problem up to $\frac{\text{depth}}{\text{depth}} = \frac{\text{volume}}{\text{volume}}$ or

$\frac{\text{depth}}{\text{volume}} = \frac{\text{depth}}{\text{volume}}$ is OK and sometimes you may want to do this for easier slide rule manipulation. Just remember to keep the relationships in order (the denominators on one scale and the numerators on the other scale). $\frac{d}{d'} = \frac{v}{v'}$ or $\frac{v}{d} = \frac{v'}{d'}$, or $\frac{d}{v} = \frac{d'}{v'}$

Go back to p. 124 and try the problem again. **Return to p. 124.**

From p. 113. Your answer $x = 2$

Very good, you have figured it out. Now we'll practice a little. Bear in mind—when a ratio is set up on the slide rule, every point on the C scale and the adjacent point on the D scale is a proportional ratio. Read either from C to D scale or vice versa. You may refer to the procedures on page 110 if necessary. Remember, locate all of the numerators on the **one** scale and all of the denominators on the **other** scale.

PROBLEM: $\frac{50}{8} = \frac{62.5}{x} = \frac{y}{4} = \frac{2}{z}$ solve for x,y,z

QUESTION: Which of the following do you agree with?

$$\frac{62.5}{10} = \frac{25}{4} = \frac{2}{0.32}$$

Go to p. 115.

$$\frac{62.5}{100} = \frac{250}{4} = \frac{2}{32}$$

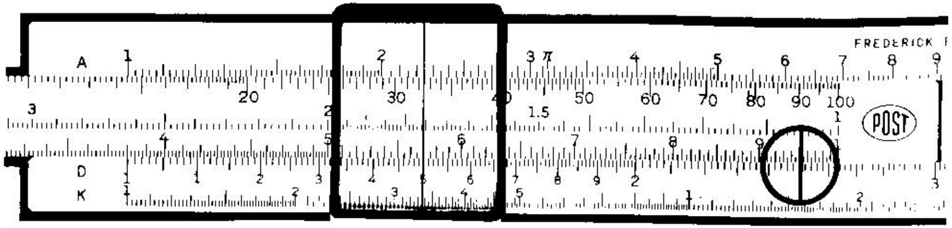
Go to p. 122.

From p. 124. Your answer: 70 cu. ft.

Very good. Now here's a problem that is similar to the ones you have dealt with so far.

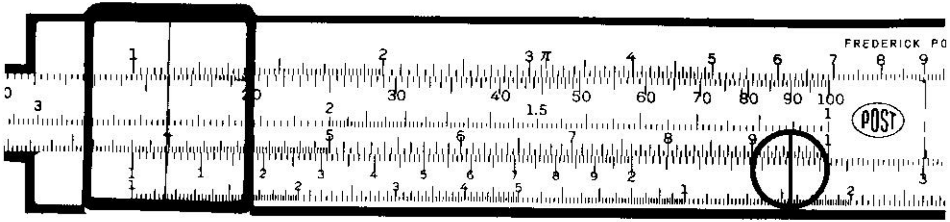
PROBLEM: If a car travels 95 miles in 2.5 hours, how far will it travel in 1.5 hours?

SUGGESTION: $\dfrac{2.5 \text{ hrs}}{95 \text{ miles}} = \dfrac{1.5}{x \text{ miles}}$



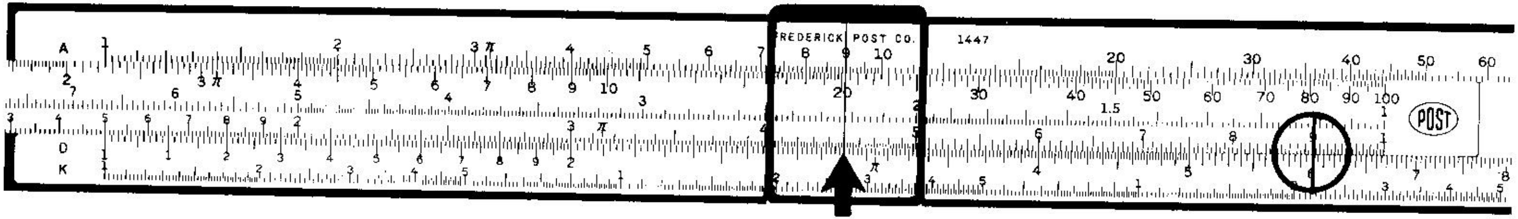
Answer:

57 miles......... **Go to p. 114.**



39.9 miles...... **Go to p. 123.**

From p. 113. Your answer 4.5 and



Let's look at the problem again.

$\frac{6}{9} = \frac{x}{3}$ The first denominator is 9 and the second denominator is 3.

Keep the numerators of the ratios on the D scale and the denominators on the C scale.

Think about the problem; $6 < 9$, therefore x must be < 3.
Turn to page 113 and set up the problem properly. Return to p. 113.

From p. 114.

Your answer: The 300cc motorcycle has 183 cu. in.

How did you do your scientific notation? Did it look like this?

$$\frac{590}{36} = \frac{300}{X}$$

$$\frac{5.9 \cdot 10^2}{3.6 \cdot 10} = \frac{3 \cdot 10^2}{X' \cdot 10}$$

Well, if you found X' as 1.83 on your D scale, then your answer should have been X = 18.3. You can check this: 3.6 < 5.9, so 1.83 < 3.

Think about this and then go directly to page 125.

From p. 118. Your answer: $\frac{62.5}{100} = \frac{250}{4} = \frac{2}{32}$

Don't blame this choice on your slide rule or technique.

Consider the original ratio $\frac{50.}{8}$

If you actually performed the indicated division, you would get about 6 (6.25). Now, if all ratios that are proportional are connected by an equality sign (=) it follows that the other ratios must also be $\cong$ 6.

Return to page 118 and apply scientific notation, rounding and estimation to the problem. Turn to p. 118.

From p. 119. Your answer: 39.9 miles

You have found the distance the car will travel in 1.05 hours, but you were looking for 1.5 hours. Remember, the scale markings between 1 and 2 on the C scale are 1, 1.1, 1.2, 1.3, 1.4, 1.5, 1.6, 1.7, 1.8, 1.9, then 2.0. Return to page 119 and correctly set the hairline to 1.5 on the D scale.

Go back to p. 119.

From p. 115 or p. 116. Your answer: $\frac{5}{2} = \frac{7.5}{3} = \frac{15}{6}$

Correct. I know you can hardly wait to try this on some problems—have a "go" at this: A cylindrical container is filled to a depth of 2 feet and holds 40 cubic feet. How many cubic feet will it have if filled to a depth of 3.5 feet?

The formula can be $\frac{\text{volume}}{\text{depth}} = \frac{\text{volume}}{\text{depth}}$ or $\frac{\text{depth}}{\text{volume}} = \frac{\text{depth}}{\text{volume}}$

If you get 175 cu. ft. **Go to p. 117.** If you get 70 cu. ft. **Go to p. 119.**

From p. 114 or p. 121 Your answer: 18.3 cu. in.

Very good. Now you can solve the following proportion problems.

Find x.

1. $\frac{639}{725} = \frac{x}{318}$

2. $\frac{21.4}{195} = \frac{x}{12.1}$

3. $\frac{60 \text{ mph}}{88 \text{ ft/sec}} = \frac{37\text{mph}}{x}$

4. $\frac{71}{705} = \frac{18.25}{x}$

5. You have 1 pound of sugar; what does it weigh in kilograms? (remember the back of your rule)

Find x, y, z.

6. $\frac{8.7}{15.2} = \frac{x}{27.6} = \frac{44.4}{y} = \frac{z}{39.3}$

To check your answers, turn to p. 126.

From p. 125. Answers to proportion problems

1. $\frac{639}{725} = \frac{x}{318}$ $\quad \frac{6.39 \cdot 10^2}{7.25 \cdot 10^2} = \frac{x' \cdot 10^2}{3.18 \cdot 10^2}$; $x = 2.80 \cdot 10^2 = \underline{280}$

2. $\frac{21.4}{195} = \frac{x}{12.1}$ $\quad \frac{2.14 \cdot 10}{1.95 \cdot 10^2} = \frac{x' \cdot 10^0}{1.21 \cdot 10}$; $x = 1.328 \cdot 10^0 = \underline{1.328}$

3. $\frac{60 \text{ mph}}{88 \text{ ft/sec}} = \frac{37 \text{mph}}{x}$ $\quad \frac{6.0 \cdot 10}{8.8 \cdot 10} = \frac{3.7 \cdot 10}{x' \cdot 10}$; $x = 5.43 \cdot 10 = \underline{54.3 \text{ ft/sec.}}$

4. $\frac{71}{705} = \frac{18.25}{x}$ $\quad \frac{7.1 \cdot 10}{7.05 \cdot 10^2} = \frac{1.825 \cdot 10}{x' \cdot 10^2}$; $x = 1.812 \cdot 10^2 = \underline{181.2}$

5. $\frac{\text{Kg}}{\text{Lb}} = \frac{127}{280} = \frac{x}{1}$ $\quad \frac{1.27 \cdot 10^2}{2.80 \cdot 10^2} = \frac{x}{1}$; $x = .454 = \underline{.454} \text{ Kg.}$

6. $\frac{8.7}{15.2} = \frac{x}{27.6} = \frac{44.4}{y} = \frac{z}{39.3}$ $\quad \frac{8.7 \cdot 10^0}{1.52 \cdot 10^1} = \frac{x' \cdot 10^0}{2.76 \cdot 10^1} = \frac{4.44 \cdot 10^1}{y' \cdot 10^2} = \frac{z \cdot 10^0}{3.93 \cdot 10^1}$ $\quad \begin{cases} x = 15.8 \cdot 10^0 = \underline{15.8} \\ y = 7.75 \cdot 10^1 = \underline{77.5} \\ z = 22.5 \cdot 10^0 = \underline{22.5} \end{cases}$

Congratulations! You have completed the program for the front of the Post 1447 Slide Rule.

Decision point:	I want to review what I have learned so far. **Go to p. 152**	I want to learn about logarithms, sines and tangents on the back of the slide. **Start on p. 127**

(Optional — You may go to p. 152 if you wish to skip logarithms, sines and tangents.)

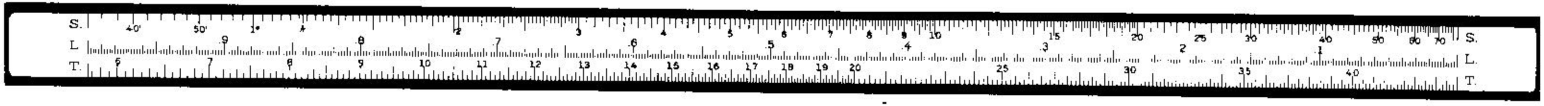
From p. 126.

The "L" scale on the back of the Post 1447 enables you to find common logarithms, called "logs".

Logarithm 3.157

Characteristic → 3 ; Mantissa → 157

First, remove the slide from the body of your rule and place it (back side showing) over the picture.



QUESTION: How is the L scale numbered?

It is numbered from right to left and has equal-spaced markings from 0 to 10. **Go to p. 137.**

It is numbered from right to left and has equal-spaced markings from 0 to 1.0. **Go to p. 132.**

Replace your slide with the B, CI, and C scales on the FRONT.

From p. 132. Your answer: Log 35 = 1.544

Right. Finding logs (characteristics and mantissas) of numbers is not difficult when you use the Post 1447 slide rule. You first express your number in scientific notation and use the exponent as the value of the characteristic. Set the hairline at the right index of the D scale. Then locate the converted number on the CI scale at the hairline. Carefully turn the slide rule over and read the mantissa of that number on the L scale at the fixed hairline. As in our last problem, log 35 has a characteristic of 1 ($3.5 \cdot 10^1$) and the mantissa located on the L scale is .544. Therefore Log 35 is written 1.544.

PROBLEM: Use your slide rule and determine the characteristic and mantissa of 785.

2.905 ....**Go to p. 130.**
2.895 ....**Go to p. 133.**

From p. 133. Your answer: I don't know how to solve problems when given the log.

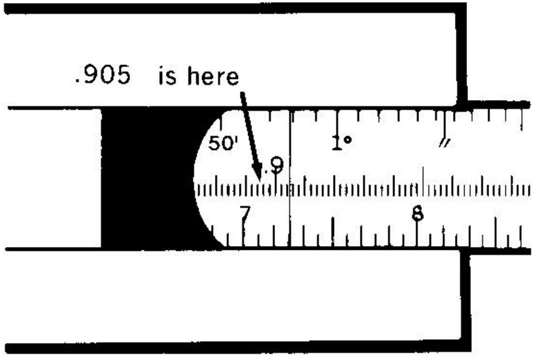
Okay, but I'll bet you really do know how to solve them. It is just the reverse of finding the log of a known number. First, you look at your problem and determine the exponent of 10. For Example: 2.3010 tells you that the number (of which .301 is the mantissa) will be multiplied by 10^2. So your problem is $X \cdot 10^2$. Next you locate .301 on the L scale the fixed hairline. Then you carefully turn the slide rule over and read the value on the CI scale.

Solve this problem: What number does this log represent? 3.624

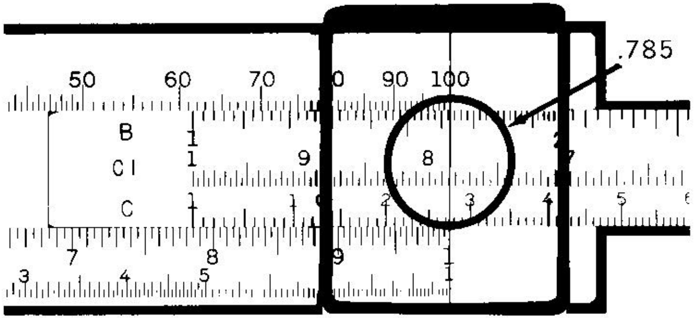
You will find that the answer is $4.2 \cdot 10^3$ or 4200. Return to p. 133.

From p. 128. Your answer: Log 785 = 2.905

How are you reading the L scale?

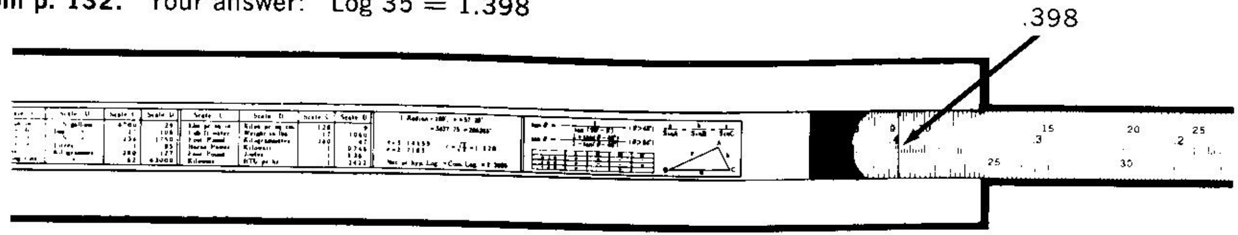


The L scale is read from right to left.

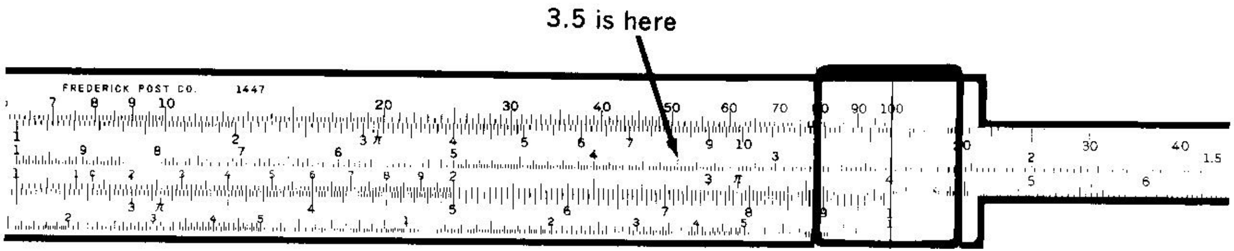


Turn to page 128 and select the correct answer.
Return to p. 128.

From p. 132. Your answer: Log 35 = 1.398



Have you forgotten that the CI scale is an Inverted C scale. It is read from right to left and **NOT** from left to right. You were asked to set 3.5 on the CI scale at the hairline.



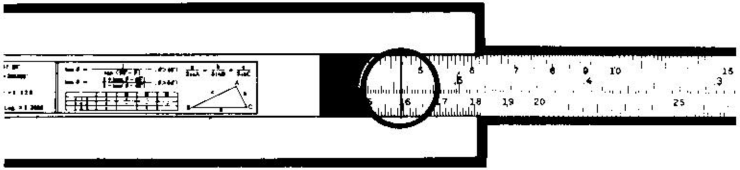
Return to page 132 and correctly solve the problem. Go back to p. 132.

From p. 127. Your answer: It is numbered from right to left and has equal-spaced markings from 0 to 1.0

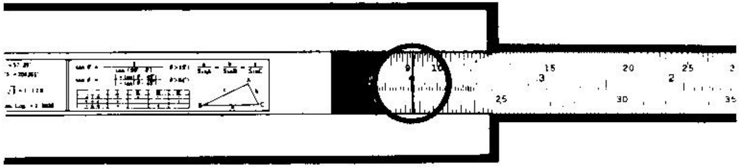
Right. The indicator hairline can be set at either D scale index, but for the purposes of this lesson we will set it at the right D scale index.

1. Express your number in scientific notation, $a \cdot 10^x$. Remember, the exponent IS your characteristic. (Write this on paper).
2. Set the hairline at the right D scale index.
3. Locate "a" on the CI scale under the hairline.
4. Carefully turn the slide rule over and read the mantissa on the L scale under the fixed hairline.

PROBLEM: Find log 35 (Set the hairline at the right index of the D scale).



$35 = 3.5 \cdot 10^1$
Log $35 = 1.5440$
Go to p. 128



$35 = 3.5 \cdot 10^1$
Log $35 = 1.3980$
Go to p. 131

From p. 128. Your answer: Log 785 = 2.895

Right. Solve the following problems with your L scale and CI scale. Write your answers on a separate sheet of paper. After you have solved all of the problems you may check your answers on the back of this page (p. 134).

1. Find the log for each of the following numbers.

   a. 3,250
   b. 646
   c. 845
   d. 1,250
   e. 25,600
   f. 14
   g. 5

2. What number does each log represent?

   Wait, I don't know how to do these problems! **Go to p. 129.**

   a. 1.778
   b. 2.301
   c. 1.544
   d. 1.624
   e. 1.699

Go to p. 134

From p. 133. Answers to Logarithm Problems

1a. Log 3,250 = 3.512
b. Log 646 = 2.810
c. Log 845 = 2.927
d. Log 1,250 = 3.097
e. Log 25,600 = 4.408
f. Log 14 = 1.146
g. Log 5 = .700

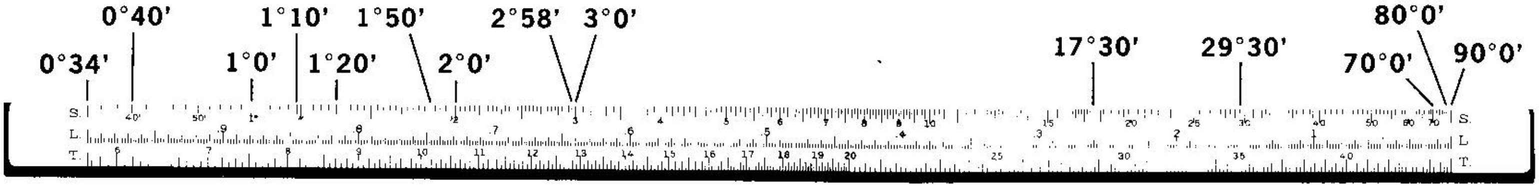
2a. $6 \cdot 10^1 = 60$
b. $2 \cdot 10^2 = 200$
c. $3.5 \cdot 10^1 = 35$
d. $4.21 \cdot 10^1 = 42.1$
e. $5.0 \cdot 10^1 = 50$

After you have checked all your answers go to page 135 and continue. **Go to p. 135**

(Optional — If you have not yet studied trigonometry, you may wish to go directly to the final review on p. 153)

From p. 134.

With the Post 1447 Slide Rule you can easily find the numerical value for the sine of any angle between 0°34' and 90°. To find the sine of a given angle you will use the B and S scales on your slide rule. The S scale is on the back of the slide and is divided to read in degrees and minutes from about 0°34' to 90°.



QUESTION: What is the range of the S scale and how many minutes are there in a degree?

The range is from 0°34 minutes to 70° and there are 50 minutes in a degree. **Go to p. 140.**

The range is from 0°34 minutes to 90° and there are 60 minutes in a degree. **Go to p. 139.**

From p. 139. Your answer: The left half of the B scale is read from .01 to .1 and the right half is read from .1 to 1.0 Very good.

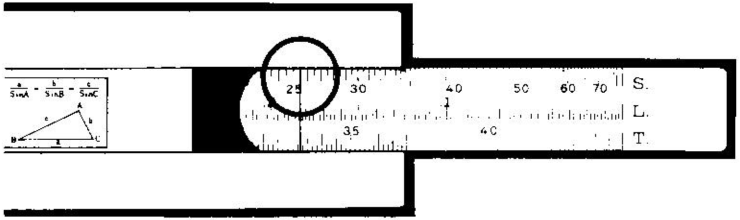
FINDING THE SINE OF A KNOWN ANGLE.

1. Move the hairline to the right A index.
2. Turn rule over and move slide so the angle measure on the **S scale** is at right fixed hairline.
3. Carefully turn rule over again and read the sine on the B scale at indicator hairline.

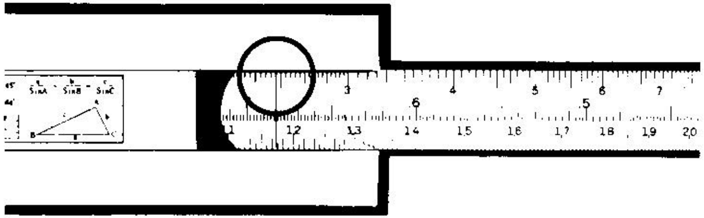
FINDING THE ANGLE MEASURE WHEN SINE IS KNOWN.

1. Move the hairline to the right A index.
2. Move slide so sine on B scale is at indicator hairline.
3. Carefully turn rule over and read angle on the S scale at right fixed hairline.

PROBLEM: Find the angle measure that has a sine of .430. Then compare your setting. DO NOT LET YOUR INDICATOR HAIRLINE SLIP.



Go to p. 143

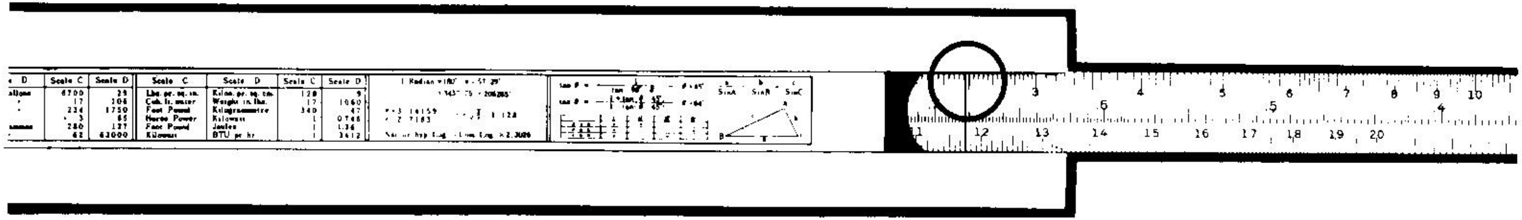


Go to p. 138

From p. 127. Your answer: The L scale is numbered from right to left and has equal-spaced markings from 0 to 10.

Each printed number on the L scale has a decimal point in front of it. Why are these numbers all less than 1? Because they are the mantissa part of the logarithm. You are reading numbers from 1 to 10 on the CI scale, so the **log** of these numbers to base ten will be $\leqq 1$. Turn to page 127 and select the correct answer. Return to p. 127

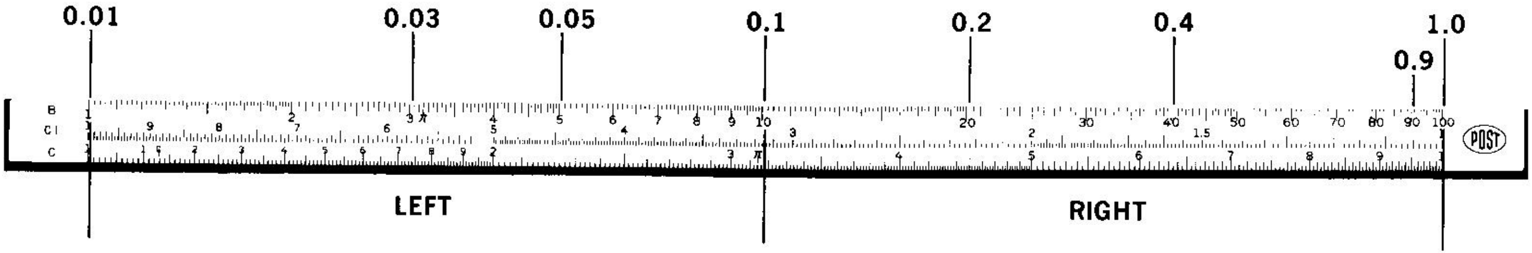
From p. 136. Your answer: Your slide rule is the same as this.



You've moved .043 on the B scale to the indicator hairline. Remember that the left half of the B scale is read from .01 to .10, therefore, all of the numerals on the left half of the scale are read as .01, .02, .03, .04, .05, .06, .07, .08, .09, and .10. Go back to page 136 and move the slide until .430 on the B scale is under the indicator hairline. Return to p. 136.

From p. 135. Your answer: Range is from 0° 34 minutes to 90°; there are 60 minutes in a degree.

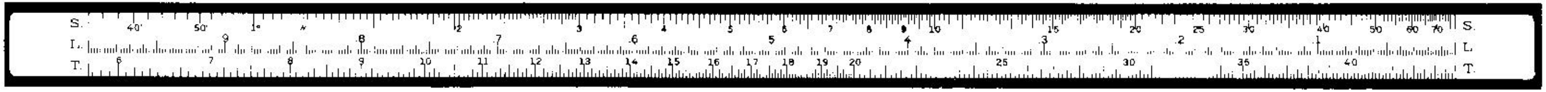
Right. When using the S scale you must remember how it is marked so that you can accurately locate a given angle measure.



QUESTION: How are the "two halves" of the B scale read?

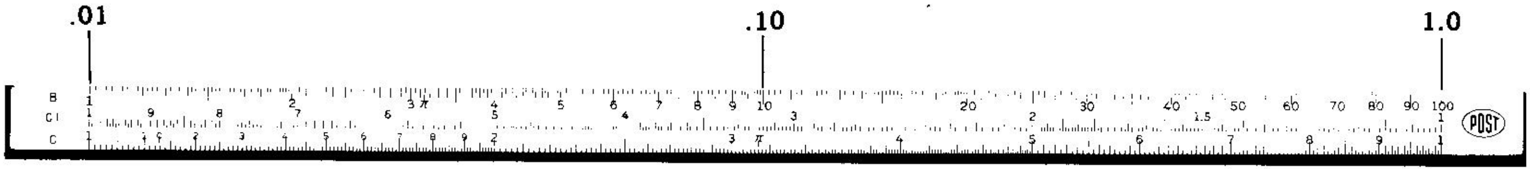
The left half is read from .01 to .1 and the right half from .1 to 1.0 **Go to p. 136.**
The left half is read from .1 to 1.0 and the right half from 1.0 to 10.0 **Go to p. 141.**
The left half is read from 1 to 10 and the right half from 10 to 100 **Go to p. 142.**

From p. 135. Your answer: The range is from 0°34' to 70° and there are 50 minutes in a degree.



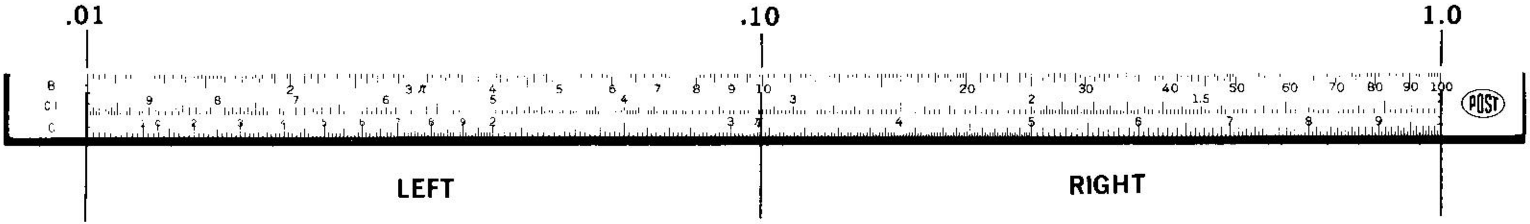
There are 60 minutes in a degree. The range of the S scale is from 0°34' to something **more** than 70°. Go back to page 135 and study the right side of the S scale again. Return to p. 135.

From p. 139. Your answer: The left half of the B scale is read from .1 to 1.0 and the right half from 1.0 to 10



The illustration shows the left half of the rule with values from .0100 to .1000 and the right half with values from .1000 to 1.000. Incidentally the midpoint on the scale (.1000) is the approximate value for sine 5°45′. Return to p. 139

From p. 139. Your answer: The left half of the B scale is read from 1 to 10 and the right half from 10 to 100



You're right in that the numbering is from 1 to 10 and from 10 to 100, but when you use the B scale with the S scale to find sines of angles you have to **think** of new values for the numbers on the B scale. Go back to page 139 and study the labeled points on the picture of the slide rule, then I think you can select the correct answer. Return to p. 139

From p. 136. Your answer: The sine of angle 25°30' = .430

Correct. Solve each of the following problems. You may refer to the procedures on page 136 if necessary. Write your answers on a separate sheet of paper. After you have solved all of the problems check your answers on the next page.

Find the sines for these angle measures.

1. Sin 20°30' = .350
2. Sin 3°40' = ________
3. Sin 5°0' = ________
4. Sin 39°0' = ________
5. Sin 70°0' = ________

Find the angle measures for these sines.

6. .150 = 8°38'
7. .067 = ________
8. .250 = ________
9. .455 = ________
10. .0128 = ________

Check your answers on p. 144

From p. 143. Answers to Sine Problems

1. .350	6. 8°38′
2. .064	7. 3°50′
3. .087	8. 14°30′
4. .630	9. 27°0′
5. .940	10. 0°44′

Decision time: Select the statement that you feel is true.

I would like to repeat the material on sines. **Go to p. 135**

I feel that I can determine the sines of angles with the B and S scales. **Go to p. 145**

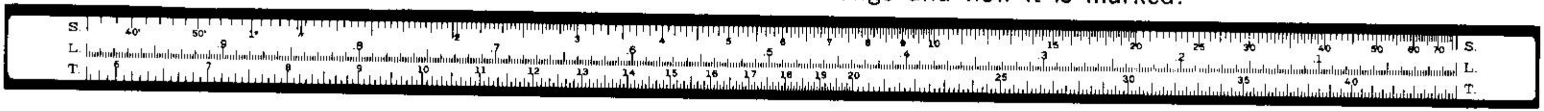
(OPTIONAL — You may go directly to p. 152 if you wish to skip this)

From p. 144.

This instructional sequence will teach you to find the tangent of any angle measure between 5°45' and 84°15'. For angle measures smaller than 5°45' and angle measures larger than 84°15' see page 163 of this booklet.

The T and C scales are used for finding the tangent of a known angle, and for finding the angle of a known tangent. The procedures are very similar to those for finding sines.

PROBLEM: Look at the T scale and determine its range and how it is marked.



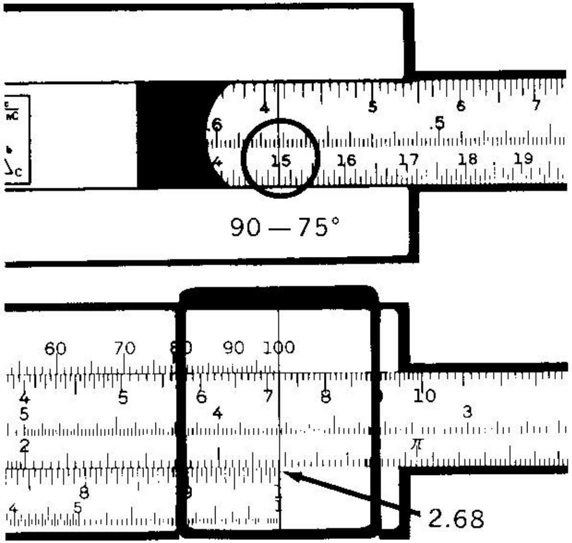
QUESTION: What is the range of the T scale?

From about 5.5° to 50° and is marked in degrees. **Go to p. 149**

From about 5°45' to 45°0' and is marked in degrees and minutes. **Go to p. 147**

From p. 148

Your answer: tan 75° = 2.68



Remember, you are dealing with an angle-measure greater than 45°; therefore its tangent is read on the **CI** scale. Think about this. Did you use the **C** scale to get your answer?

Go back to page 148 and solve the problem using the CI scale. **Return to p. 148.**

From p. 145. Your answer: From about 5°45' to 45°0' and is marked in degrees and minutes.

Right. I think if you study the following procedures you can easily solve the problems

Finding the Tangent when an angle measure of less than 45° is known.

1. Move the indicator hairline to the right D scale index.
2. Carefully turn the rule over and locate the known angle measure on the T scale.
3. Turn the rule, read the tangent on the C scale at the indicator hairline.

Example: Tangent of 28°0'? tan 28° = .533

Finding the angle measure of less than 45° when the Tangent is known.

1. Move the indicator hairline to the right D scale index.
2. Move the known tangent on the C scale to the indicator hairline.
3. Read the angle on the T scale at the right fixed hairline.

PROBLEMS:

Find: a. tan 31°0'? ____________

b. tan 45°0'? ____________

c. tan 9°5'? ____________

d. .145 is tan of? ____________

e. .555 is tan of? ____________

f. .424 is tan of? ____________

Check your answers on p. 148.

From p. 147. The answers are:

a. .601	c. .160	e. 29°0'
b. 1.000	d. 8°15'	f. 23°0'

If you had any trouble with the problems, go back to page 147 and try again. Remember that for angles that are less than 45°, the C scale has a range of .1 to 1.0 (reading from left to right on the C scale).

To solve for angles greater than 45°, apply the following rule.

RULE: $\tan x = \frac{1}{\tan(90\text{-}x)}$ Example: $\tan 65° = \frac{1}{\tan(90°\text{-}65°)} = \frac{1}{\tan 25°} = \frac{1}{.4660} = 2.150$

In other words, for angles greater than 45°, this suggests using the CI scale as in the following.

1. Subtract the angle from 90°.
2. Set the indicator hairline to the right D scale index.
3. Carefully turn your rule over and move the angle (90°-x) on the T scale to the fixed hairline.
4. Read the tangent on the CI scale at the indicator hairline.

PROBLEM:

Use your slide rule and find tan 75°.

2.68 . . . . **Go to p. 146.**

3.73 . . . . **Go to p. 150.**

From p. 145. Your answer: From about 5.5° to 50° and is marked in degrees.

If you'll study the back of your slide, you'll find that the range does **not** go to 50°. Return to page 145, study the information again and select the correct answer. Return to p. 145

From p. 148. Your answer: tan 75° = 3.73

Very good. Here's a simple rule to help you remember tangents.
RULE: Tangents **smaller** than 1 are for angles **smaller** than 45° (C scale).
Tangents **greater** than 1 are for angles **greater** than 45° (CI scale).

Example: .600 (C scale) is tan 31°0'
1.665 (CI scale) is tan 59°0' (90°—59°)

Solve the following problems before you check the answers. Record your answers on a separate sheet.

1. tan 70° ? 2.74	6. .448 is tan ? 24°10'
2. tan 35° ? ______	7. .306 is tan ? ______
3. tan 21°50' ? ______	8. 2.14 is tan ? ______
4. tan 16°10' ? ______	9. 1.60 is tan ? ______
5. tan 50° ? ______	10. 1.19 is tan ? ______

Check your answers on p. 151.

From p. 150. The answers to the problems on page 150 are:

1. tan 70° = 2.74
2. tan 35° = .700
3. tan 21°50' = .400
4. tan 16°10' = .288
5. tan 50° = 1.19
6. .448 = tan 24°10'
7. .306 = tan 17°
8. 2.14 = tan 65°
9. 1.60 = tan 58°
10. 1.19 = tan 50°

Congratulations! You have finished the program on your Post 1447 rule. For a final review, turn the page.

Go to p. 152

From p. 151

A quick review of the following information will be of value:

Solve each problem accurately.
Locate the decimal point properly.
Observe the factor notation for each problem -- $a \cdot 10^x$.
Have a separate sheet of paper to record necessary information.
Carefully analyze each problem.
Inspect the slide rule and determine which scales and indexes will be used.
Never **hurry** yourself.
and
Study the problem before you start solving it with the slide rule.
Total the exponents and write all problems in the simplest form.
Tangents are found on the T and C Scales.
Identify all of the factors in a **given** problem.
Precisely locate all values on the slide rule within acceptable limits.

Go to p. 153

From p. 152.

REVIEW

Multiplication using the C and D scales.

PROCEDURES: 262 x 24.5 (Example)

1. Express factors in scientific notation, numbers between 1 and 10 times a power of 10.
   $2.62 \cdot 10^2 \times 2.45 \cdot 10$
2. Estimate the product [$\sim$ 3 x 2 = 6]
3. Using your slide rule, set up the problem.
   (If you use the Right C Index, include 10 in your slide rule product)
   Use the estimate to check the decimal point and the correctness of the product on your slide rule.
4. To solve the problem in step 3
   a. Move Left C Index to 2.62 — D scale.
   b. Move hairline to 2.45 — C.
   c. Read at hairline, 6.42 — D.
   d. Apply combined exponent $6.42 \cdot 10^3 = \underline{6420}$

PROBLEMS: Use the above procedures and check the answers to these problems:

1. 945 x 360 = 340,000
2. 695 x 72 = 50,000
3. 145 x 40 = 5800
4. 765 x 40 = 30,600

Go to p. 154.

From p. 153.

REVIEW

Division with C & D scales.

PROCEDURES: $\frac{262}{24.5}$

1. Express each number in scientific notation. Combine exponents. $\frac{2.62 \cdot 10^2}{2.45 \cdot 10^1} = \frac{2.62}{2.45} \cdot 10$

2. Estimate quotient without exponent. Is Q< 1 or > 1? $\left[\frac{2.62}{2.45} ; Q > 1\right]$

3. Use your slide rule to set up the stated problem.
   a. Move hairline to 2.62 on D
   b. Move slide to 2.45 on C at hairline
   c. Read quotient at Left C Index, 1.070 on D

4. Apply exponent. $1.070 \cdot 10^1 = \underline{10.70}$

PROBLEMS:

1. $\frac{422}{5.25} =$

   $\frac{4.22}{5.25} \cdot 10^2 =$

   $\left[\frac{4}{5} ; Q < 1\right]$

   $= .804 \cdot 10^2$

   $= \underline{80.4}$

2. $\frac{.006}{.007} =$

   $\frac{6 \cdot 10^{-3}}{7 \cdot 10^{-3}} =$

   $\left[\frac{6}{7} ; Q < 1\right]$

   $= \underline{.857}$

3. $\frac{500}{.004} =$

   $\frac{5 \cdot 10^2}{4 \cdot 10^{-3}} =$

   $\left[\frac{5}{4} ; Q > 1\right]$

   $= 1.25 \cdot 10^5$

   $= \underline{125{,}000}$

Go to p. 155

From p. 154.

REVIEW

Reciprocals - The C and CI scales

The reciprocal of a number is 1 divided by that number: The reciprocal of 2 is $\frac{1}{2}$ or 0.5; the reciprocal of 0.5 is $\frac{1}{0.5}$ or 2. You will find that the reciprocal of any number more than 1 is always less than one and vice versa. The number 1 is a special case since $1 \div 1$ is 1.

PROCEDURES: Example: $\frac{1}{18}$

1. Express the number in scientific notation, $a \cdot 10^x$

   $\frac{1}{1.8 \cdot 10^1}$
2. Set the hairline to number on C scale. Read CI.

   $\frac{1}{1.8} = 5.55$
3. Apply the changed exponent, $x' = -x - 1$

   $5.55 \cdot 10^{-2} = \underline{.0555}$

PROBLEMS

Verify the following on your slide rule:

$$\frac{1}{485} = \frac{1}{4.85 \cdot 10^2} = 2.06 \cdot 10^{-3} = \underline{.00206}$$

$$\frac{1}{.041} = \frac{1}{4.1 \cdot 10^{-2}} = 2.44 \cdot 10^1 = \underline{24.4}$$

Go to p. 156

From p. 155.

REVIEW

Multiplication and Division using the C, CI, and D scales.

Example: $\dfrac{482 \times 57.5}{40}$

1. Express in scientific notation: $\dfrac{4.82 \cdot 10^2 \times 5.75 \cdot 10}{4 \cdot 10}$

2. Simplify exponents and combine: $\dfrac{4.82 \times 5.75}{4} \cdot 10^2$

3. Estimate $\left[\dfrac{5 \times 6}{4} \approx 7\right]$

4. Calculate a. Set hairline to 4.82 — D
   b. Move CI scale to 5.75 hairline (4.82 x 5.75)
   c. Set hairline to 4 — CI $\left(\dfrac{4.82 \times 5.75}{4}\right)$
   d. Read 6.92 — D. Set decimal from estimate

5. Apply exponent $6.92 \cdot 10^2 = \underline{692}$

PROBLEMS:

1. $\dfrac{7 \times 4 \times 3}{6 \times 3 \times 2} = \underline{2.33}$

2. $\dfrac{615 \times .05 \times 32.1}{.008 \times 63} = \underline{1959}$

Go to p. 157.

From p. 156.

REVIEW

Squares and Square roots — using A and D scales

PROCEDURE: (To square a number)

1. Use scientific notation and write down results. For example, $23^2 = (2.3 \cdot 10)^2$
2. Square the number and **double** the exponent of 10 ($4 \cdot 10^2$). Estimated answer is 400.
3. Move hairline to 2.3 on the D scale and read 5.29 at the hairline on the A scale.
4. Multiply the A scale value by the appropriate power of 10 ($5.29 \cdot 10^2 = 529$).

PROCEDURE (to find the square root of a number):

1. Express the number as a value between 1 and 100, using an **even** power of 10. ($b \cdot 10^{2x}$)
   For example: $23{,}000 = 2.3 \cdot 10^4$. Record the exponent.
2. Divide exponent by 2.
3. Remember the A scale ranges from 1 to 100 and set the hairline at the converted number, 2.3.
4. Read number (between 1 and 10) on D scale at the hairline, and multiply by the appropriate power of 10. (as calculated in step #2)

PROBLEMS:

The square root of:

840 = ________ (29)

32.5 = ________ (5.7)

The square of:

16.3 = ________ (266)

42 = ________ (1760)

Go to p. 158.

From p. 157.

REVIEW

Finding Cubes and Cube Roots

The D and K scales are used for these operations. The K scale has three sections. The left section ranges from 1 to 10, the middle section from 10 to 100, the right section from 100 to 1,000.

PROCEDURES FOR CUBING NUMBERS:

1. Express the number to a value between 1 and 10; THEN MULTIPLY the exponent of 10 by 3. (10^{3x}).
2. Set the hairline to the converted number on the D scale.
3. Read the cube of your number on the K scale. THEN DETERMINE the range of the K scale section you are reading. (1 to 10, or 10 to 100, or 100 to 1,000).
4. Multiply the K scale value by the appropriate power of 10 (as determined in step #1).

PROCEDURES FOR FINDING THE CUBE ROOT OF A NUMBER.

1. Move the decimal point IN GROUPS OF THREE to express the number between 1 and 1000. Exponent must be divisible by 3.
2. Set the hairline to the converted number on the **appropriate section** of the K scale.
3. Read the cube root on the D scale at the hairline.
4. Multiply the D scale value by 10 to ONE THIRD of the calculated exponent.

EXAMPLE: The cube root of 27,000 $= 3 \cdot 10^1 = 30$

Go to p. 159.

From p. 158.

REVIEW

A **ratio** is an indicated division. A **proportion** is a statement that two or more ratios are equal.

PROCEDURES: $\frac{a}{b} = \frac{a'}{b'} = \frac{a''}{b''}$

1. Set the hairline to the **a** value on D scale.
2. Move the C scale until the **b** value is at the hairline.
3. Set the hairline to the known value of each stated ratio. Remember, the **numerators** are located on **one scale** and the **denominators** are located on the **other scale.**
4. When you cannot locate a proportional ratio due to an off-scale condition, you should:
   a. Set the hairline to the C scale index.
   b. Move the opposite C scale index to the hairline.
   c. Set the hairline as in step #3 above.

PROBLEMS:

1. $\frac{16 \text{ oz.}}{1 \text{ lb.}} = \frac{x \text{ oz.}}{2.5 \text{ lb.}} = \frac{128 \text{ oz.}}{y \text{ lb.}}$

   $x = 40$ oz. $y = 8$ lb.

2. $\frac{420 \text{ mi.}}{5 \text{ hr. } 45 \text{ min.}} = \frac{x \text{ mi.}}{1 \text{ hr.}}$

   (Note - use 5.75 for 5 hr. 45 min.)

   $x = 73$ mi.

NOTE: If you studied the program covering Sines, Tangents and Logs, go on to p. 160; otherwise, this concludes your review.

REVIEW

From p. 159

Logarithms and the CI and L scales.

PROCEDURES:

1. Express your number as a value between 1 and 10 and record the power of 10. Remember the value of the exponent is the value of the characteristic.
2. Place the hairline to the right D scale index.
3. Slide the converted number on the CI scale to the hairline.
4. Carefully turn the slide rule over and read the mantissa on the L scale at the fixed hairline.
5. Record the characteristic (a whole number) and the mantissa (always less than 1).

PROBLEMS: Determine the logarithms of:

1. $\log 3250 = 3.512$
2. $\log 646 = 2.810$
3. $\log 845 = 2.926$
4. $\log 14 = 1.146$

Go to p. 161

REVIEW

From p. 160.

Finding sines (For angles smaller than 0°34' see page 163).

PROCEDURES FOR A KNOWN ANGLE MEASURE

1. Set the indicator hairline to the right A index.
2. Carefully turn the rule over, move the S scale until the known angle measure is under the right fixed hairline.
3. Turn the rule over again, read the sine on the B scale under the indicator hairline.

PROCEDURES FOR A KNOWN SINE

1. Set the indicator hairline to the right A index.
2. Move the B scale until the known sine is at the indicator hairline.
3. Carefully turn the rule over, read the angle at the fixed hairline.

PROBLEMS: Use your slide rule and find:

1. sin 20°30' = .350
   sin 37°0' = .600

2. The angle measure of sine:
   .150 = 8°40'
   .0698 = 4°

Go to p. 162

From p. 161.

REVIEW

Finding tangents (For angles smaller than 5°45' and greater than 84°15' see page 163).

PROCEDURES FOR ANGLES SMALLER THAN 45°:

1. Set the indicator hairline to the right D scale index.
2. Carefully turn the rule over, move the T scale until the known angle is at the right fixed hairline.
3. Turn the rule over again, read the tangent on the C scale at the indicator hairline (tangents of angles less than 45° are less than 1).

PROCEDURES FOR ANGLES GREATER THAN 45°:

1. Subtract the angle from 90° (90°-x) and record.
2. Set the indicator hairline to the right D scale index.
3. Carefully turn the rule over, move the T scale until the recorded angle (determined in step #1) is at the right fixed hairline.
4. Turn the rule over again, read the tangent on the CI scale at the indicator hairline. (tangents of angles greater than 45° are greater than 1).

PROBLEMS: Use your slide rule and find the tangents of the following angles:

a. tan 35° = .700 b. tan 70° = 2.75 c. tan 21°50' = .400

Go to p. 163.

Sines and Tangents of Very Small Angles

For determining the sine or tangent of a very small angle, two gage points are provided on the S scale. The one identified by the symbol (') is called the minutes gage point and is found next to the 2° mark on the S scale. The second gage point marked ('') is found near the 1°10' mark on the S scale. They represent the value of the angle in radians. Their use is based on the fact that for very small angles, sin x = tan x = x (in radians), approximately.

Example: Find sin 3'.

Since sin 3' = 3' (in radians), solve 3 x 1' (in radians). The procedure when using these gage points is the same as the use of the CI and D scale combination for multiplication. With the slide turned so that the trig scales are face up, set the minutes gage mark at 3 on the A scale. Over the right index of the S scale read 0.000873 on the A scale.

Example: Find sin 3''.

Set the seconds gage mark at 3 on the A scale. At the left index of the S scale, read 0.0000145 on the A scale.

The decimal point in the above examples is located by noting that:

1' —0.0003 radians (approximately)
1''—0.000005 radians (approximately)

Tangents of Angles from 0°34' to 5°45'

The values of tangents and sines of angles smaller than 5°45' are so nearly alike that they may be considered identical for slide rule computations. Consequently, for angles from 0°34' to 5°45', tangents can be read directly using the S scale and the left half of the A or B scales, as described in the section on sines.

EXPLANATION OF OTHER GAGE POINTS

A graduation identified with the symbol (π) appears at the value 3.1416 on the A, B, C and D scales for convenience in making computations involving this constant.

An unidentified line is graduated on the right-hand end of the A and B scales at the value 78.5. This represents $\frac{\pi}{4}$ and is useful in making calculations involving areas of circles. For example, when the right index of the B scale is set at this gage point on the A scale, the relationship of the C scale to the A scale becomes such that the area of a circle can be read at the hairline on the A scale, when the cursor hairline is set to its diameter read on the C scale.

The gage point on the C scale marked (c) represents the constant $\frac{4}{\pi}$

SCALE CONVERSION TABLE

Scale C	Scale D	Scale C	Scale D
Dia. circle	Circumf. circle	226	710
Side of sq.	Diagl. of sq.	70	99
Inches	Millimetres	5	127
Feet	Metres	292	89
Yards	Metres	35	32
Miles	Kilometres	87	140
Sq. in.	Sq. centimetre	31	200
Sq. ft.	Sq. metre	140	13
Sq. yd.	Sq. metre	61	51
Cub. in.	Cub. centimetre	36	590
Cub. ft.	Cub. metres	106	3
Cub. in.	Imp. gallons	6100	22
Cub. in.	U. S. gallons	6700	29
Cub. ft.	Imp. gallons	17	106
Cub. ft.	U. S. gallons	234	1750
Cub. ft.	Litres	3	85
Lbs.	Kilogrammes	280	127
Long tons	Kilogrammes	62	63000
Lbs. pr. sq. in.	Kilos. pr. sq. cm.	128	9
Cub. ft. water	Weight in. lbs.	17	1060
Foot pound	Kilogrammetre	340	47
Horse Power	Kilowatt	1	0.746
Foot Pound	Joules	1	1.36
Kilowatt	BTU pr. hr.	1	3412

$$1 \text{ Radian} = 180°/\pi = 57.29° = 3437.75' = 206265''$$

$\pi = 3.14159$ $\quad$ $c = \sqrt{\frac{4}{\pi}} = 1.128$

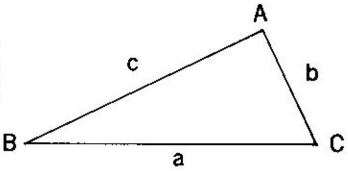
$e = 2.7183$

Nat. or hyp. Log. = Com. Log. × 2.3026

$$\tan\theta = \frac{1}{\tan(90° - \theta)} \quad (\theta > 45°) \qquad \frac{a}{\text{Sin}A} = \frac{b}{\text{Sin}B} = \frac{c}{\text{Sin}C}$$

$$\tan\theta = \frac{1 + \tan(\theta - 45°)}{1 - \tan(\theta - 45°)} \quad (\theta > 84°)$$

	I	II	III	IV
sin	+	+	−	−
cos	+	−	−	−
tan	+	−	+	+

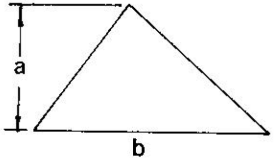


DECIMAL EQUIVALENTS

1/64	.015625	17/64	.265625	33/64	.515625	49/64	.765625
1/32	.03125	9/32	.28125	17/32	.53125	25/32	.78125
3/64	.046875	19/64	.296875	35/64	.546875	51/64	.796875
1/16	.0625	5/16	.3125	9/16	.5625	13/16	.8125
5/64	.078125	21/64	.328125	37/64	.578125	53/64	.828125
3/32	.09375	11/32	.34375	19/32	.59375	27/32	.84375
7/64	.109375	23/64	.359375	39/64	.609375	55/64	.859375
1/8	.125	3/8	.375	5/8	.625	7/8	.875
9/64	.140625	25/64	.390625	41/64	.640625	57/64	.890625
5/32	.15625	13/32	.40625	21/32	.65625	29/32	.90625
11/64	.171875	27/64	.421875	43/64	.671875	59/64	.921875
3/16	.1875	7/16	.4375	11/16	.6875	15/16	.9375
13/64	.203125	29/64	.453125	45/64	.703125	61/64	.953125
7/32	.21875	15/32	.46875	23/32	.71875	31/32	.96875
15/64	.234375	31/64	.484375	47/64	.734375	63/64	.984375
1/4	.25	1/2	.5	3/4	.75	1	1.

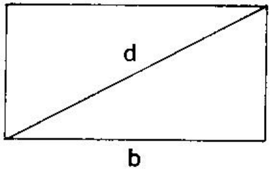
Generally, the scales should only be read to an accuracy of three significant digits. Settings as accurate as four significant digits can be made on the C and D scales for numbers having 1 as the **first digit.**

GEOMETRIC CONSTRUCTIONS & APPLICATIONS



Triangle

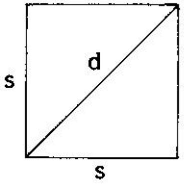
$\text{Area} = \frac{1}{2}\,ab$



Rectangle

$\text{Area} = ab$

$d = \sqrt{a^2 + b^2}$

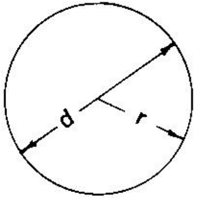


Square

$\text{Area} = s \times s = s^2$

$d = s\sqrt{2}$

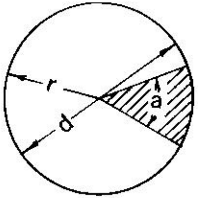
$s = \frac{1}{2}\,d\sqrt{2}$



Circle

$\text{Area} = \pi r^2$

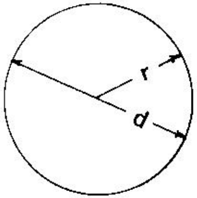
$\text{Area} = \frac{\pi d^2}{4}$



Sector

$\text{Area} = \pi r^2 \times \frac{a}{360}$

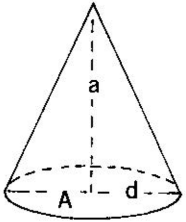
$\text{Area} = \frac{\pi d^2}{4} \times \frac{a}{360}$



Sphere

$\text{Volume} = \frac{4}{3}\pi r^3$

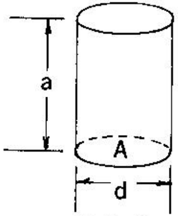
$\text{Volume} = \frac{1}{6}\pi d^3$



Cone

A = area of base

$\text{Volume} = \frac{1}{3}A\ a = \frac{1}{3}\left(\frac{\pi d^2}{4} \times a\right)$



Cylinder

A = area of base

$\text{Volume} = A\ a = \frac{\pi d^2}{4} \times a$

It is our sincere hope that the skills you have attained through use of this program will serve you well in your continuing student or professional career. Those of you who are interested in mathematics, science, or engineering have developed a foundation upon which you can build more complex slide rule skills, which you will find extremely valuable as you continue in these fields. Frederick Post Company hopes to be of continued assistance to you, both in your educational development, and later, in the practice of your chosen profession.

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