SUN
HEMMI

INSTRUCTION MANUAL FOR HEMMI 259D, 260, 279D SLIDE RULE

HEMMI

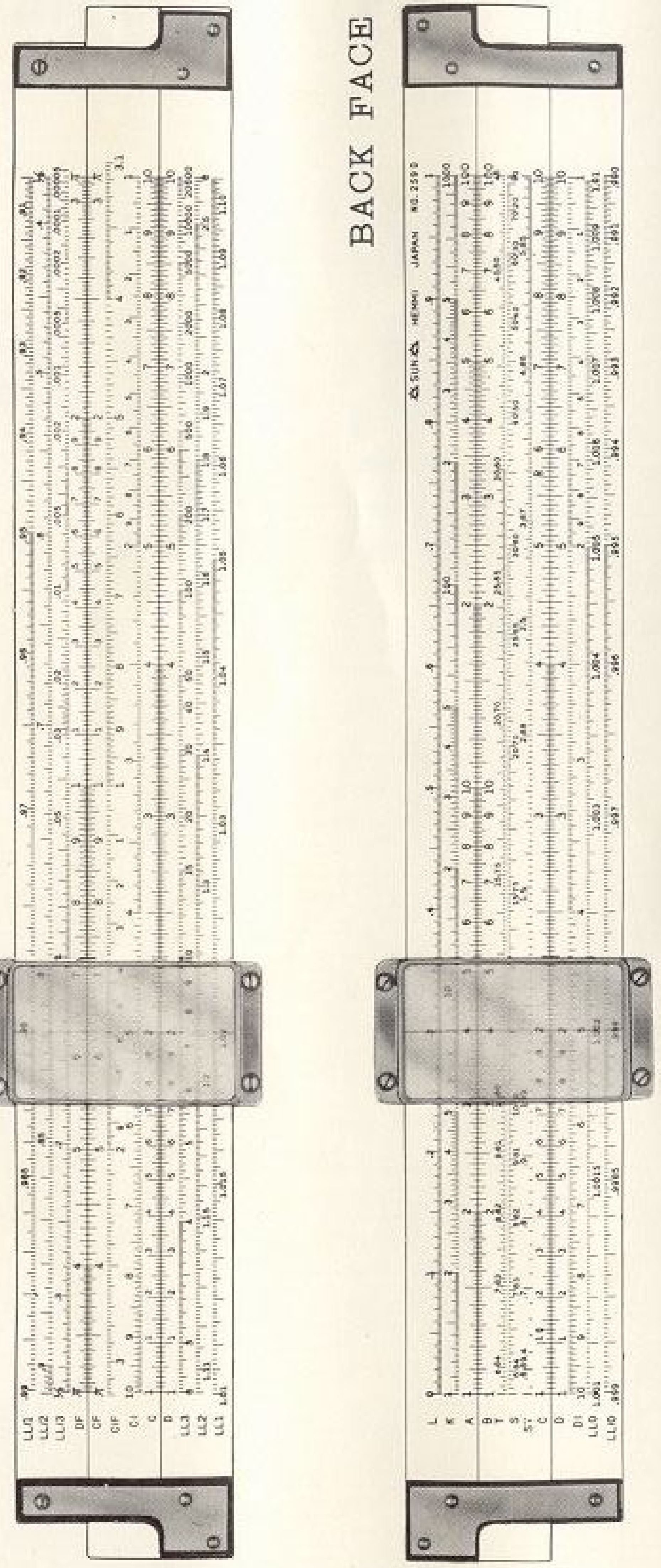
HEMMI SLIDE RULE CO., LTD.

TOKYO, JAPAN

NO. 259D SLIDE RULE

FRONT FACE

BACK FACE



INSTRUCTION MANUAL

FOR HEMMI NO. 259D (25cm DUPLEX TYPE) 279D (50cm DUPLEX TYPE) 260 (25cm DUPLEX TYPE) SLIDE RULE

The scales of Hemmi slide rules have been especially designed and arranged for efficient use by experienced engineers and incorporate the following special features:

(1) EFFICENT MULTIPLICATION AND DIVISION

Since the rule is equipped with DF, CF and CIF scales, the troublesome interchanging of indices is unnecessary.

(2) PERFECT EXPONENTIAL CALCULATION

Eight LL scales are provided to make A^x type calculations possible even when A is a decimal fraction and x has a negative value.

(3) RIGHT TRIANGLES AND VECTORS CAN BE EASILY CALCULATED

Since the "Rietz" system is employed in the trigonometric function scales and complementary angles are printed in red, right triangle and vector calculations are easier than ever. Right triangles, vector, and complex number calculations can be simplified by using these scales in conjunction with the DI scale.

(4) NO.260

In addition to all the special features listed above, the No.260 slide rule is also equipped with the P scale to facilitate the determination of $\cos\theta$, $\sqrt{1-x^2}$, and other calculations by merely setting the indicator.
The mutual relationship between the scales is shown at the right end of each scale. The indicator is equipped with three hairlines to facilitate calculation of the area of a circle and also horsepower ⟷ kW conversions.

CHAPTER 1. READING THE SCALES.

In order to master the slide rule, you must first practice reading the scales quickly and accurately. This chapter explains how to read the D scale which is the fundamental scale of the No.259D slide rule and is one used most often.

(1) SCALE DIVISIONS

Divisions of the D scale are not uniform and differ as follows.

Between 1-2 One division is 0.01

Between 2-4 One division is 0.02

Between 4-10 One division is 0.05

Values between lines can be read by visual approximation.

An actual example is given below.

(2) SIGNIFICANT FIGURES

The D scale is read without regard to decimal point location. For example, 0.237, 2.37, and 237 are read 237 (two three seven) on the D scale. When reading the D scale, the decimal point can be generally ignored and the numbers are directly read as 237 (two three seven). In 237 (two three seven), the 2 (two) is called the first "significant figure.".

(3) INDEX LINES

The lines at the left and right ends of the D scale and labeled 1 and 10 respectively are called the "fixed index lines". The corresponding lines on the C scale are called the "slide index lines".

SLIDE RULE DIAGRAM

For the reader's convenience, calculating procedure will be explained in diagram form in this instruction manual. The symbols used in the diagrams are:

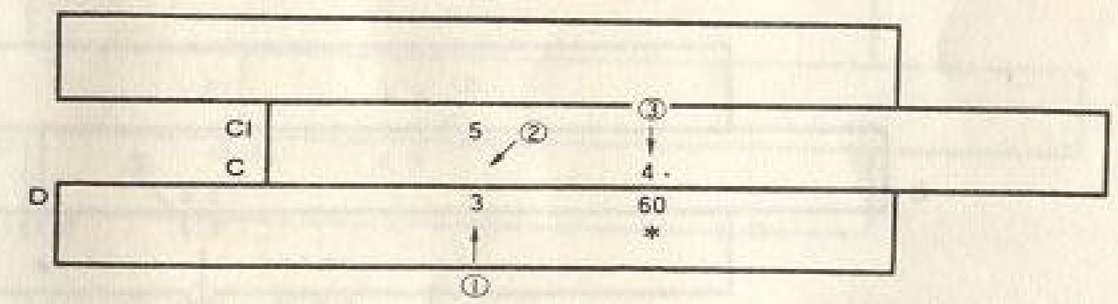
Slide Operation	↙↗ ↘↖	Moving the slide to the position of the arrow with respect to the body of the rule.
Indicator Operation	↓↑	Setting the hairline of the indicator to the arrow positions on the body and slide.
	*	The position at which the answer is read.

The numeral in the small circle indicates the procedure order. The below diagram shows the slide rule operation required to calculate $3\times5\times4=60$ using the C, D and CI scales.

(1) Set the hairline over 3 on the D scale.

(2) Move 5 on the CI scale under the hairline.

(3) Reset the hairline over 4 on the C scale and read the answer 60 on the D scale under the hairline.



(Note) The vertical lines at both right and left ends of the diagram do not indicate the actual end lines of the slide rule, but only serve to indicate the location of the indices.

CHAPTER 2. MULTIPLICATION AND DIVISION (1)

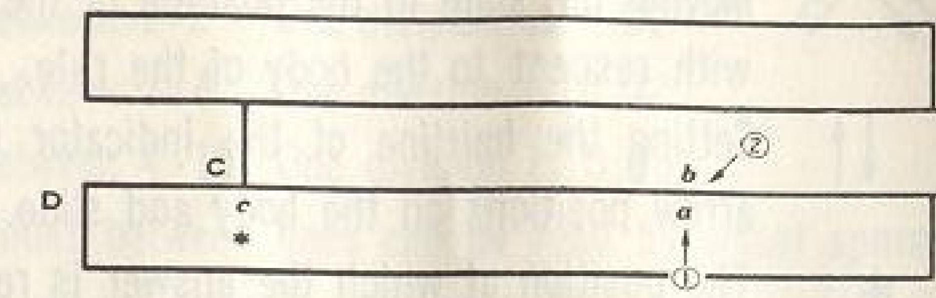
§ 1. DIVISION

FUNDAMENTAL OPERATION (1) $a \div b = c$

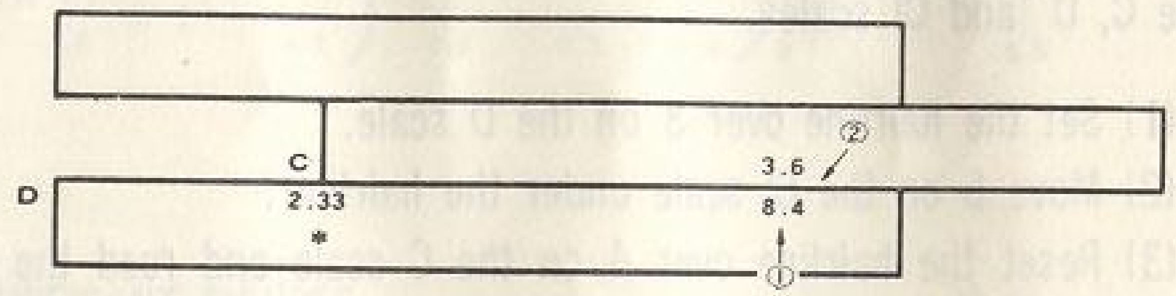
(1) Set the hairline over a on the D scale,

(2) Move b on the C scale under the hairline,

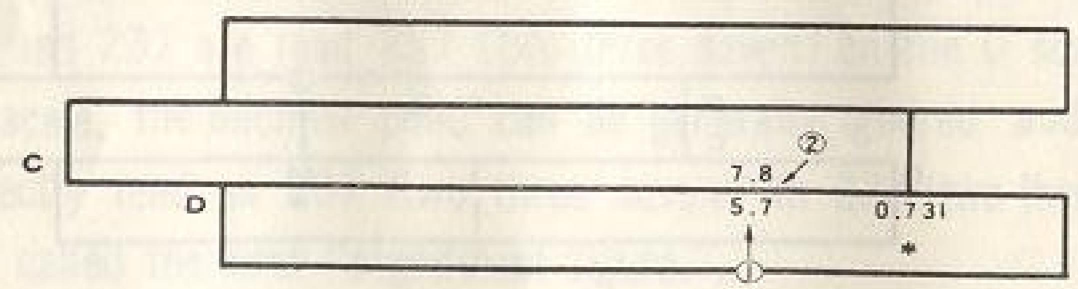
read the answer c on the D scale opposite the index of the C scale.



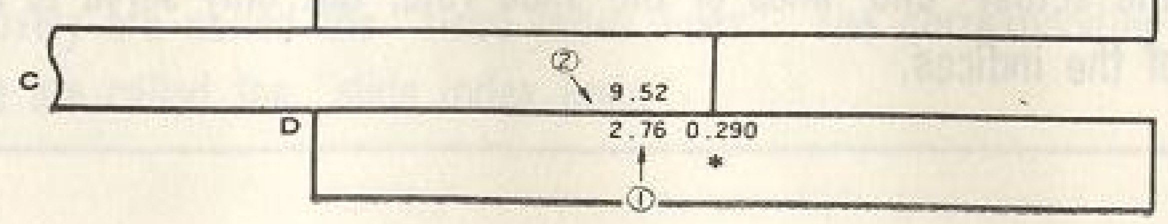
Ex. 2.1 8.4÷3.6=2.33



Ex. 2.2 5.7÷7.8=0.731



Ex. 2.3 2.76÷9.52=0.290



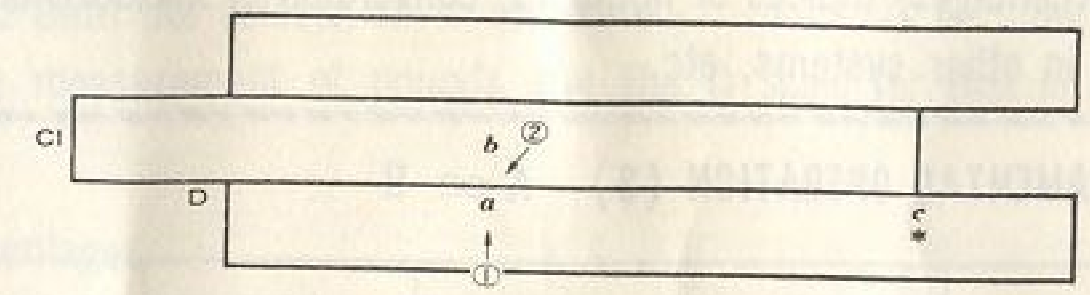
§ 2. MULTIPLICATION

FUNDAMENTAL OPERATION (2) $a \times b = c$

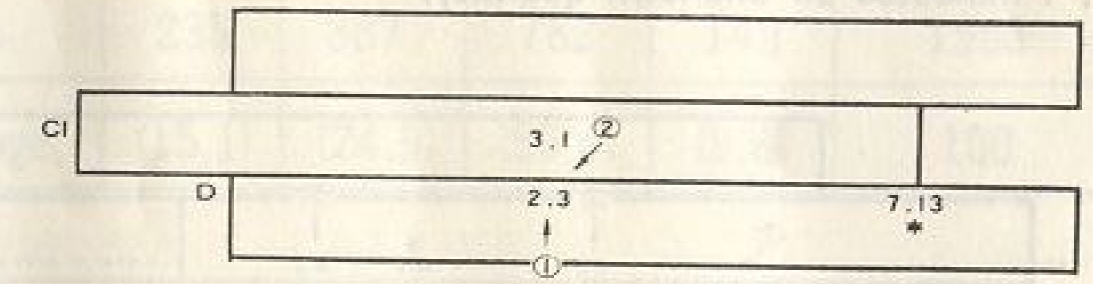
(1) Set the hairline over a on the D scale,

(2) Move b on the CI scale under the hairline,

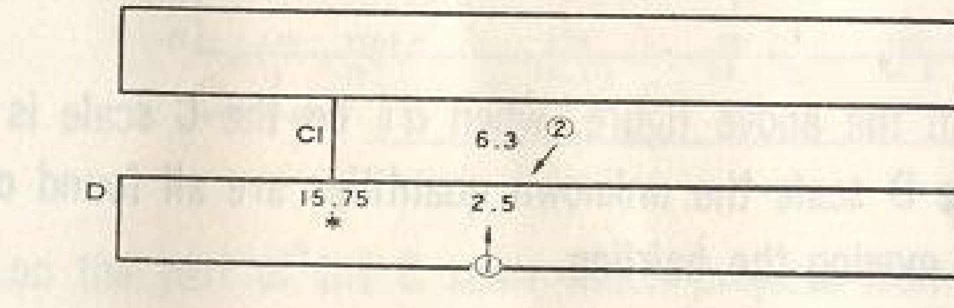
read the answer c on the D scale opposite the index of the CI scale.



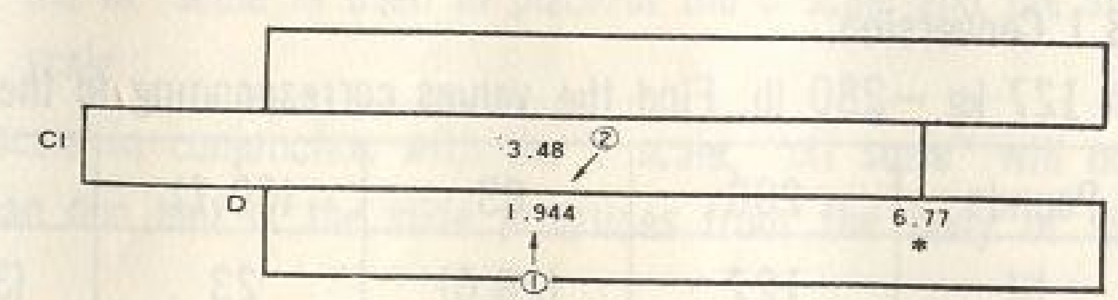
Ex. 2.4 2.3×3.1=7.13



Ex. 2.5 2.5×6.3=15.75



Ex. 2.6 1.944×3.48=6.77



CHAPTER 3. PROPORTION AND INVERSE PROPORTION

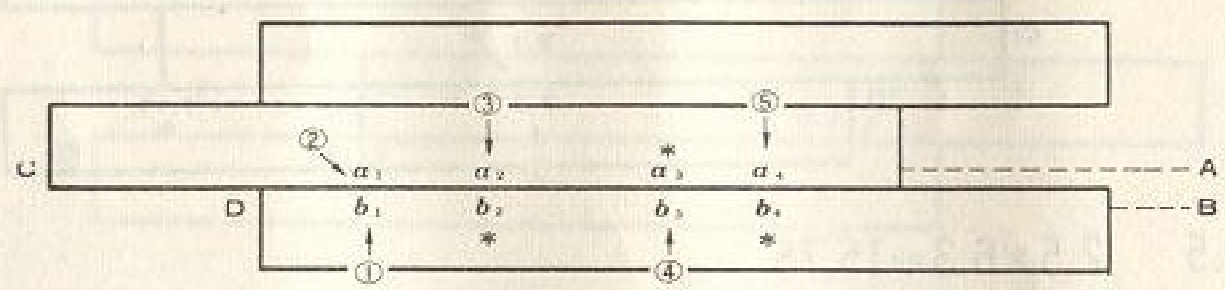
§ 1. PROPORTION

When the slide is set in any position, the ratio of any number on the D scale to its opposite on the C scale is the same as the ratio of any other number on the D scale to its opposite on the C scale. In other words, the D scale is directly proportional to the C scale. This relationship is used to calculate percentages, indices of numbers, conversion of measurements to their equivalents in other systems, etc.

FUNDAMENTAL OPERATION (3) A ∝ B

A	a_1	a_2	(a_3)	a_4
B	b_1	(b_2)	b_3	(b_4)

( ) indicates an unknown quantity.

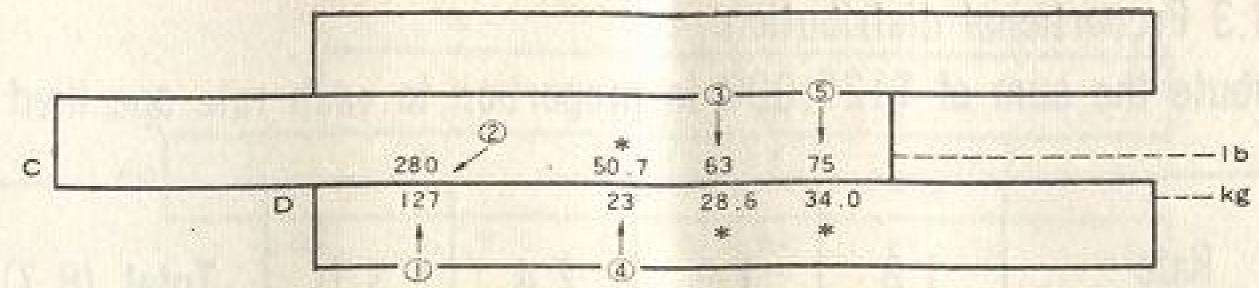


As illustrated in the above figure, when a_1 on the C scale is set opposite b_1 on the D scale the unknown quantities are all found on the C or D scales by moving the hairline.

Ex. 3.1 Conversion.

Given 127 kg = 280 lb. Find the values corresponding to the given values.

Pounds	280	63	(50.7)	75
kg	127	(28.6)	23	(34.0)

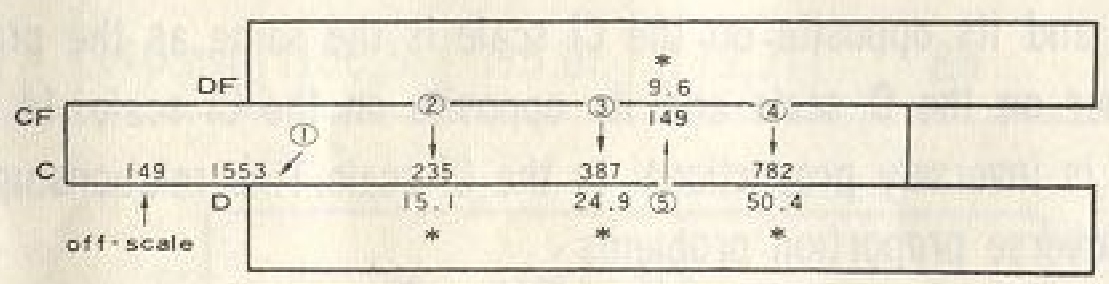


(Note) In calculating proportional problems the C scale must be used for one measurement and the D scale for the other. Intrerchanging the scales is not permitted until the calculation is completed. In Ex. 3.1., the C scale is used for the measurement of pounds and the D scale for that of kilo-grams.

Ex. 3.2 Percentages.

Complete the table below.

Product	A	B	C	D	Total
Sales	235	387	782	149	1553
Percentage	(15.1)	(24.9)	(50.4)	(9.6)	100



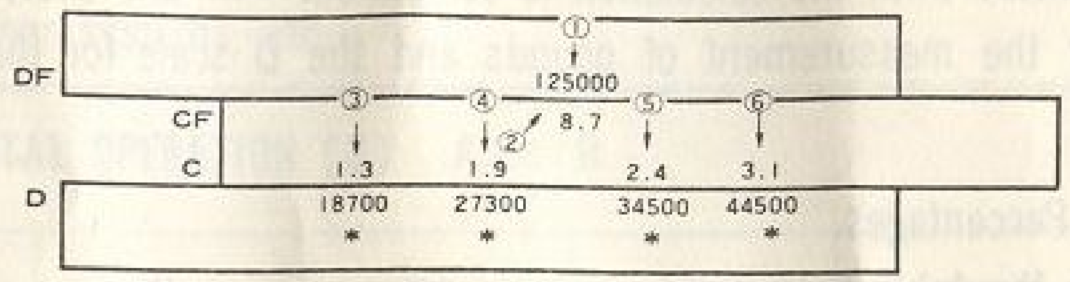
149 is on the part of the C scale which projects from the slide rule and its opposite on the D scale cannot be read. This is called "off-scale". In case of "off-scale", the CF scale is used in place of the C scale and the answer is read on the DF scale.

Using the CF scale in conjunction with the C scale, "off scale" will not occur unless more than one haif of the slide protrudes from the body of the slide rule.

Ex. 3.3 Proportional distribution

Distribute the sum of $125,000 in proportion to each rate specified below.

Rate	1.3	1.9	2.4	3.1	Total (8.7)
Amount	(18,700)	(27,300)	(34,500)	(44, 500)	$ 125,000



In Ex. 3.3 when 8.7 on the C scale is set opposite 125,000 on the D scale, more than half of the slide protrudes from the body. Therefore, the CF scale is used in conjunction with the DF scale as illustrated.

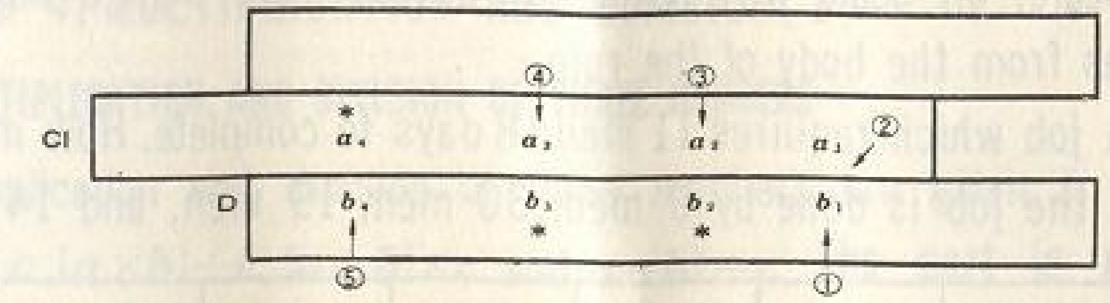
§ 2. INVERSE PROPORTION

When the slide is set in any position, the product of any number on the D scale and its opposite on the CI scale is the same as the product of any other number on the D scale and its opposite on the CI scale. In other words, the D scale is inversely proportional to the CI scale. This relationsnip is used to calculate inverse proportion problems

FUNDAMENTAL OPERATION (4) $A \propto \frac{1}{B}$ $A \times B = \text{Constant}$

A	a_1	a_2	a_3	(a_4)
B	b_1	(b_2)	(b_3)	b_4

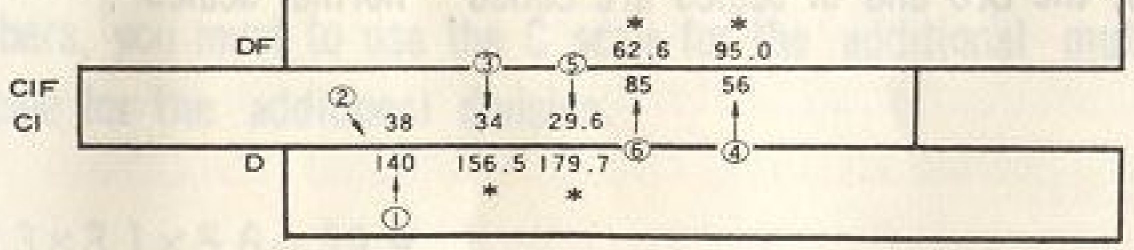
( ) indicates an unknown quantity.



When a_1 on the CI scale is set opposite b_1 on the D scale, the product of $a_1 \times b_1$ is equal to that of $a_2 \times b_2$, that of $a_3 \times b_3$, and also equal to that of $a_4 \times b_4$. Therefore, b_2, b_3, and a_4 can be found by merely moving the hairline of the indicator.

Ex. 3.4 A bicycle runs at 38 km per hour, and takes 140 minutes to go from one town to another. Calculate how many minutes it will take if the bicycle is travelling at 34 km per hour, 56 km per hour, or 29.6 km per hour.

Speed	38 km	34	56	29.6	(62.6)
Time required	140 min	(156.5)	(95.0)	(179.7)	85

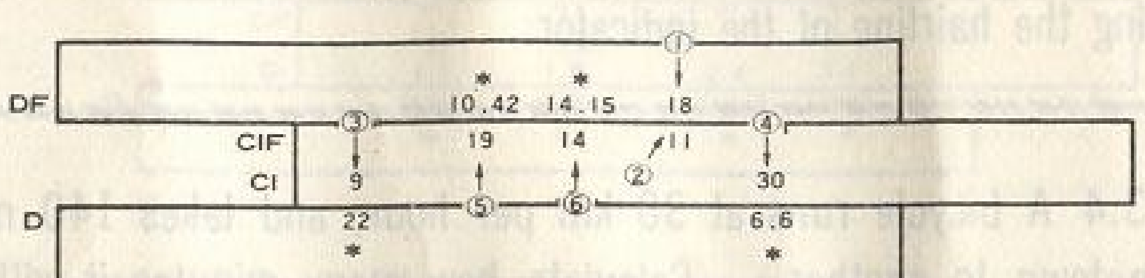


In solving inverse proportion problems, unlike proportional problems, you can freely switch the scales from one to another, but it is preferable to select and use the scales so that the answer is always read on the D or DF scale.

In Ex. 3.4., 56 and 85 run off scale on the CI scale. Therefore the CIF scale can be used instead of the CI scale. Using the CIF scale in conjunction with the CI scale, off scale will not occur unless more than a half of the slide protrudes from the body of the rule.

Ex. 3.5 A job which requires 11 men 18 days to complete. How many days will it take if the job is done by 9 men, 30 men, 19 men, and 14 men?

No. of men	11	9	30	19	14
Time required	18	(22)	(6.6)	(10.42)	(14.15)



In Ex. 3.5, setting 18 on the D scale opposite 11 on the CI scale, more than one half of the slide protrudes from the body. Therefore, as illustrated above, the DF scale is used in conjunction with the CIF scale.

The DF, CF and CIF scales are generally called "folded scales" and permit efficient multiplication and division of three or more numbers as well as averting off scale positions when working with proportions and inverse proportions. Whereas, the D,C and CI scales are called "normal scales".

CHAPTER 4. MULTIPLICATION AND DIVISION(2)

§1. MULTIPLICATION AND DIVISION OF THREE NUMBERS

Multiplication and division of three numbers are given in the forms of $(a\times b)\times c$, $(a\times b)\div c$, $(a\div b)\times c$ and $(a\div b)\div c$. The part in parentheses is calculated in the manner previously explained and the additional multiplication or division is, usually, performed with one additional indicator operation.

FUNDAMENTAL OPERATION (5) Multiplication and division of three numbers.

(1) $(a\times b)\times c=d$, $(a\div b)\times c=d$

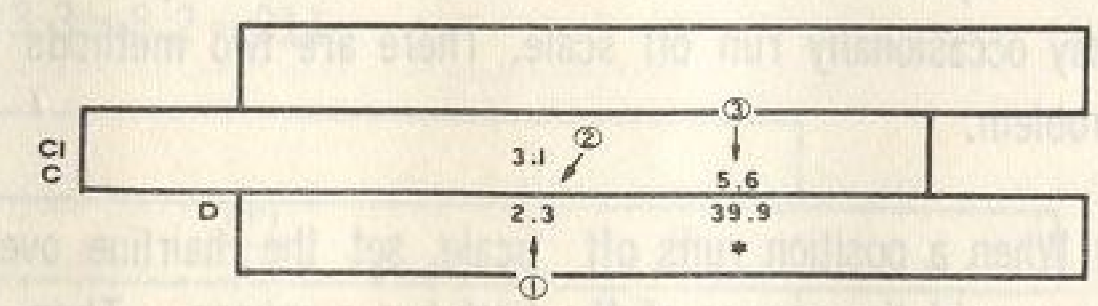
For additional multiplication to follow the calculation $(a\times b)$ or $(a\div b)$, set the hairline over c on the C scale and read the answer d on the D scale under the hairline.

(2) $(a\times b)\div c=d$, $(a\div b)\div c=d$

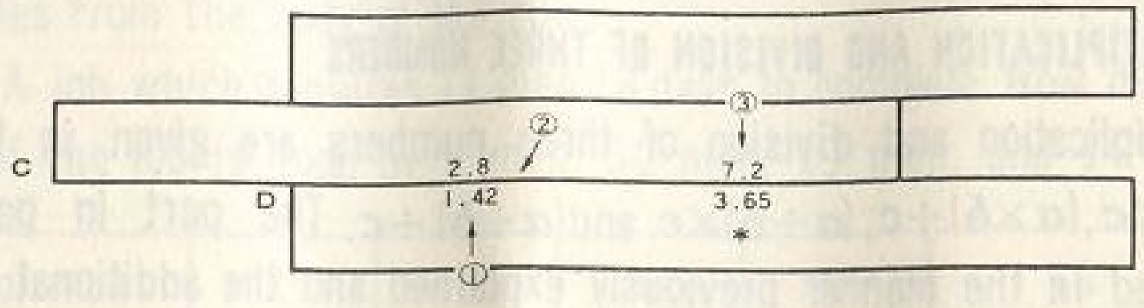
For additional division to follow the calculation $(a\div b)$ or $(a\times b)$, set the hairline over c on the CI scale and read the answer d on the D scale under the hairline.

In multiplication and division of two numbers, you use the CI scale for multiplication and the C scale for division. However, in multiplication and division of three numbers, you must to use the C scale for the additional multiplication and the CI scale for the additional division.

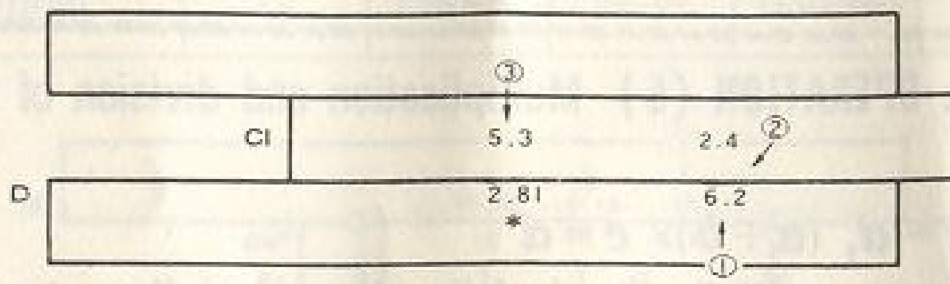
Ex. 4.1 $2.3\times3.1\times5.6=39.9$



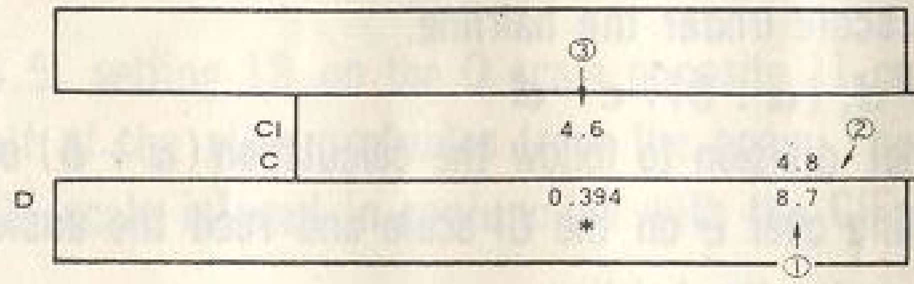
Ex. 4.2 $1.42 \div 2.8 \times 7.2 = 3.65$



Ex. 4.3 $6.2 \times 2.4 \div 5.3 = 2.81$



Ex. 4.4 $8.7 \div 4.8 \div 4.6 = 0.394$

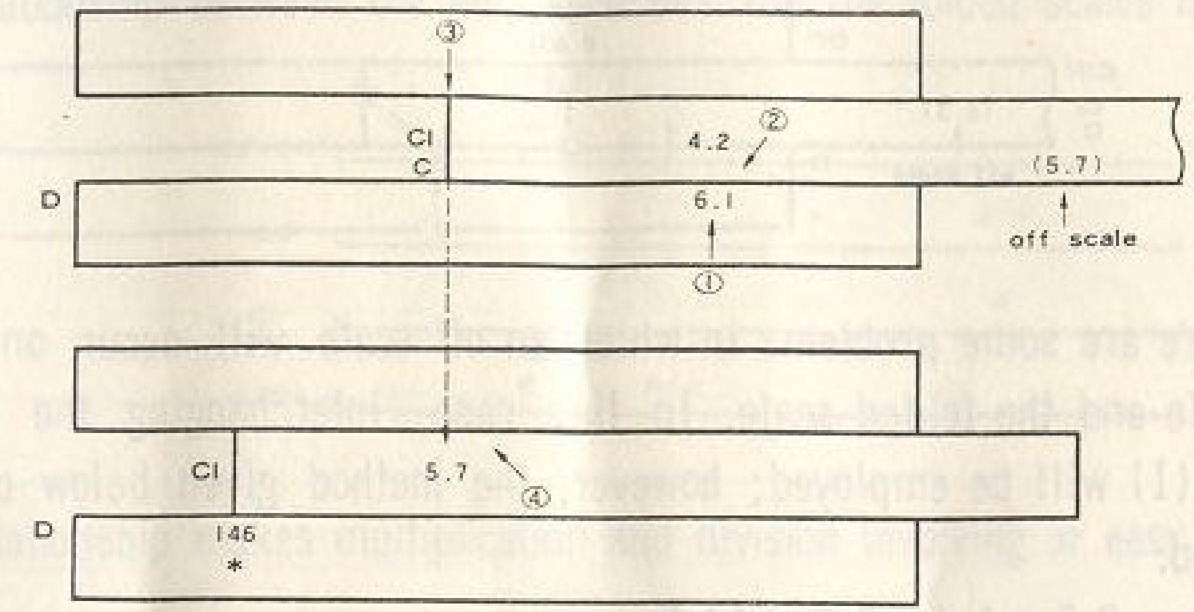


§2. OFF SCALE

In multiplication and division calculations, a position on the C or CI scale may occasionally run off scale. There are two methods to solve this off scale problem.

(1) When a position runs off scale, set the hairline over the position on which you read the answer of the first two numbers. Then, move the slide to bring the third number under the hairline.

Ex. 4.5 $6.1 \times 4.2 \times 5.7 = 146$



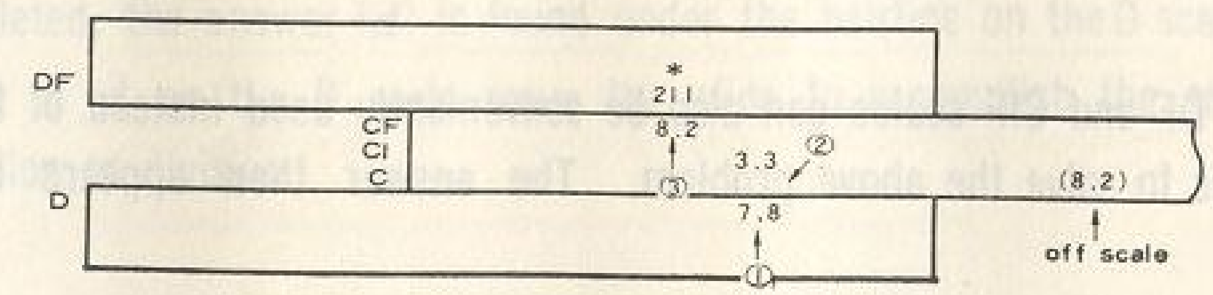
The third number 5.7 on the C scale runs off scale. Set the hairline back over the left index of the C scale and move the slide to bring 5.7 on the CI scale under the hairline. Then, read the answer 146 on the D scale opposite the index of the CI scale. In fact, selection of the scale is exactly the same as in multiplication and division of two numbers.

(2) Folded scales (DF, CF, and CIF)

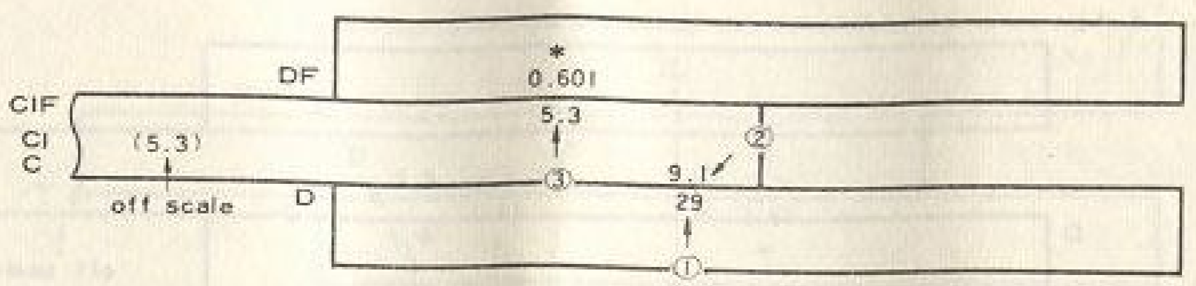
In method (1), one more movement of the slide is necessary compared to when an off scale does not occur. However, the folded scales can be conveniently employed when an off scale occurs.

The folded scales are used in the same manner as In tne case of proportion and inverse proportion problems. When an off scale occurs on the C scale the CF scale can be used, and when an oft scale occurs on the CI scale the CIF scale can be used. In this case the answer appears under the hairline on the DF scale.

Ex. 4.6 $7.8 \times 3.3 \times 8.2 = 211$

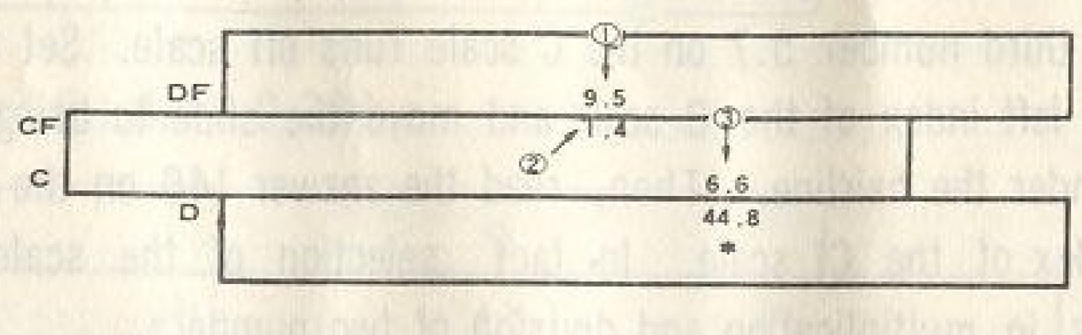


Ex. 4.7 $\quad 29 \div 9.1 \div 5.3 = 0.601$



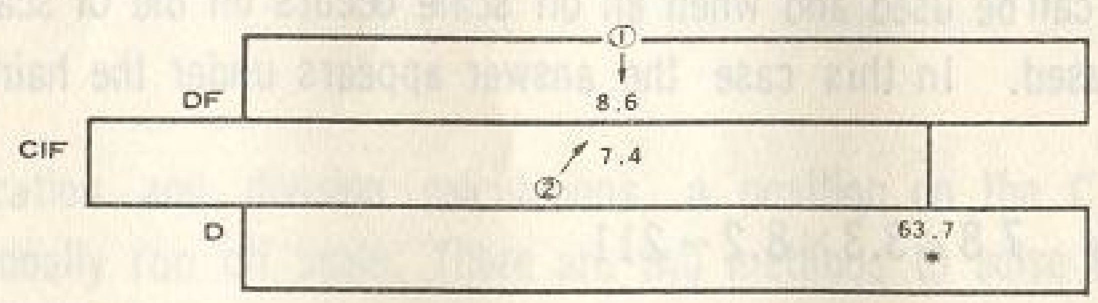
There are some problems in which an off scale will occur on both normal scale and the folded scale. In this case, interchanging the indices in method (1) will be employed; however, the method given below can be also employed.

Ex. 4.8 $\quad 9.5 \div 1.4 \times 6.6 = 44.8$



In the above example, when calculating 9.5÷1.4 using the C and D scales, more than one half of the slide protrudes from the rule and, the third number 6.6 runs off scale on both the C scale and CF scale. As shown in the above diagram, calculation can be made by using the DF and CF scales without an off scale occuring.

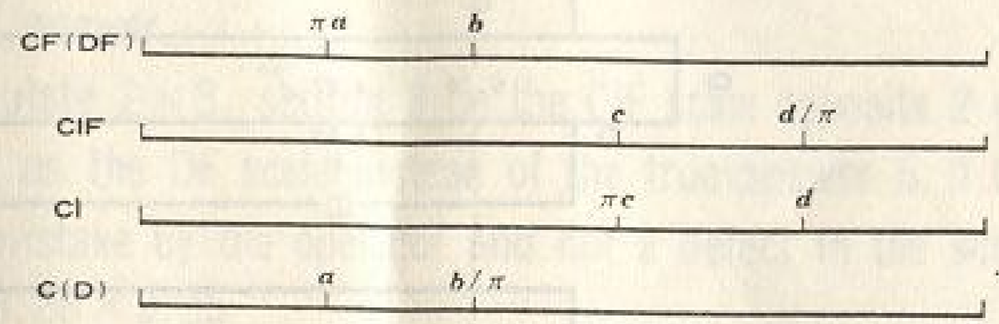
Ex. 4.9 $\quad 8.6 \times 7.4 = 63.7$



The DF and CIF scales can also be conveniently used instead of the D and CI scales to solve the above problem. The answer then appears on the D scale.

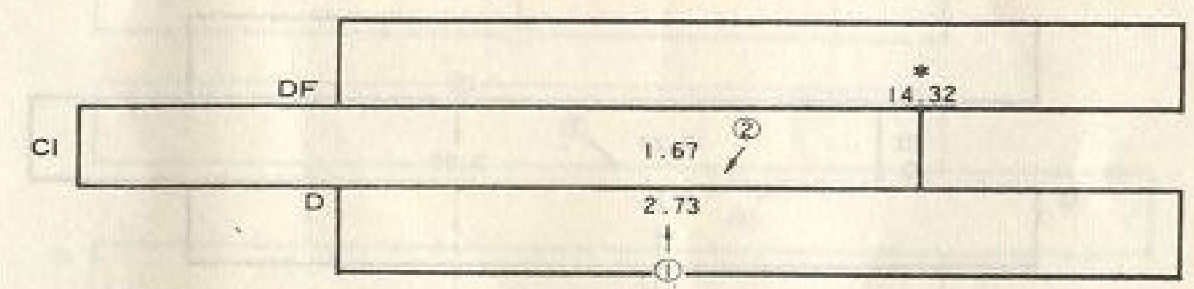
§3. MULTIPLICATION AND DIVISION INVOLVING π

The relationship between the normal scales and the folded scales is shown below.

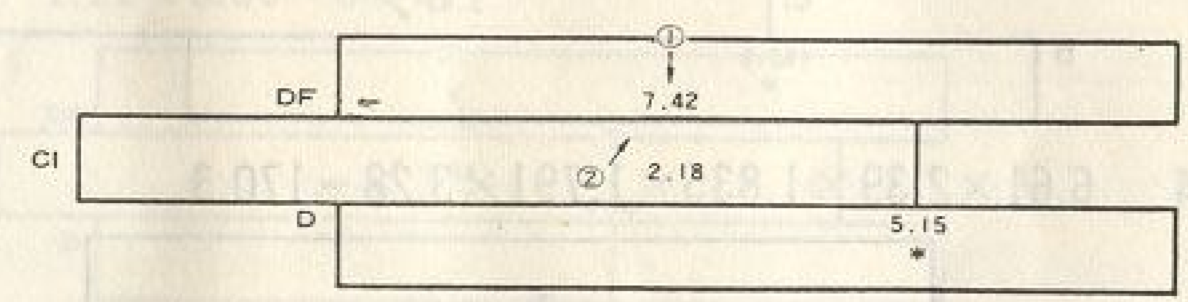


This relationship makes multiplication and division involving π easy.

Ex. 4.10 $\quad 2.73 \times 1.67 \times \pi = 14.32$



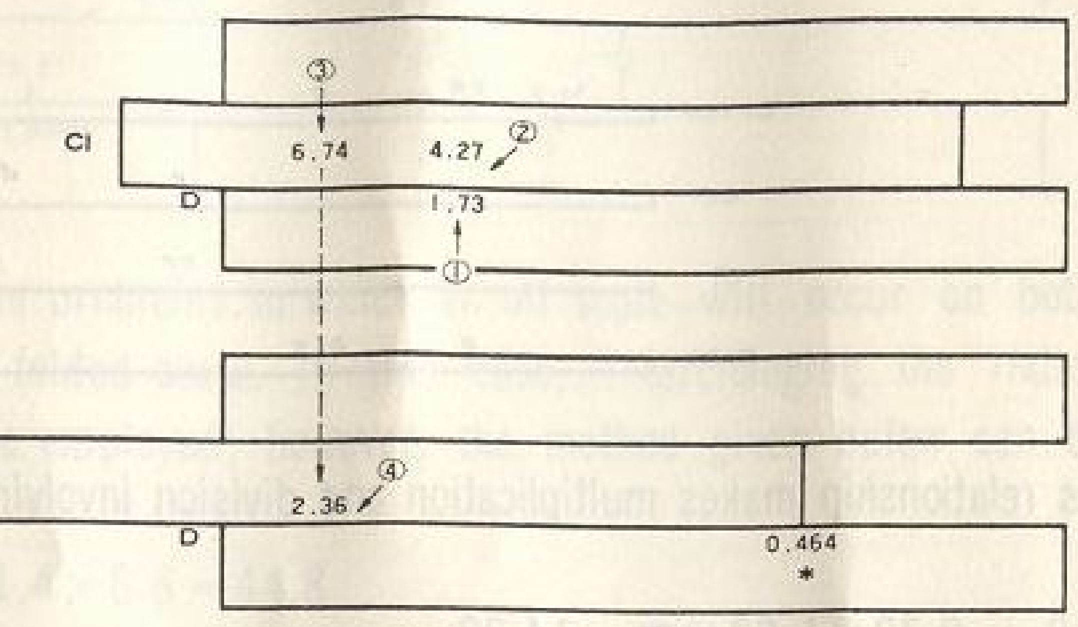
Ex. 4.11 $\quad \dfrac{7.42 \times 2.18}{\pi} = 5.15$



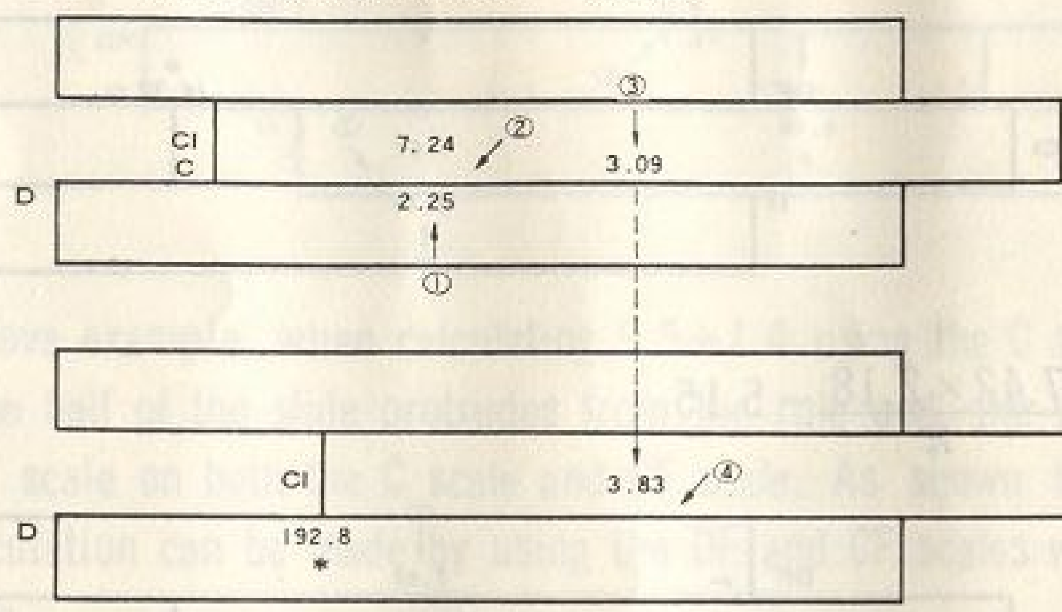
§4. MULTIPLICATION AND DIVISION OF MORE THAN FOUR NUMBERS

When the multiplication and division of three numbers, such as $a \times b \times c = d$ is completed, the answer (d) is found under the hairline on the D scale. Using this value of d on the D scale move the slide to accomplish the remaining multiplication or division.

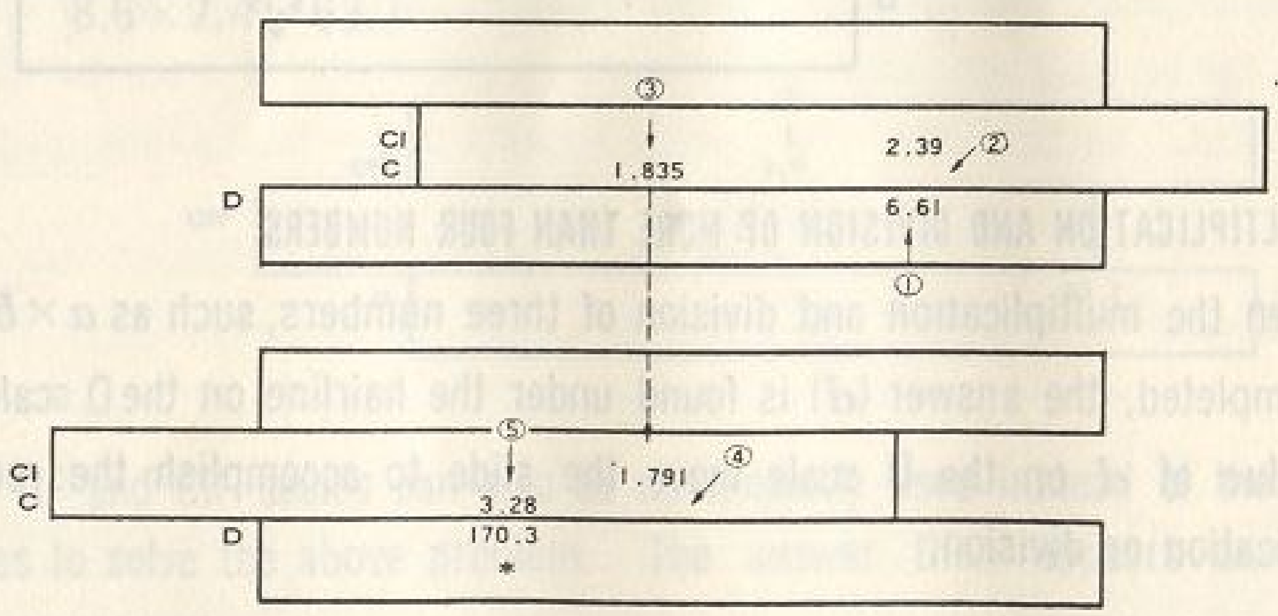
$$\text{Ex. 4.12} \quad \frac{1.73 \times 4.27}{6.74 \times 2.36} = 0.464$$



$$\text{Ex. 4.13} \quad 2.25 \times 7.24 \times 3.09 \times 3.83 = 192.8$$



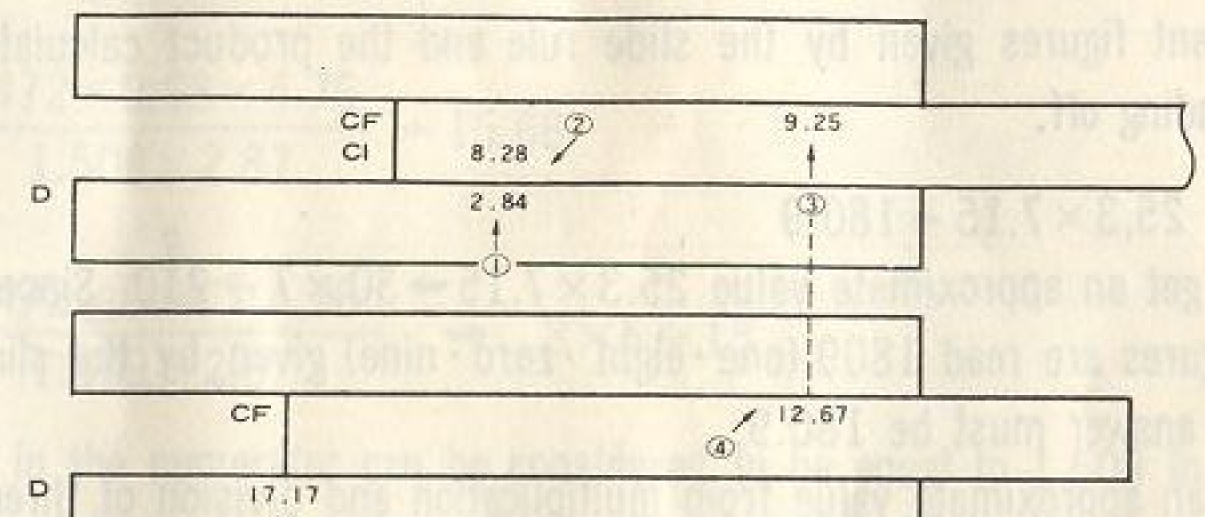
$$\text{Ex. 4.14} \quad 6.61 \times 2.39 \times 1.835 \times 1.791 \times 3.28 = 170.3$$



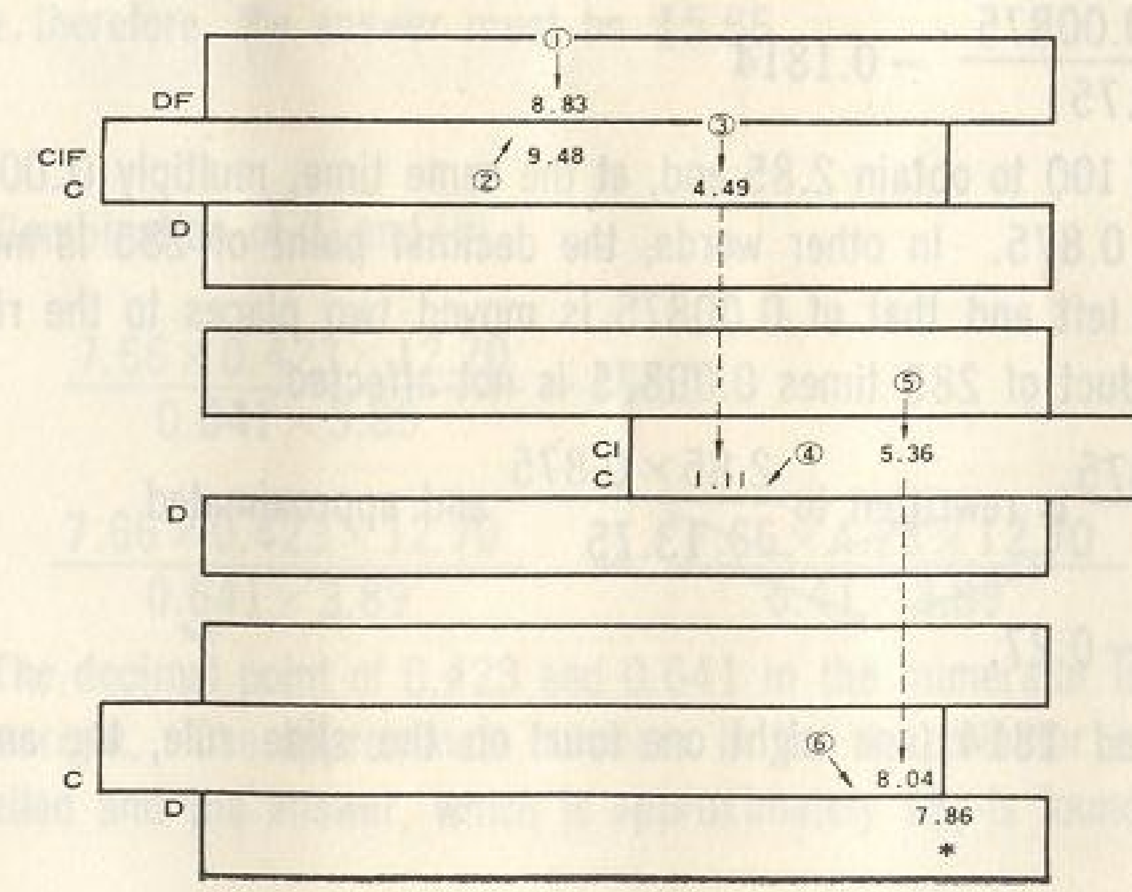
The folded scale can be conveniently used when an off scale occurs. However, once a folded scale is used, it must also be used for the next slide operation. Note that alternate use of a normal scale and a folded scale will result in an incorrect answer.

For example, to calculate 2×3, setting 3 on the CIF scale opposite 2 on the D scale results in 5.92 on the DF scale instead of the true answer 6. If this happens, it indicates a mistake by the operator and not a defect in the slide rule.

$$\text{Ex. 4.15} \quad \frac{2.84 \times 8.28 \times 9.25}{12.67} = 17.17$$



$$\text{Ex. 4.16} \quad \frac{8.83 \times 9.48 \times 4.49}{1.11 \times 5.36 \times 8.04} = 7.86$$



§ 5. PLACING THE DECIMAL POINT

Since slide rule calculations of multiplication and division problems yield only the significant figures of the answer, it is necessary to determine the proper location of the decimal point before the problem is completed. There are many methods used to properly place the decimal point. Several of the most polular will be described here.

(a) Approximation

The location of the decimal point can be determined by comparing the significant figures given by the slide rule and the product calculated mentally by rounding off.

Ex. $25.3 \times 7.15 = 180.9$

To get an approximate value $25.3 \times 7.15 \rightarrow 30 \times 7 = 210$. Since the significant figures are read 1809 (one · eight · zero · nine) given by the slide rule, the correct answer must be 180.9.

To get an approximate value from multiplication and division of three and more factors may be difficult. In this case, the following method can be employed.

(i) Moving the decimal point

Ex. $\dfrac{285 \times 0.00875}{13.75} = 0.1814$

Divide 285 by 100 to obtain 2.85 and, at the same time, multiply 0.00875 by 100 to obtain 0.875. In other words, the decimal point of 285 is moved two places to the left and that of 0.00875 is moved two places to the right, therefore, the product of 285 times 0.00875 is not affected.

$\dfrac{285 \times 0.00875}{13.75}$ is rewritten to $\dfrac{2.85 \times 0.875}{13.75}$ and approximated

to $\dfrac{3 \times 0.9}{10} = 0.27$.

Since you read 1814 (one eight one four) on the slide rule, the answer must be 0.1814.

Ex. $\dfrac{1.346}{0.00265} = 508$

$$\frac{1.346}{0.00265} \rightarrow \frac{1346}{2.65} \rightarrow \frac{1000}{3} \rightarrow 300$$

(ii) Reducing fractions

If a number in the numerater has a value close to that of a number in the denominator, they can be cancelled out and an approximate figure is obtained.

Ex. $\dfrac{1.472 \times 9.68 \times 4.76}{1.509 \times 2.87} = 15.66$

$$\frac{\cancel{1.472} \times \overset{3}{\cancel{9.68}} \times 4.76}{\cancel{1.509} \times \cancel{2.87}} \rightarrow 3 \times 5 = 15$$

1.472 in the numerator can be considered to be equal to 1.509 in the denominator and they can therefore be cancelled out. 9.68 in the numerator is approximately 9 and 2.87 in the denominator is approximately 3. 4.76 in the numerator is approximately 5. Using the slide rule, you read 1566 on the D scale, therefore, the answer must be 15.66

(iii) Combination of (i) and (ii)

Ex. $\dfrac{7.66 \times 0.423 \times 12.70}{0.641 \times 3.89} = 16.50$

$$\frac{7.66 \times 0.423 \times 12.70}{0.641 \times 3.89} \rightarrow \frac{\cancel{7.66} \times \cancel{4.23} \times 12.70}{\cancel{6.41} \times \cancel{3.89}} \rightarrow 13$$

The decimal point of 0.423 and 0.641 in the numerator is shifted one place to the right. The approximate numbers in the denominator and numerator are cancelled and the answer, which is approximately 13, is found.

(b) Exponent

Any number can be expressed as $N \times 10^P$ where $1 \leqq N < 10$.
This method of writing numbers is useful in determining the location of the decimal point in difficult problems involving combined operations.

Ex. $\dfrac{1587 \times 0.0503 \times 0.381}{0.00815} = 3730$

$$\frac{1587 \times 0.0503 \times 0.381}{0.00815} = \frac{1.587 \times 10^3 \times 5.03 \times 10^{-2} \times 3.81 \times 10^{-1}}{8.15 \times 10^{-3}}$$

$$= \frac{1.587 \times 5.03 \times 3.81}{8.15} \times 10^{3-2-1-(-3)}$$

$$= \frac{2 \times 5 \times 4}{8} \times 10^{3-2-1-(-3)} = 5 \times 10^3 = 5000$$

CHAPTER 5. SQUARES AND SQUARE ROOTS

The "place number" is used to find squares and square roots as well as placing the decimal point of squares and square roots.
When the given number is greater than 1, the place number is the number of digits to the left of the decimal point. When the given number is smaller than 1, the place number is the number of zeros between the decimal point and the first significant digit but the sign is minus.
For example, the place number of 2.97 is 1, of 29.7 is 2, of 2970 is 4, and of 0.0297 is -1 The place number of 0.297 is 0.

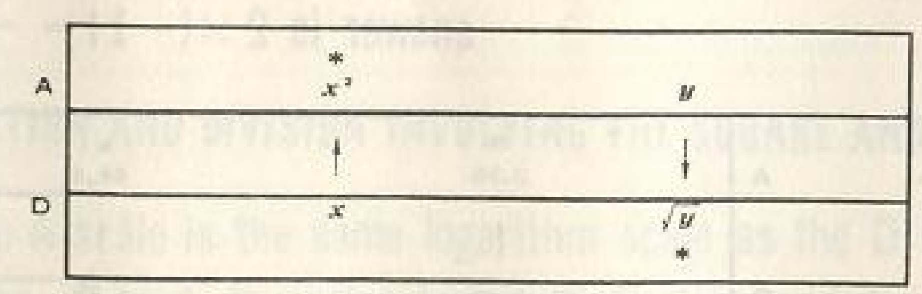
§1. SQUARES AND SQUARE ROOTS

The A scale, which is identical to the B scale, consists of two D scales connected together and reduced to exactly 1/2 of their original length. The A scale is used with the C, D or CI scale to perform the calculations of the square and square root of numbers.
Since they consist of two D scales, the A and B scales are called "two cycle scales" whereas the fundamental C, D and CI scales are called "one cycle scales".

FUNDAMENTAL OPERATION (6) x^2, $\sqrt{y}$

(1) When the hairline is set over x on the D scale, x^2 is read on the A scale under the hairline.

(2) When the hairline is set over y on the A scale, $\sqrt{y}$ is read on the D scale under the hairline.



The location of the decimal point of the square read on the A scale is determined using the place number as follows:

a) When the answer is read on the left half section of the A scale (1~10), the "place number" of x^2 = 2 ("place number" of x) − 1

b) When the answer is read on the right half section of the A scale(10~100), the "place number" of x^2 = 2 ("place number" of x)

Ex. 5.1 $172^2 = 29600$ ·············· The place number of 172 is 3. Hence, the place number in the answer is $2\times3-1=5$

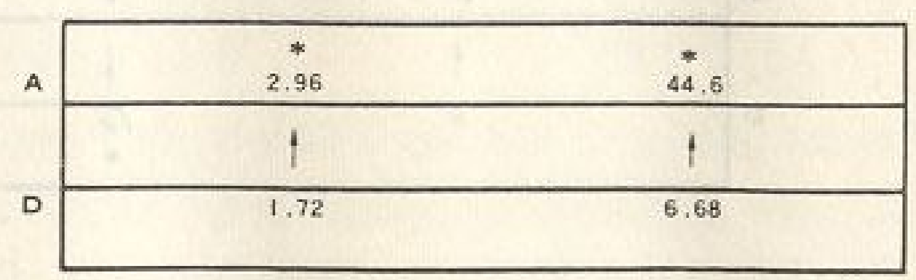
$17.2^2 = 296$ ················ The place number of 17.2 is 2. Hence, the place number in the answer is $2\times2-1=3$

$0.172^2 = 0.0296$ ··········· The place number of 0.172 is 0 Hence, the place number in the answer is $2\times0-1=-1$

Ex. 5.2 $668^2 = 446000$ ············ The place number of 668 is 3
$= 4.46\times10^5$ Hence, the place number in the answer is $2\times3=6$

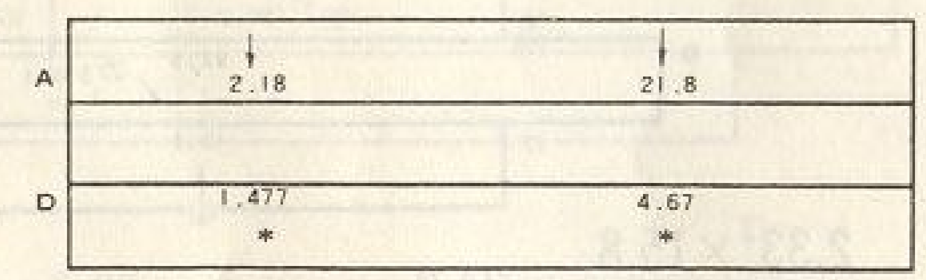
$0.668^2 = 0.446$ ············ The place number of 0.668 is 0 Hence, the place number in the answer is $2\times0=0$

$0.0668^2 = 0.00446$ ········ The place number of 0.0668 is − 1 Hence, the place number in the answer is $2\times(-1) = -2$



When the hairline is set over x on the A scale, $\sqrt{x}$ appears under the hairline on the D scale. Since the A scale consists of two identical sections, only the correct section can be used. Set off the number whose square root is to be found into two digits groups from the decimal point toward the first significant figure of the number. If the group in which the first significant figure appears has only one digit (the first significant digit only), use the left half of the A scale. If it has two digits (the first significant digit and one more digit), use the right half of the A scale.

Ex. 5.3	21│80│00 (right half)	Place number······3	$\sqrt{218000} = 467$
	2│18│00 (left half)	Place number······3	$\sqrt{21800} = 147.7$
	21│80 (right half)	Place number······2	$\sqrt{2180} = 46.7$
	2│18 (left half)	Place number······2	$\sqrt{218} = 14.77$
	0.21│8 (right half)	Place number······0	$\sqrt{0.218} = 0.467$
	0.02│18 (left half)	Place number······0	$\sqrt{0.0218} = 0.1477$
	0.00│21│8 (right half)	Place number···−1	$\sqrt{0.00218} = 0.0467$
	0.00│02│18 (left half)	Place number···−1	$\sqrt{0.000218} = 0.01477$



§2. MULTIPLICATION AND DIVISION INVOLVING THE SQUARE AND SQUARE ROOT

Basically, the A scale is the same logarithm scale as the D scale. Therefore, you can use the A and B scales for multiplication and division in the same manner as you use the C, D and CI scales.

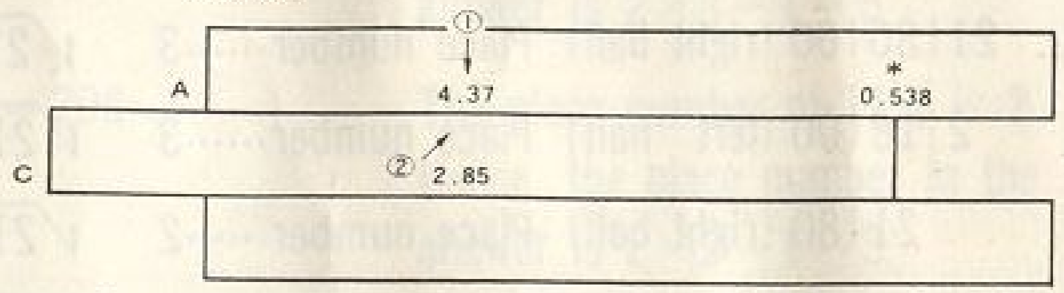
FUNDAMENTAL OPERATION (7)

Multiplication and division involving squares

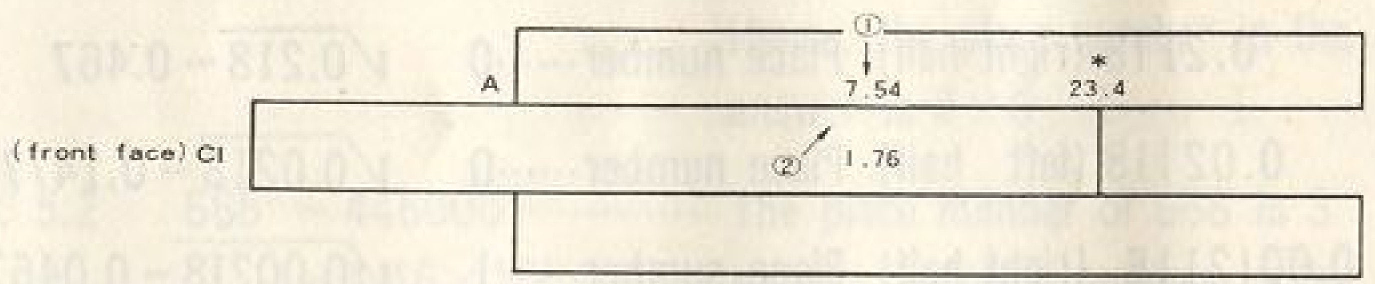
(1) Set the number to be squared on the one cycle scale (C, D, or CI) and the number not to be squared on the two cycle scale (A or B)

(2) Read the answer on the A scale.

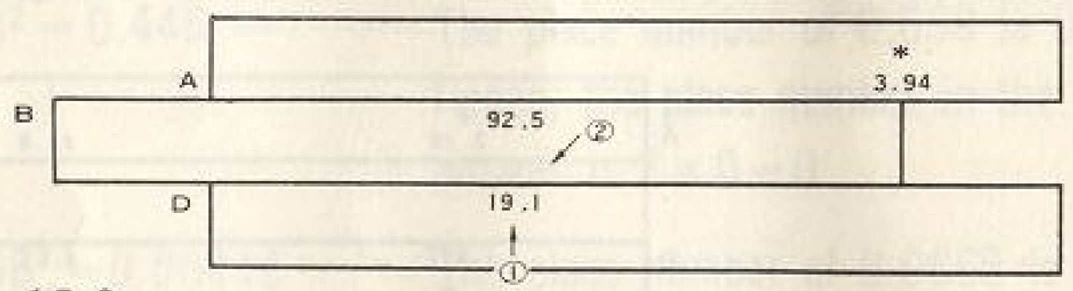
Ex. 5.4 $4.37 \div 2.85^2 = 0.538$



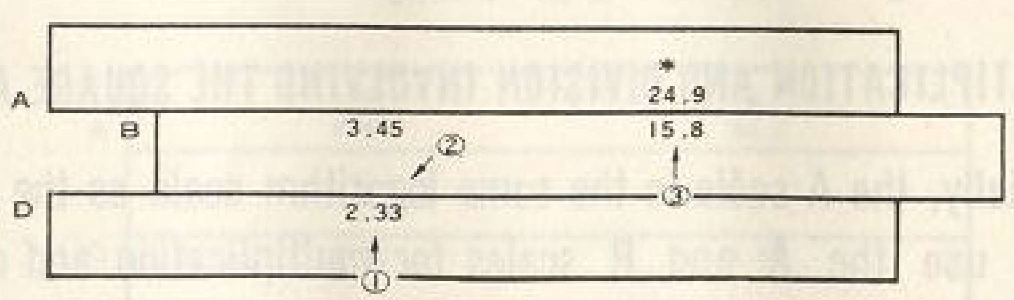
Ex. 5.5 $7.54 \times 1.76^2 = 23.4$



Ex. 5.6 $19.1^2 \div 92.5 = 3.94$



Ex. 5.7 $\dfrac{2.33^2 \times 15.8}{3.45} = 24.9$



(Note) In multiplication or division involving squares, you can freely use either half section of the A or B scale to minimize the distance the slide must be moved.

FUNDAMENTAL OPERATION (8)

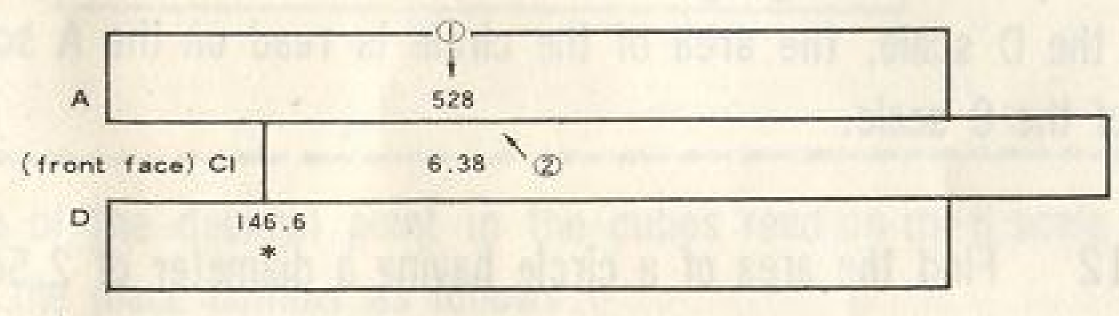
Multiplication and division involving the square roots of numbers.

(1) The number whose square root is to be found should always be set on the two cycle scale (A or B), and the number whose square root is not to be found should be set on the one cycle scale (C, D or CI).

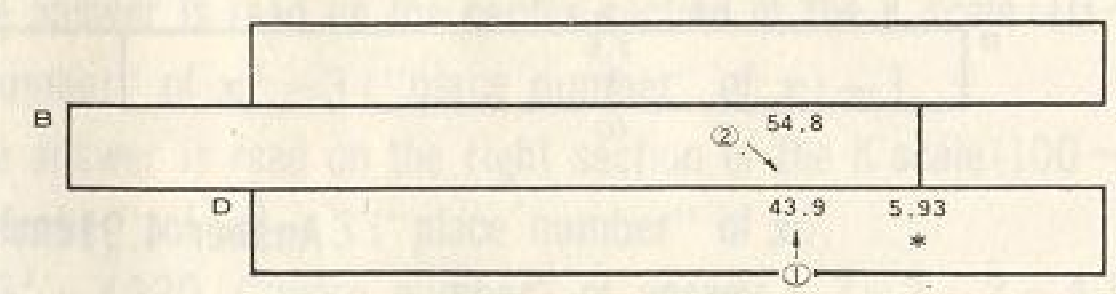
(2) Read the answer on the D scale.

In multiplication and division which involve the square roots of numbers, the correct section of the A scale must be used. The correct section of the A scale to be used can be determined in the manner previously described.

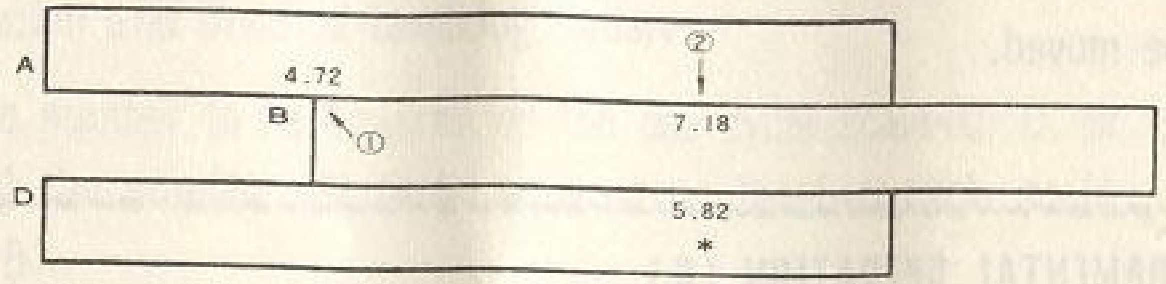
Ex. 5.8 $\sqrt{528} \times 6.38 = 146.6$



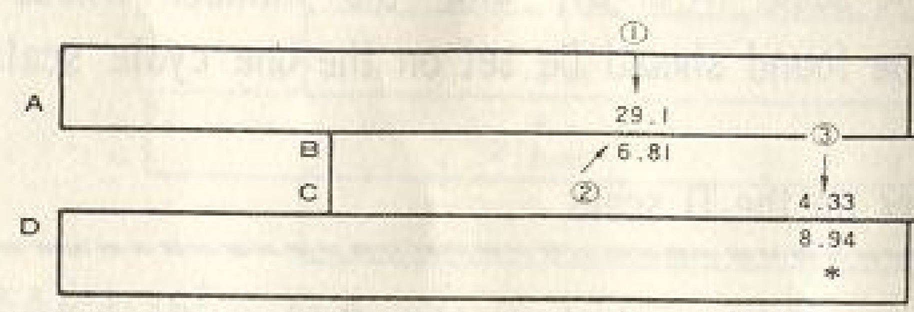
Ex. 5.9 $43.9 \div \sqrt{54.8} = 5.93$



Ex. 5.10 $\sqrt{4.72 \times 7.18} = 5.82$



Ex. 5.11 $\dfrac{\sqrt{29.1 \times 4.33}}{\sqrt{6.81}} = 8.94$

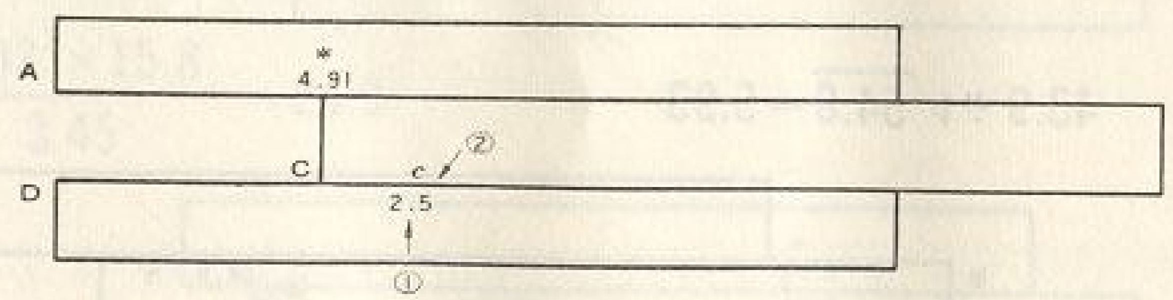


§ 3. THE AREA OF A CIRCLE

A gauge mark "*c*" is imprinted on the C scale at the 1.128 position. This is used with the D scale to find the area of a circle.

When you set the gauge mark "*c*" on the C scale opposite the diameter set on the D scale, the area of the circle is read on the A scale opposite the index of the C scale.

Ex. 5.12 Find the area of a circle having a diameter of 2.5cm.



Answer 4.91cm²

CHAPTER 6. CUBES AND CUBE ROOTS

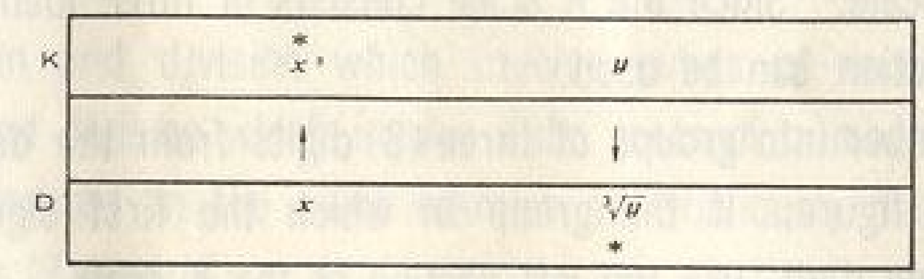
The K scale consists of three D scales connected together and reduced to exactly 1/3 of its original length. The K scale is called " three cycle scale" and is used with the C, D and CI scales to perform the calculations of the cubes and cube roots of numbers.

§ 1. CUBES AND CUBE ROOTS

FUNDAMENTAL OPERATION (9) $x^3, \sqrt[3]{y}$

(1) When the hairline is set over x on the D scale, x^3 is read under the hairline on the K scale.

(2) When the hairline is set over y on the K scale, $\sqrt[3]{y}$ is read under the hairline on the D scale.



The location of the decimal point in the cubes read on the K scale is determined by using the place number as follows:

a. When the answer is read on the left section of the K scale (1 ~ 10), "place number" of x^3 = 3 ("place number" of x) − 2.

b. When the answer is read on the center section of the K scale (10 ~ 100), "place number" of x^3 = 3 ("place number" of x) − 1.

c. When the answer is read on the right section of the K scale (100 ~ 1000), "place number" of x^3 = 3 ("place number" of x).

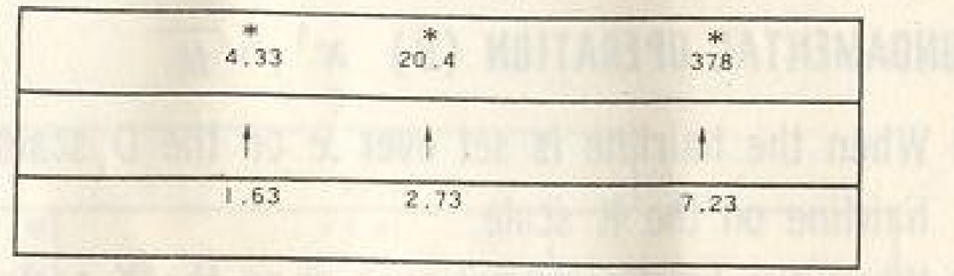
Ex. 6.1 $16.3^3 = 4330$ ("place number" of answer = $3 \times 2 - 2 = 4$)
$0.163^3 = 0.00433$ ("place number" of answer = $3 \times 0 - 2 = -2$)

$273^3 = 20400000$ ("place number" of answer $= 3\times3-1=8$)
$= 2.04\times10^7$

$0.0273^3 = 0.0000204$ ("place number" of answer $= 3\times(-1)-1=-4$)
$= 2.04\times10^{-5}$

$72.3^3 = 378000$ ("place number" of answer $= 3\times2=6$)
$= 3.78\times10^5$

$0.00723^3 = 0.000000378$ ("place number" of answer $= 3\times(-2)=-6$)
$= 3.78\times10^{-7}$



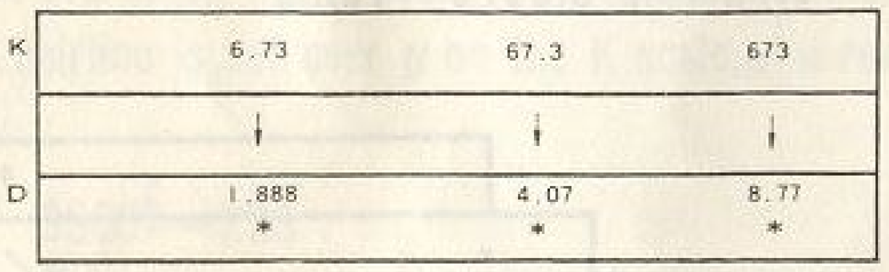
When the hairline is set over x on the K scale, $\sqrt[3]{x}$ is found under the hairline on the D scale. Since the K scale consists of three identical sections, only the correct section can be used.

Set off the number into groups of three (3) digits from the decimal point to the first significant figure. If the group in which the first significant figure appears has only one digit, use the left section of the K scale. If the group has two digits, use the center section of the K scale, and if three, the right section of the K scale.

The location of the decimal point in the cube roots read on the D scale is determined in the manner previously described.

Ex. 6.2 Find the cube roots of the following numbers.

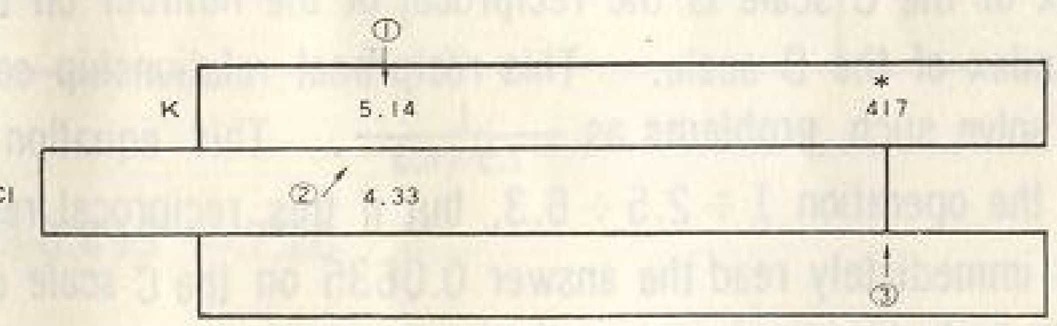
673 |000 (right)	Place number of the answer…… 2 $\sqrt[3]{673000}=87.7$
67|300 (center)	Place number of the answer…… 2 $\sqrt[3]{67300}=40.7$
6 |730 (left)	Place number of the answer…… 2 $\sqrt[3]{6730}=18.88$
0.673 (right)	Place number of the answer…… 0 $\sqrt[3]{0.673}=0.877$
0.067 |3 (center)	Place number of the answer…… 0 $\sqrt[3]{0.0673}=0.407$
0.006 |73 (left)	Place number of the answer…… 0 $\sqrt[3]{0.00673}=0.1888$
0.000 |673 (right)	Place number of the answer… −1 $\sqrt[3]{0.000673}=0.0877$



§2. MULTIPLICATION AND DIVISION INVOLVING CUBES AND CUBE ROOTS

Multiplication and division which involve cubes of numbers, as well as multiplication and division which involve cube roots of numbers are, with minor exceptions, calculated in the same manner as previously described in fundamental operations (7) and (8).

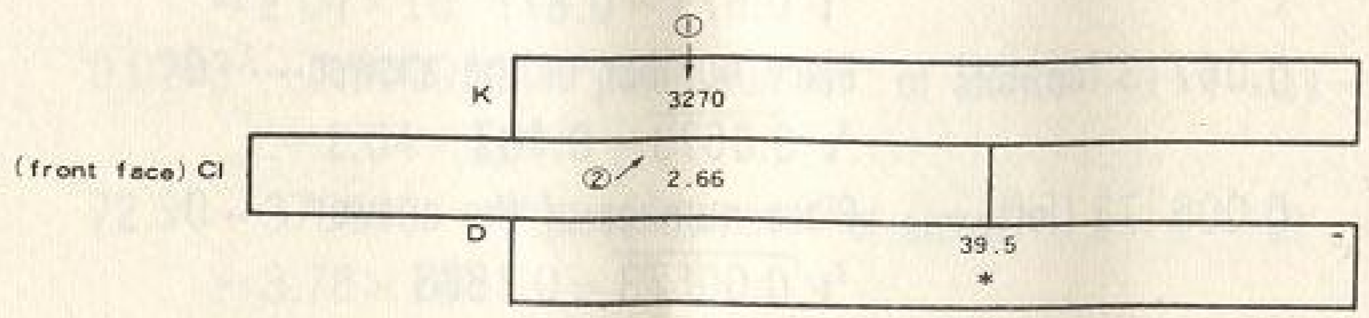
Ex. 6.3 $5.14\times4.33^3=417$



(Note) In the case of division involving cube roots, the C scale is used instead of the CI scale.

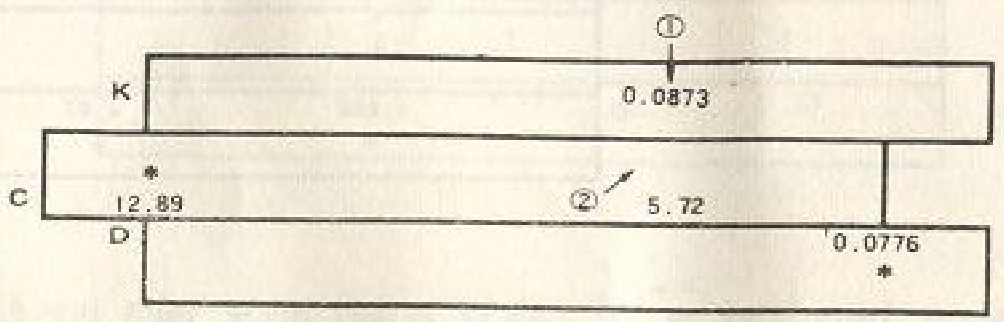
In $a^3 \div b$, first find a^3 and then perform division with two numbers using the C and D scales.

Ex. 6.4 $\sqrt[3]{3270 \times 2.66} = 39.5$



Ex. 6.5 $\sqrt[3]{0.0873} \div 5.72 = 0.0776$

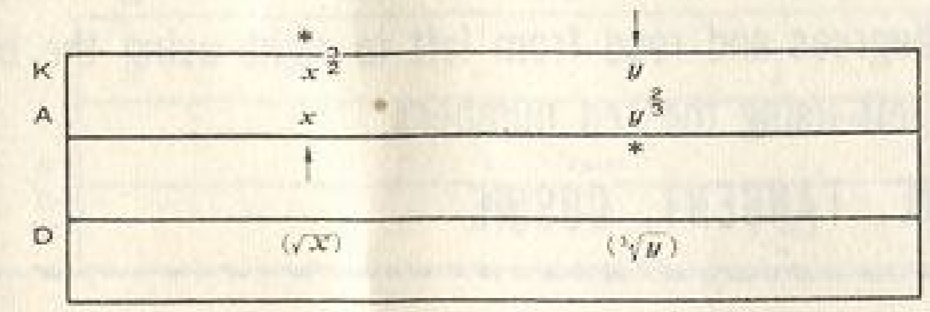
$5.72 \div \sqrt[3]{0.0873} = 12.89$



In Ex. 6.5, the equation $\sqrt[3]{0.0873} \div 5.72 = 0.0776$ is the reciprocal of the second equation $5.72 \div \sqrt[3]{0.0873} = 12.89$, and 0.0776 is read on the D scale opposite the index of the C scale, and at the same time, 12.89 is read on the C scale opposite the index of the D scale. From this, it can be seen that when the slide is set in any position, the number on the D scale opposite the index of the C scale is the reciprocal of the number on the C scale opposite the index of the D scale. This reciprocal relationship can be conveniently used to solve such problems as $\frac{1}{2.5 \times 6.3}$. This equation is usually solved through the operation $1 \div 2.5 \div 6.3$, but if this reciprocal relationship is used, you can immediately read the answer 0.0635 on the C scale opposite the index of the D scale by merely calculating 2.5×6.3.

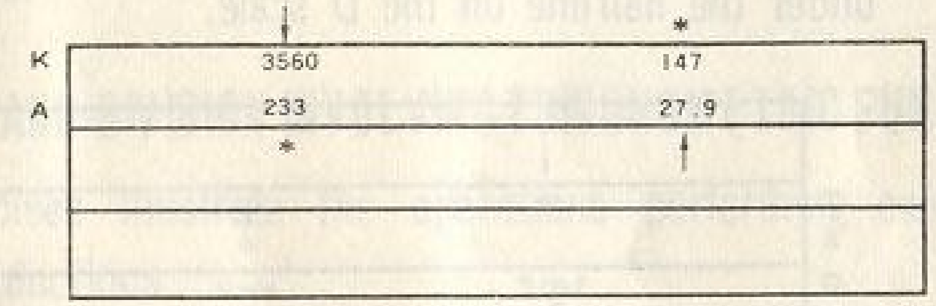
§ 3. $\frac{3}{2}$ POWER AND $\frac{2}{3}$ POWER

The A and K scales can be used to solve $x^{\frac{3}{2}}$ or $y^{\frac{2}{3}}$

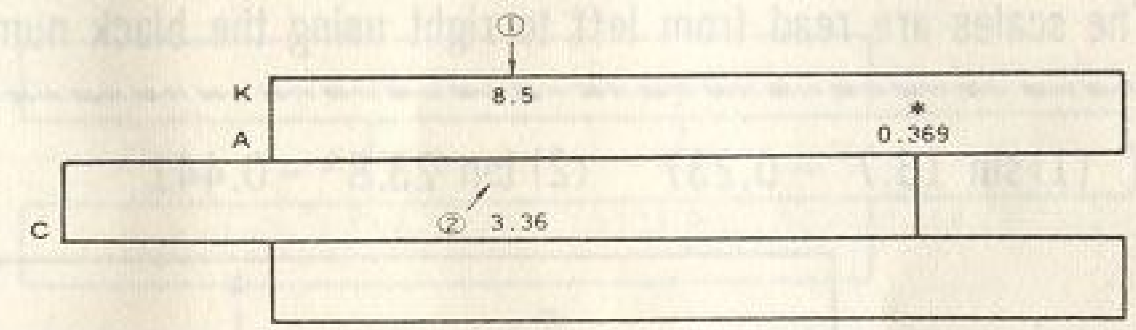


When the hairline is set over x on the A scale, $x^{\frac{3}{2}}$ is read under the hairline on the K scale. When the hairline is set over y on the K scale, $y^{\frac{2}{3}}$ is read under the hairline on the A scale.

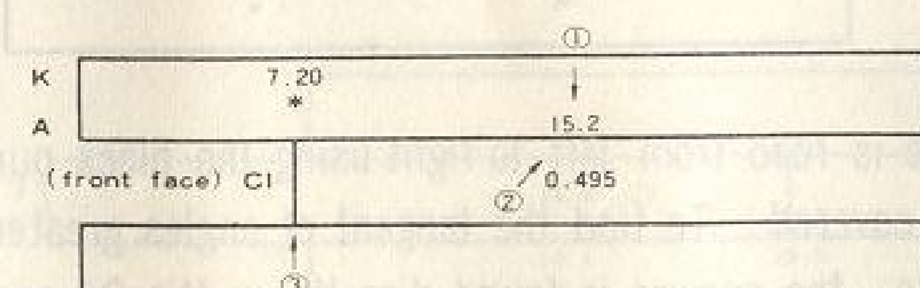
Ex. 6.6 $27.9^{\frac{3}{2}} = 147$ $\quad 3560^{\frac{2}{3}} = 233$



Ex. 6.7 $8.5^{\frac{2}{3}} \div 3.36^2 = 0.369$



Ex. 6.8 $15.2^{\frac{3}{2}} \times 0.495^3 = 7.20$



CHAPTER 7. TRIGONOMETRIC FUNCTIONS

The S scale is used to find the sine of an angle. The T scale is used to find the tangent of an angle. These scales are graduated in degrees and decimals of degrees and read from left to right using the black numbers and from right to left using the red numbers.

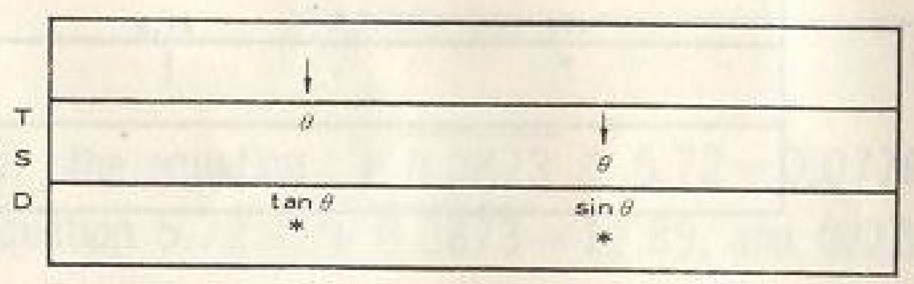
§1. SINE, TANGENT, COSINE

FUNDAMENTAL OPERATION (10) Sinθ, Tanθ

When the slide is closed, and

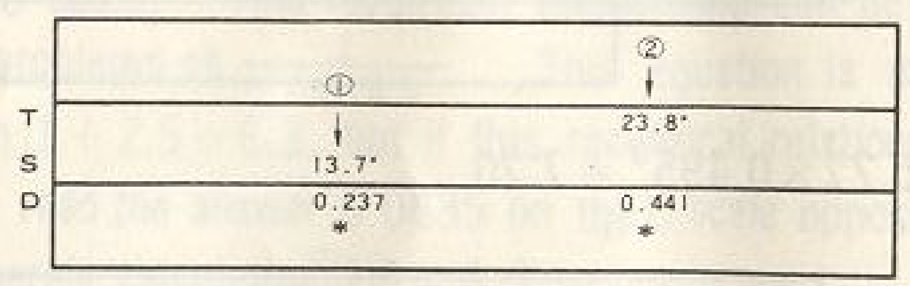
(1) The hairline is set over θ on the S scale, sin θ is read under the hairline on the D scale.

(2) When the hairline is set over θ on the T scale, tan θ is read under the hairline on the D scale.



The scales are read from left to right using the black numbers.

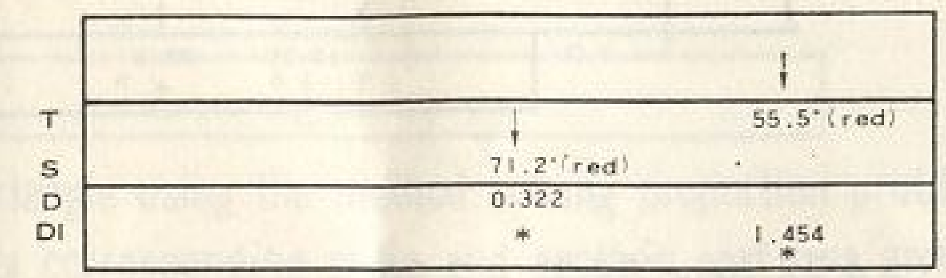
Ex. 7.1 (1) sin 13.7° = 0.237 (2) tan 23.8° = 0.441



When the T scale is read from left to right using the black numbers angles from 0° to 45° are covered. To find the tangent of angles greater than 45°, use the red numbers, the answer is found directly on the DI scale.

When finding the cosine, the red numbers of the S scale are used basing on the relation cos θ = sin (90° − θ) and the answer is read on the D scale.

Ex. 7.2 (1) tan 55.5° = 1.454 (2) cos 71.2° = 0.322

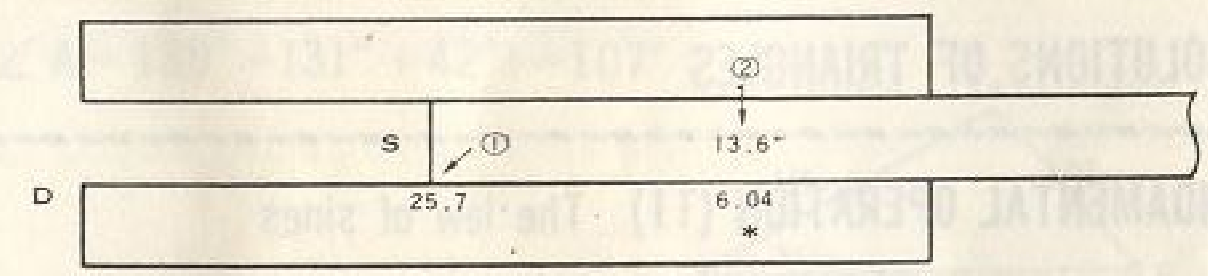


cot θ, sec θ and cosec θ are found to reciprocal of tan θ, cos θ and sin θ, respectively. Since a value under the hairline on the D scale is the reciprocal of the value under the hairline on the DI scale, this relationship can be conveniently used.

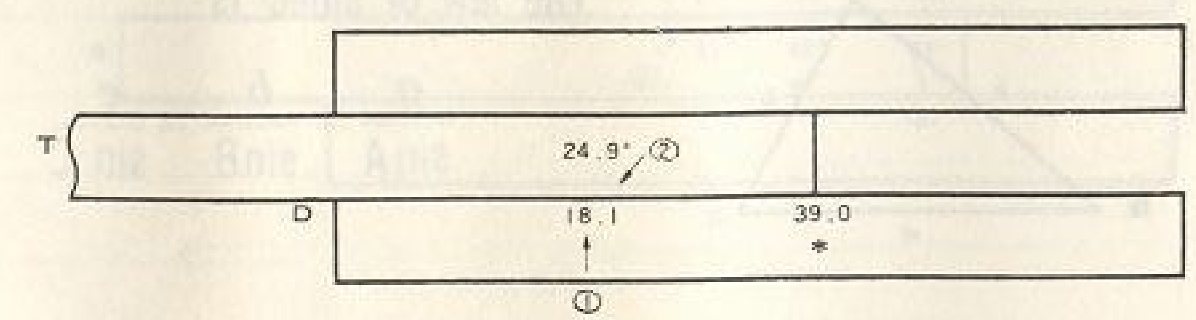
§2. MULTIPLICATION AND DIVISION INVOLVING TRIGONOMETRIC FUNCTIONS

The following exercises illustrate the operations performing calculations involving trigonometric functions.

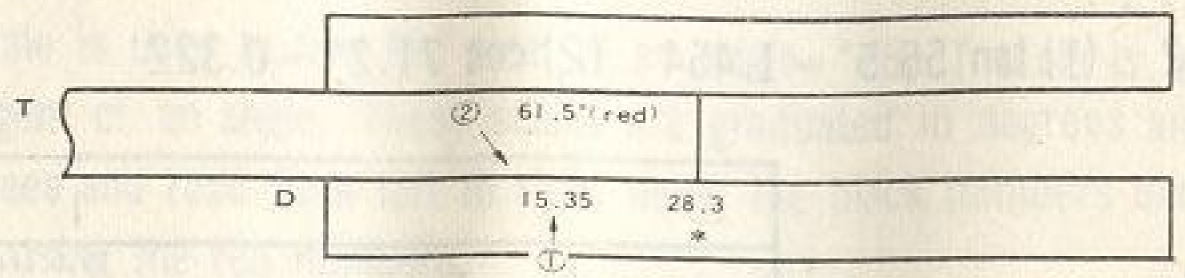
Ex. 7.3 25.7 × sin 13.6° = 6.04



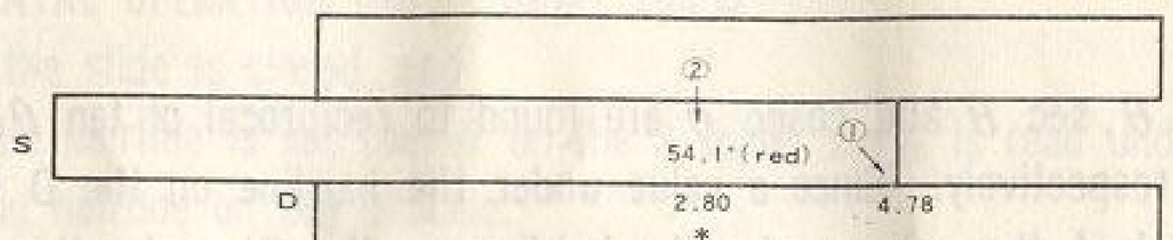
Ex. 7.4 18.1 ÷ tan 24.9° = 39.0



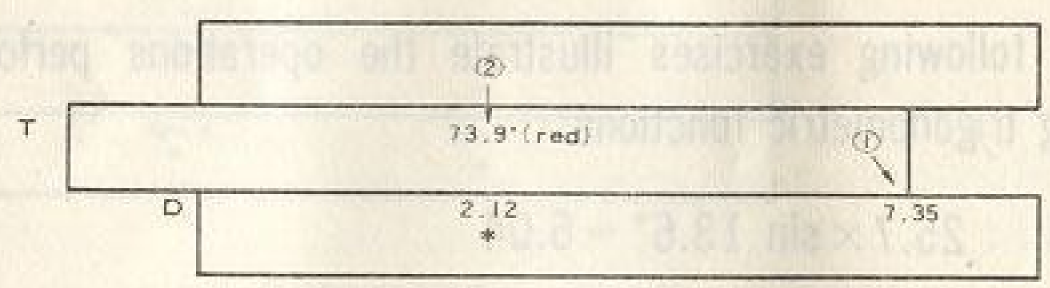
Ex. 7.5 $15.35 \times \tan 61.5^\circ = 28.3$



Ex. 7.6 $4.78 \times \cos 54.1^\circ = 2.80$



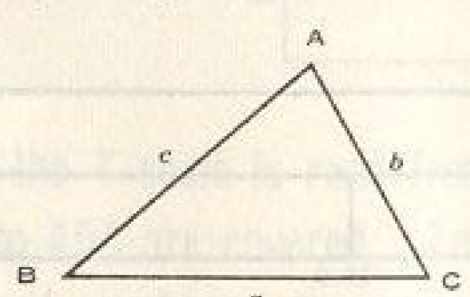
Ex. 7.7 $7.35 \times \cot 73.9^\circ = 2.12$



§ 3. SOLUTIONS OF TRIANGLES

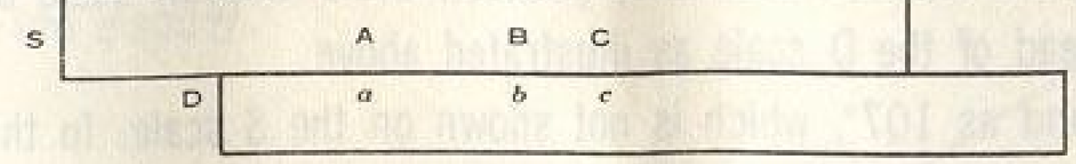
FUNDAMENTAL OPERATION (11) The law of sines

Given the triangle ABC, a is the side corresponding to A, b is the side corresponding to B, and c to C.



The law of sines is

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

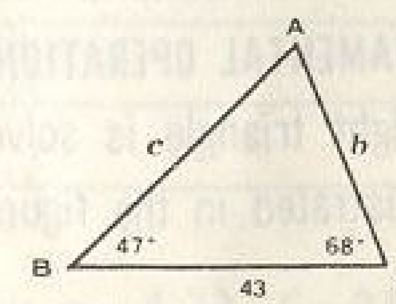


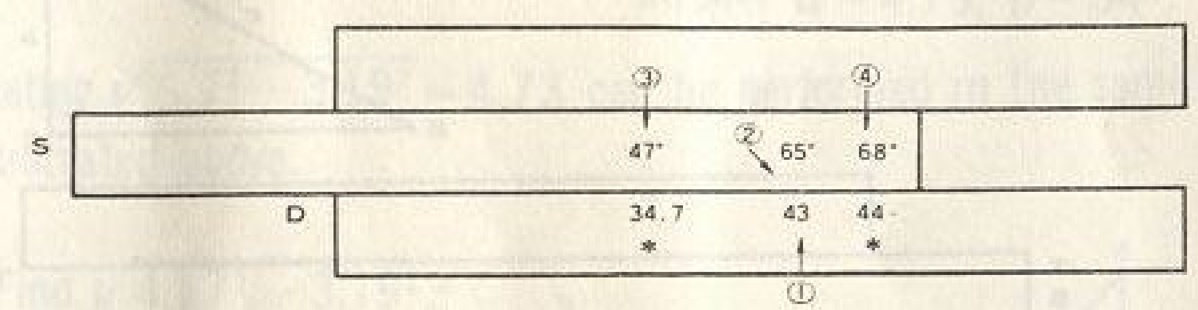
We can solve any triangle using the method solving proportion problems, when a side and its corresponding angle and another part are given.

Ex. 7.8 Find b and c.

$\angle A = 180^\circ - (47^\circ + 68^\circ)$
$= 65^\circ$

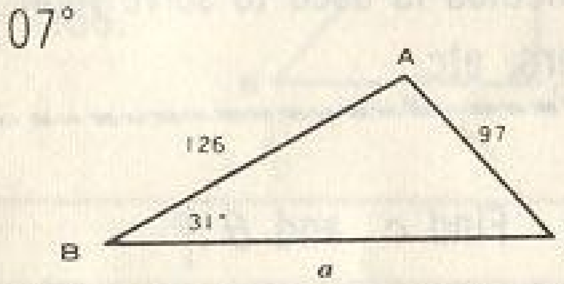
Answer $b = 34.7$, $c = 44.0$

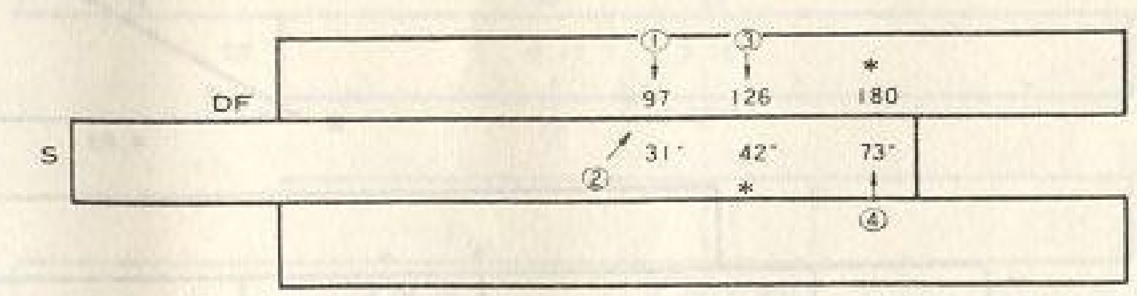




Ex. 7.9 Find $\angle$A, $\angle$C and a.

$\angle A = 180^\circ - (31^\circ + 42^\circ) = 107^\circ$





Answer $\angle A = 107^\circ$, $\angle C = 42^\circ$, $a = 180$

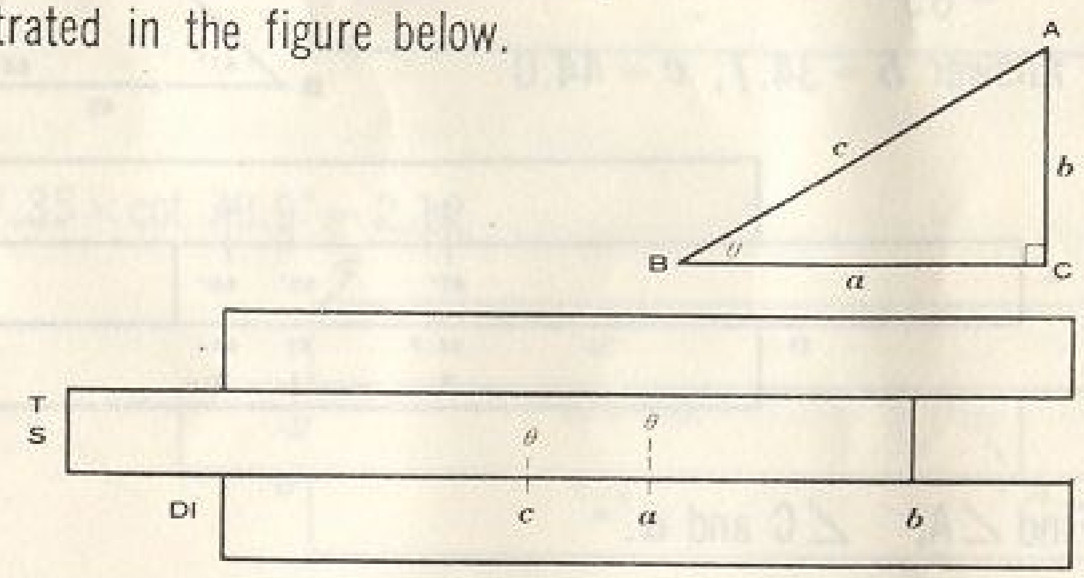
In Ex. 7. 9, 126 on the D scale will run off scale if you set 31° on the S scale opposite 97 on the D scale. You may continue the calculation by interchanging the indices. However, you can avoid this off scale by using the DF scale instead of the D scale as illustrated above.

∠A is found as 107°, which is not shown on the S scale. In this case, the complementary angle 180° − 107° = 73° is set on the S scale basing on a relation $\sin\theta = \sin(180° - \theta)$.

§4. SOLUTION OF RIGHT TRIANGLES

FUNDAMENTAL OPERATION (12) Right triangles

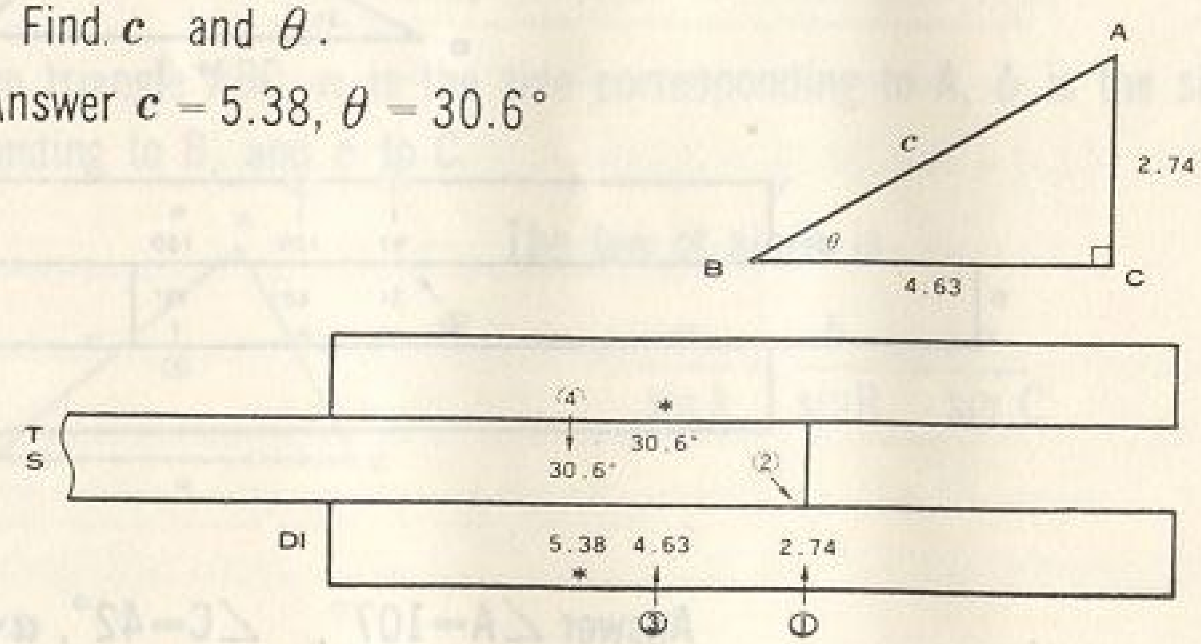
The right triangle is solved by setting the slide as illustrated in the figure below.



This method is used to solve right triangles, vector calculations, complex numbers, etc.

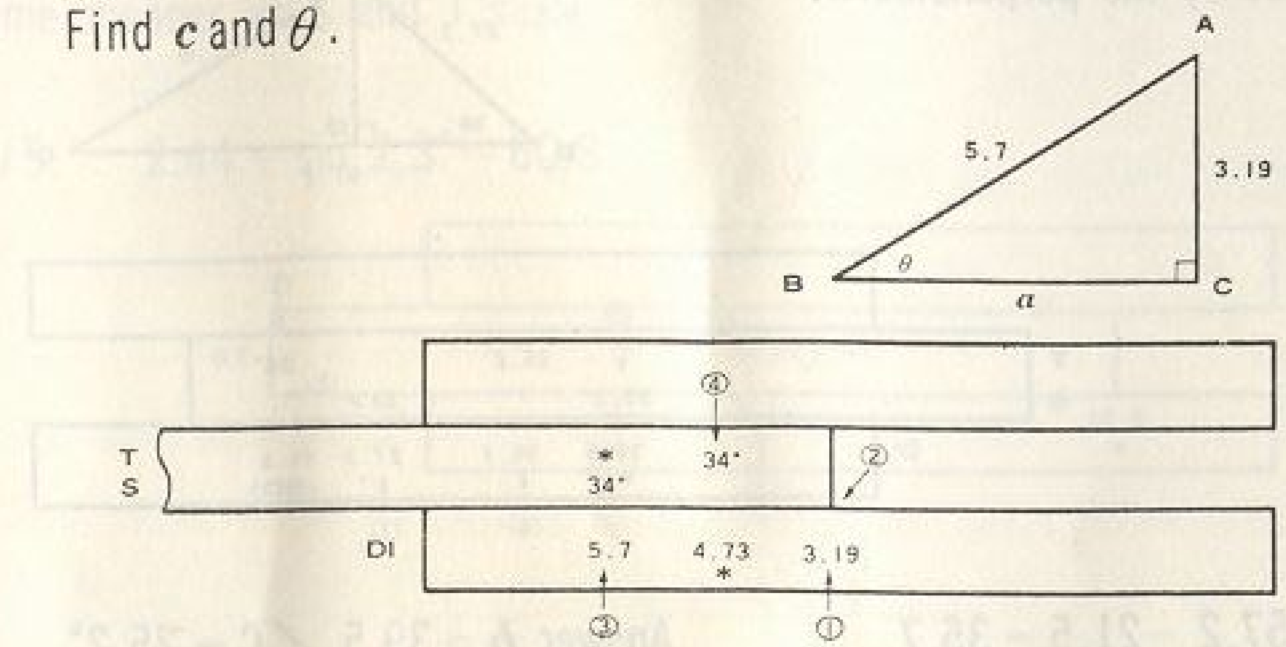
Ex. 7.10 Find c and θ.

Answer $c = 5.38$, $\theta = 30.6°$



(Note) $\sqrt{2.74^2 + 4.63^2} = 5.38$ is also calculated using the method illustrated. In this case θ is called "parameter".

Ex. 7.11 Find c and θ.

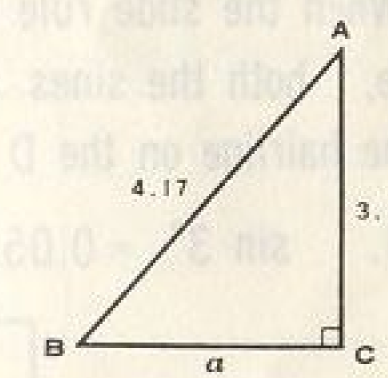


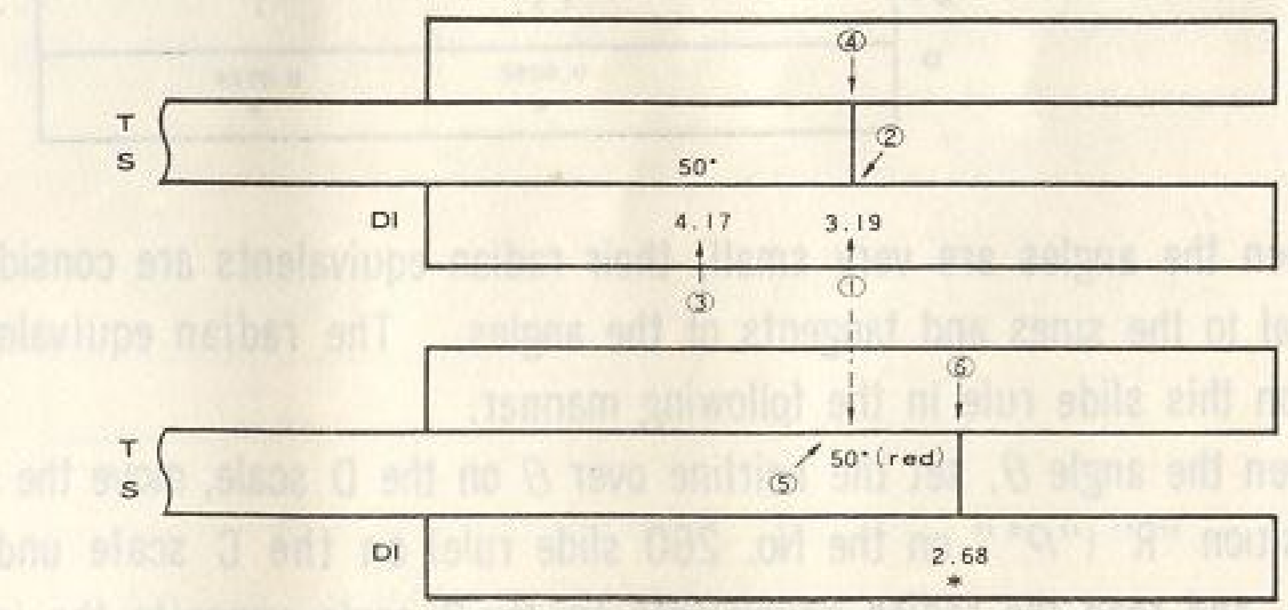
Answer $a = 4.73$, $\theta = 34°$

(Note) Calculating $\sqrt{5.7^2 - 3.19^2} = 4.73$ can be performed in the same manner as illustrated above.

Ex. 7.12 Find $\sqrt{4.17^2 - 3.19^2}$

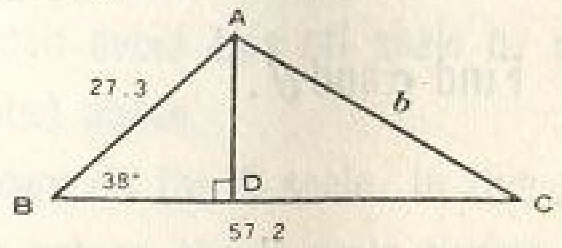
This problem is solved with the same method used to find a of the right triangle in which $b = 3.19$ and $c = 4.17$ and B = 50°. Answer 2.68.

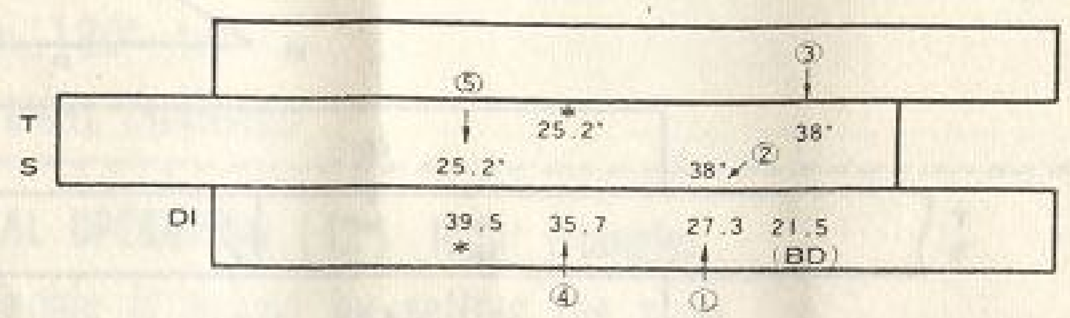




Ex. 7.13 Find b and ∠C of the triangle below.

In this case, the triangle is divided into two triangles by the perpendicular.



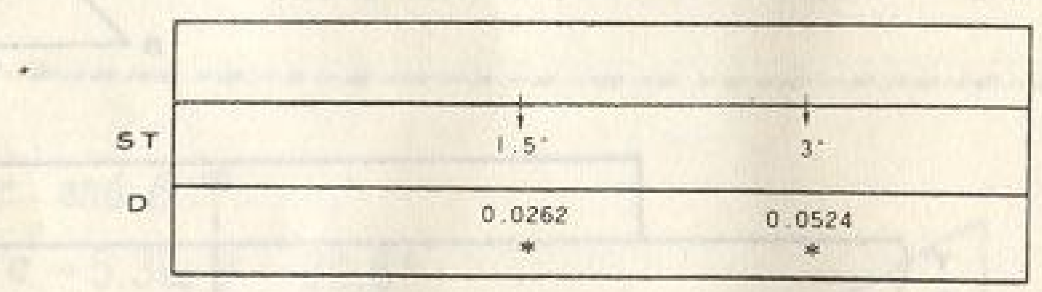


DC = 57.2 − 21.5 = 35.7   Answer b = 39.5, ∠C = 25.2°

§ 5. SINES AND TANGENTS OF VERY SMALL ANGLES

The sines and tangents of angles smaller than 6° are found with the ST scale. When the slide rule is closed, and the hairline is set over θ on the ST scale, both the sines and tangents of angles smaller than 6° can be read under the hairline on the D scale.

Ex. 7.14. sin 3° = 0.0524   tan 1.5° = 0.0262

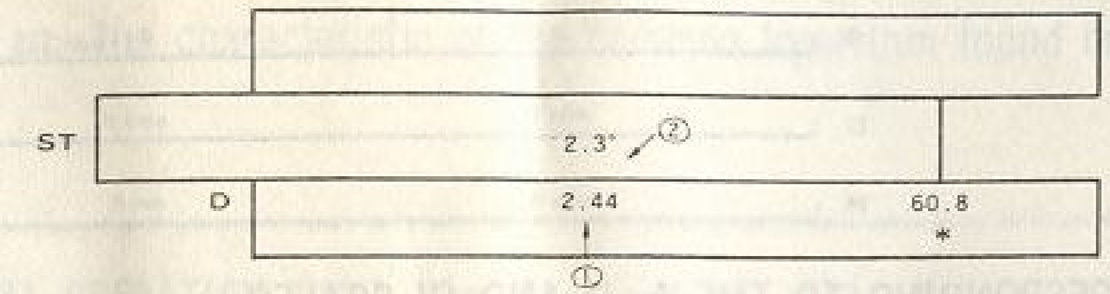


When the angles are very small, their radian equivalents are considered to be equal to the sines and tangents of the angles. The radian equivalents are found on this slide rule in the following manner.

Given the angle θ, set the hairline over θ on the D scale, move the slide to the position "R" ("ρ°" on the No. 260 slide rule) on the C scale under the hairline, and read the radian equivalents on the D scale opposite the index of

the C scale. The "R" represents the value of one(1) radian $= \frac{180°}{\pi} = 57.29°$. The ST scale is used for multiplication and division with trigonometric function in the same manner as S and T scale

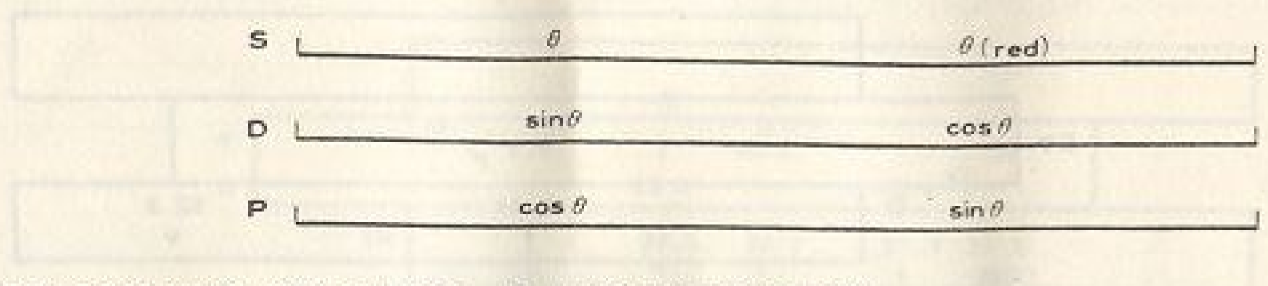
Ex. 7.15. 2.44 ÷ sin 2.3° = 60.8



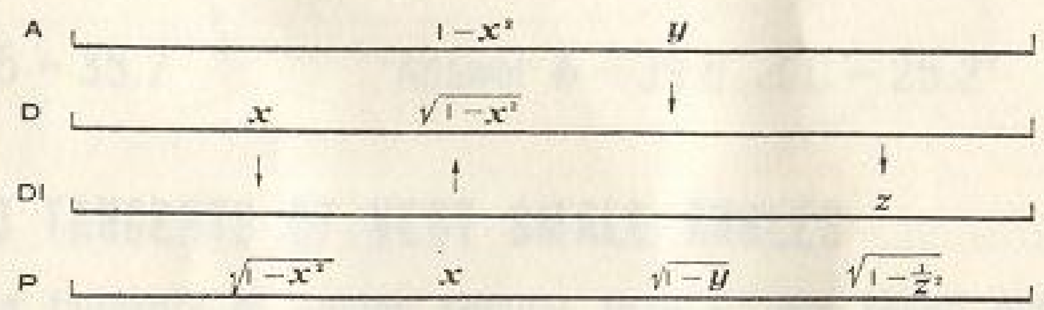
§ 6. HOW TO USE THE P SCALE

The No. 260 is equipped with the P scale. This scale provides $\cos\theta$ corresponding the S scale, and also can be used to calculate $\sqrt{1-x^2}$ corresponding with the D and A scales. The below diagram shows the corresponding relationships.

(1) CORRESPONDING TO THE S SCALE

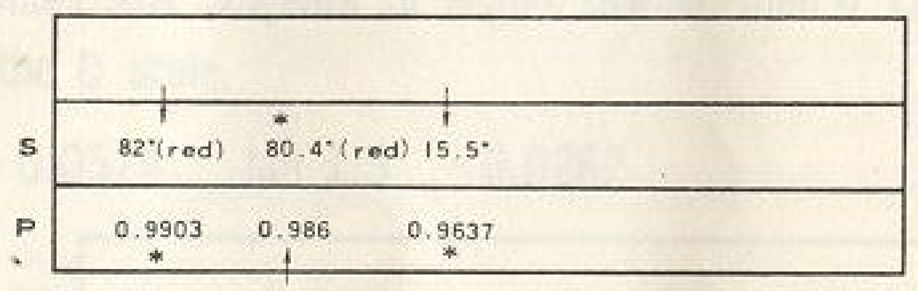


(2) CORRESPONDING TO THE A, D AND DI SCALES



Ex. 7.16 $\cos 15.5^\circ = 0.9637$ $\sin 82^\circ = 0.9903$

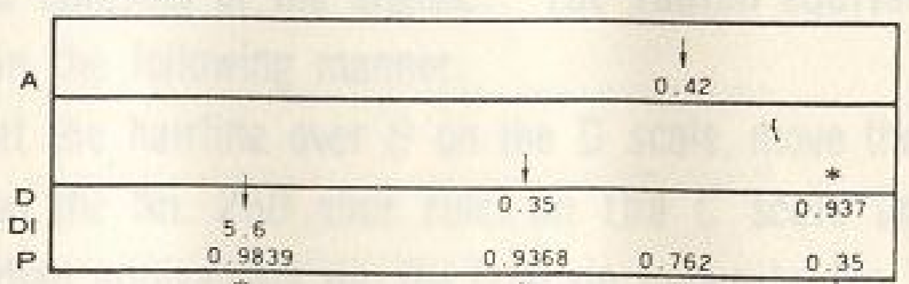
$\arcsin 0.986 = 80.4^\circ$



As the above examples show, $\cos\theta$ (when θ is smaller than 45°) and $\sin\theta$ (when θ is greater than 45°) can be more accurately found using the p scale than using the D scale.

Ex. 7.17 $\sqrt{1-0.35^2} = 0.9368$ $\sqrt{1-0.42} = 0.762$

$$\sqrt{1-\frac{1}{5.6^2}} = 0.9839$$



CHAPTER 8. LOGARITHMS AND EXPONENTS

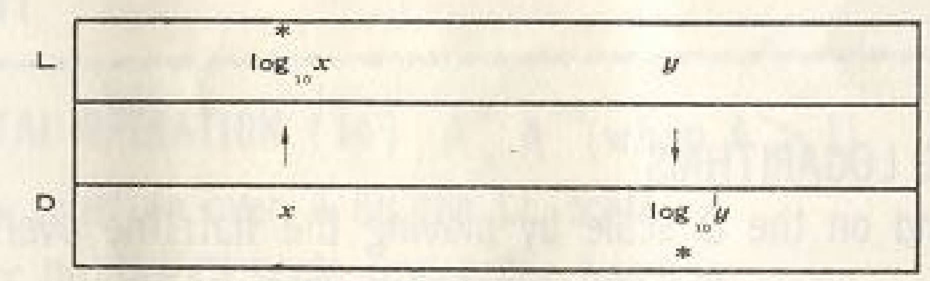
§ 1. COMMON LOGARITHMS

The L scale, which is a uniformly divided scale, is used with the D scale to find the mantissa of common logarithms. The characteristic of the logarithm is found by the place number of the given number. If the place number of the given number is m, the characteristic of the common logarithm found on the D scale is $m-1$.

FUNDAMENTAL OPERATION (13) $\log_{10} x$, $\text{antilog}_{10}\, y\,(10^y)$

(1) When the hairline is set over x on the D scale, $\log_{10} x$ is read under the hairline on the L scale.

(2) When the hairline is set over the mantissa of y on the L scale, the significant digits of $\text{antilog}_{10} y$ are read under the hairline on the D scale.

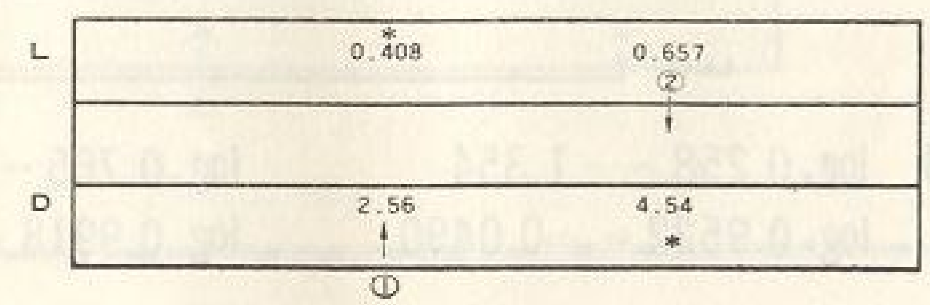


(Note) Special attention should be paid to the No. 260 slide rule that the L scale is located on the lower fixed scale.

Ex 8.1 (1) $\log_{10} 2.56 = 0.408$ (2) $\text{antilog}_{10} 0.657 = 4.54$

$\log_{10} 256 = 2.408$ $\text{antilog}_{10} 1.657 = 45.4$

$\log_{10} 0.0256 = \bar{2}.408$ $\text{antilog}_{10} \bar{1}.657 = 0.454$



(Note) From the result of $\log_{10} 0.0256 = \bar{2}.408$, the characteristic of $\log_{10}$ 0.0256 is a minus number. This should be rewritten $(-2)+0.408=-1.592$ for further calculation. If the DI. scale is used instead of the D scale, the mantissa 0.592 is directly read on the L scale.

§ 2. NATURAL LOGARITHMS

The log log scales LLO, LL1, LL2 and LL3 are called the LL scales and are used to obtain the natural logarithm of a number and powers and roots of numbers from 1.001 to 22,000. The scales LL/0, LL/1, LL/2 and LL/3 are called the reciprocal log log scales and used in the same manner as are the LL scales but are for numbers less than 1, and cover the range extending from 0.00005 to 0.999.

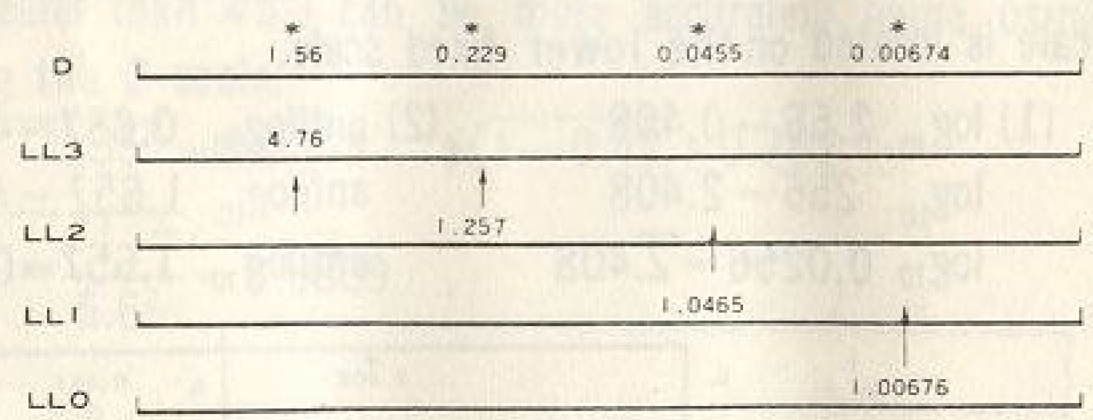
The LL scales are, so are the reciprocal log log scales, read with the location of the decimal point and these numbers either smaller than 0.00005 or larger than 22,000 can not be direct obtained on the log log scales.

FINDING NATURAL LOGARITHMS

$\log_e x$ is found on the D scale by moving the hairline over x on the L L scale.

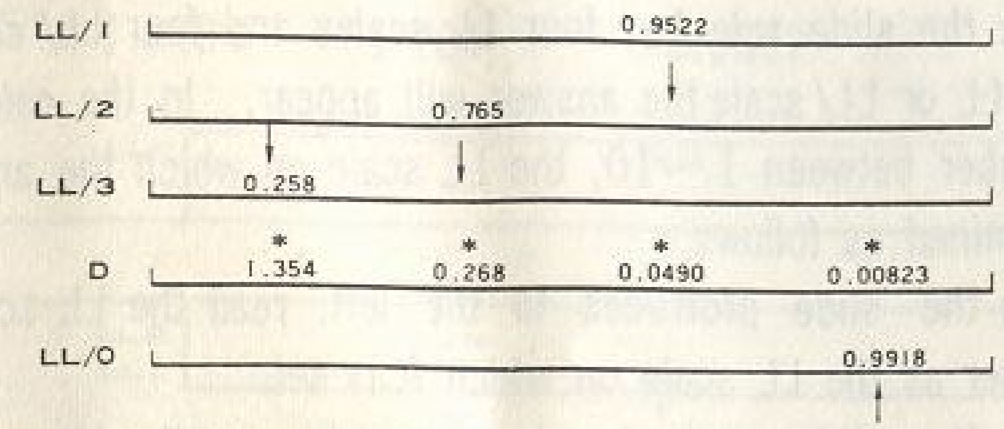
Ex. 8.2 $\log_e 4.76 = 1.56$ $\qquad$ $\log_e 1.257 = 0.229$

$\log_e 1.0465 = 0.0455$ $\qquad$ $\log_e 1.00676 = 0.00674$



Ex. 8.3 $\log_e 0.258 = -1.354$ $\qquad$ $\log_e 0.765 = -0.268$

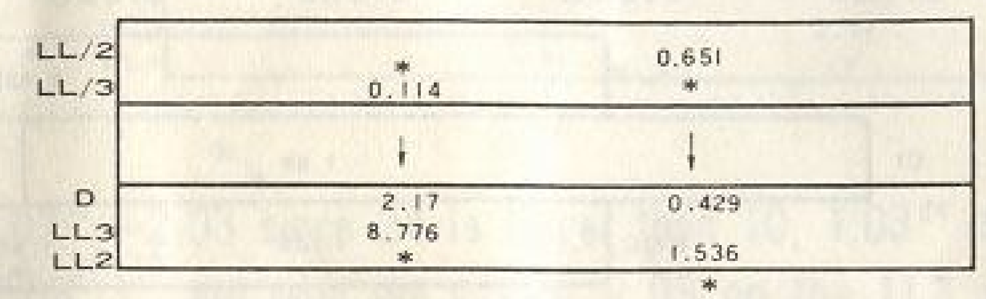
$\log_e 0.9522 = -0.0490$ $\qquad$ $\log 0.9918 = -0.00823$



The relationship between the place number of natural logarithms and the numbers (0. 1. 2. 3) on the LL scale can be seen in Ex. 8.2, 8.3.

Ex. 8.4 $\qquad e^{2.17} = 8.776$ $\qquad e^{-2.17} = 0.114$

$e^{0.429} = 1.536$ $\qquad e^{-0.429} = 0.651$



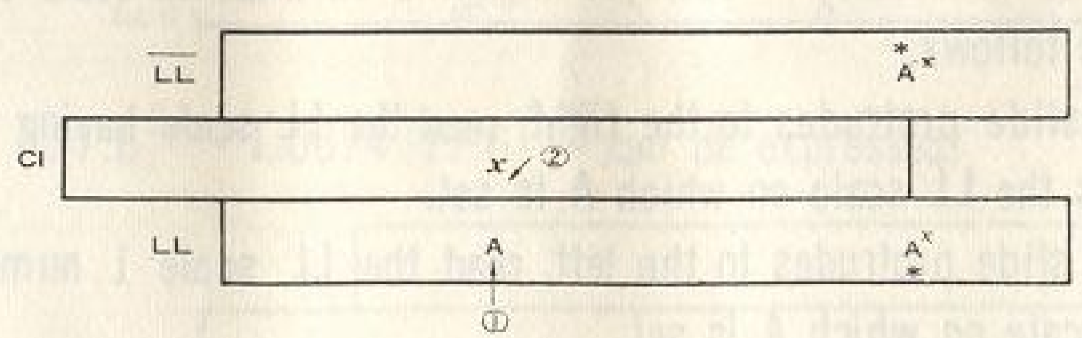
§ 3. EXPONENT

FUNDAMENTAL OPERATION (14) A^x, A^{-x} (when $A > 1$)

(1) Set the hairline over A on the LL scale.

(2) Move x on the CI scale under the hairline.

Read the answer on the LL scale in the case of A^x and on the LL/ scale in the case of A^{-x} opposite the index of the CI scale.



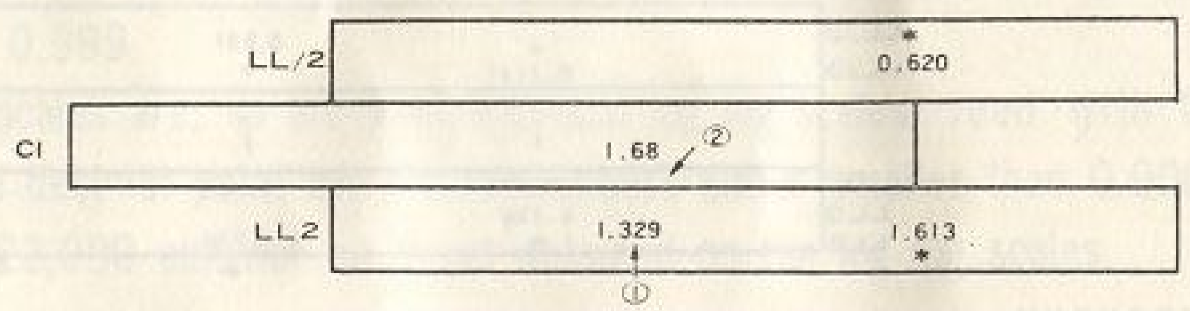
Since the slide rule has four LL scales and four LL/ scales, you must find on what LL or LL/ scale the answer will appear. In the calculation of A^x, if x is a number between $1 \sim 10$, the LL scale on which the answer appears will be determined as follows.

(1) When the slide protrudes to the left, read the LL scale having the same number as the LL scale on which A is set.

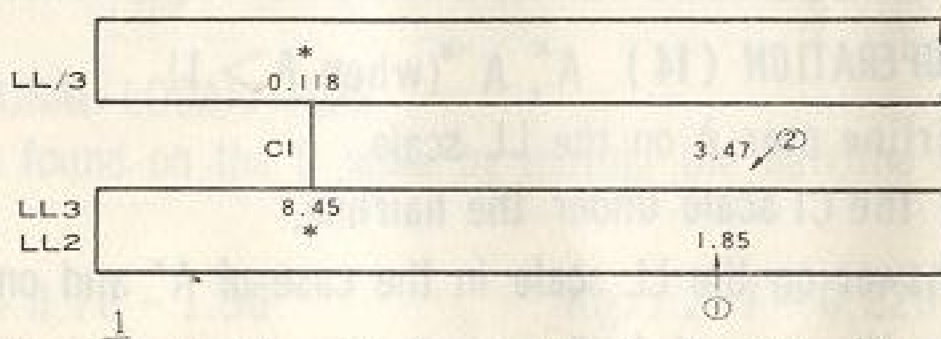
(2) When the slide protrudes to the right, read the LL scale 1 number higher than the LL scale on which A is set.

A^{-x} can be found using the LL/scale having the same number as the LL scale on which A^x is found.

Ex. 8.5 $1.329^{1.68} = 1.613$ $1.329^{-1.68} = 0.620$



Ex. 8.6 $1.85^{3.47} = 8.45$ $1.85^{-3.47} = 0.118$



To calculate $A^{\frac{1}{x}}$, the C scale is used instead of the CI scale.

To obtain the value of $A^{\frac{1}{x}}$

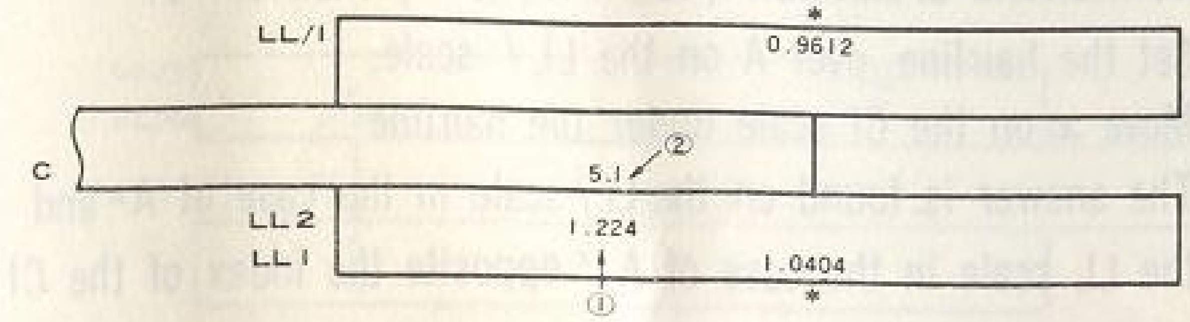
If x is a number between $1 \sim 10.$, you will find on what LL scale the answer will appear as follows.

(1) When the slide protrudes to the right, read the LL scale having the same number as the LL scale on which A is set.

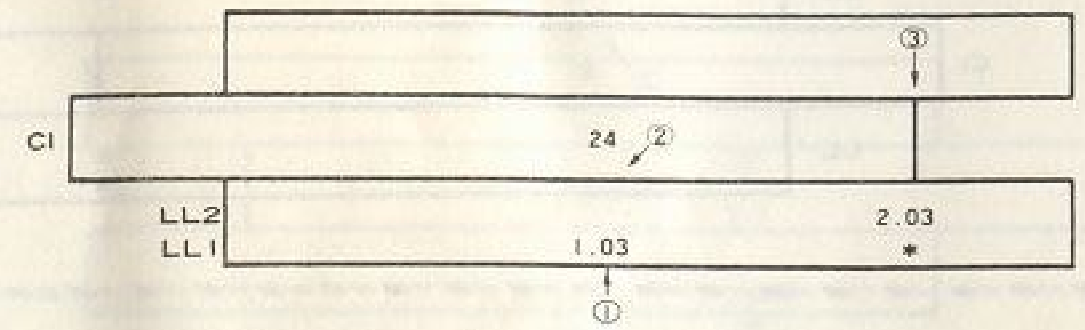
(2) When the slide protrudes to the left, read the LL scale 1 number lower than the LL scale on which A is set.

$A^{-\frac{1}{x}}$ can be found using the LL/ scale having the same number as the LL scale on which $A^{\frac{1}{x}}$ is found.

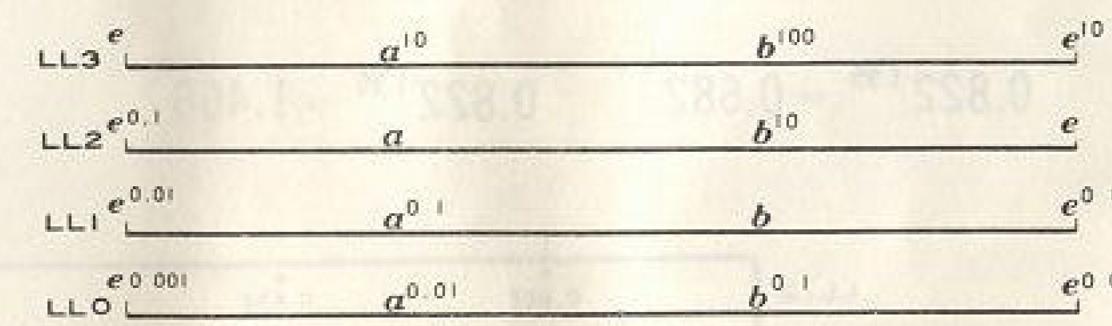
Ex. 8.7 $1.224^{\frac{1}{5.1}} = 1.0404$ $1.224^{-\frac{1}{5.1}} = 0.9612$



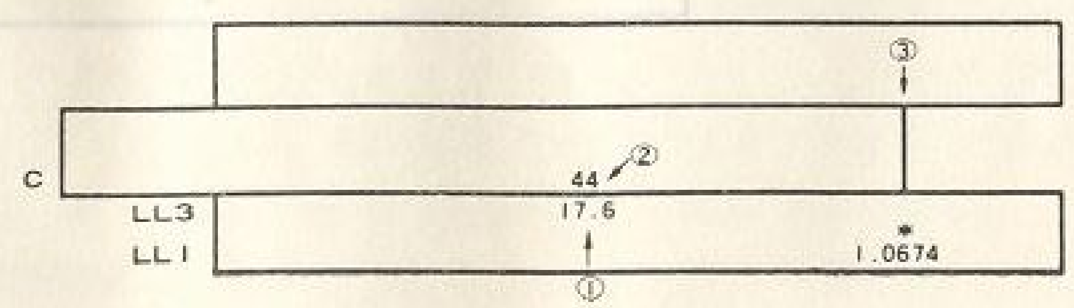
Ex. 8.8 $1.03^{24} = 2.03$



In calculating $1.03^{24} = 2.03$ since 24 is larger than 10, 1.03^{24} is rewritten to $1.03^{2.4\times10} = (1.03^{2.4})^{10}$ and read the answer 2.03 on the LL2 scale opposite the position you can read the answer of 1.03^{24} on the LL1 scale. It is based on the principle that any number on the LL2 scale is the 10th power of the LL1 scale and any number on the LL3 scale is the 10th power of the LL2 scale. This relationship is shown below.



Ex. 8.9 $17.6^{\frac{1}{44}} = 1.0674$ ($17.6^{\frac{1}{4.4}\times 0.1}$ can be expressed)

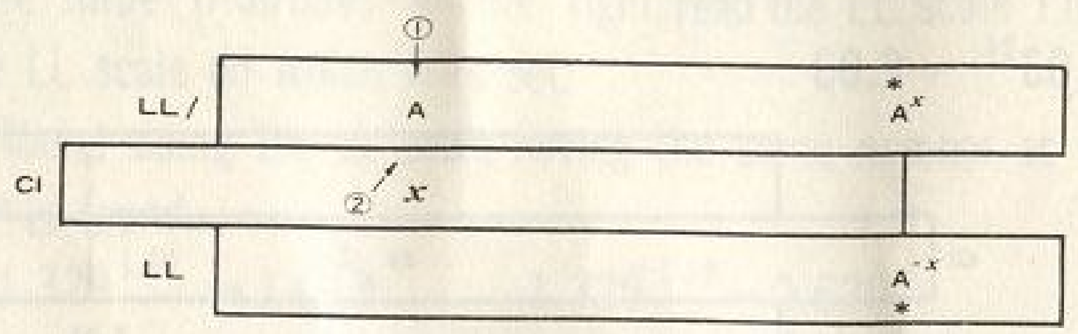


FUNDAMENTAL OPERATION (15) A^x, A^{-x} (when A < 1)

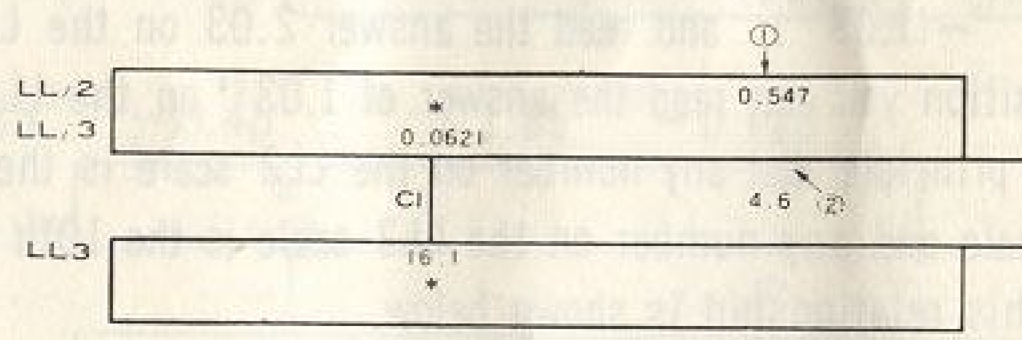
(1) Set the hairline over A on the LL/ scale.

(2) Move x on the CI scale under the hairline

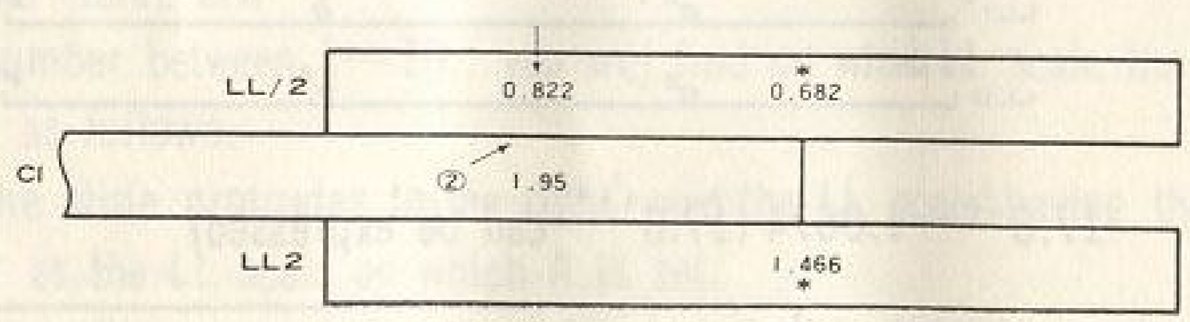
The answer is found on the LL/ scale in the case of A^x and on the LL scale in the case of A^{-x} opposite the index of the CI scale.



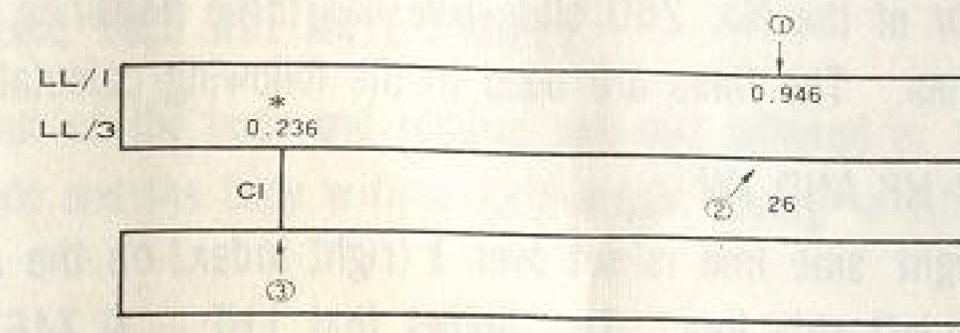
Ex. 8.10 $0.547^{4.6} = 0.0621$ $0.547^{-4.6} = 16.1$



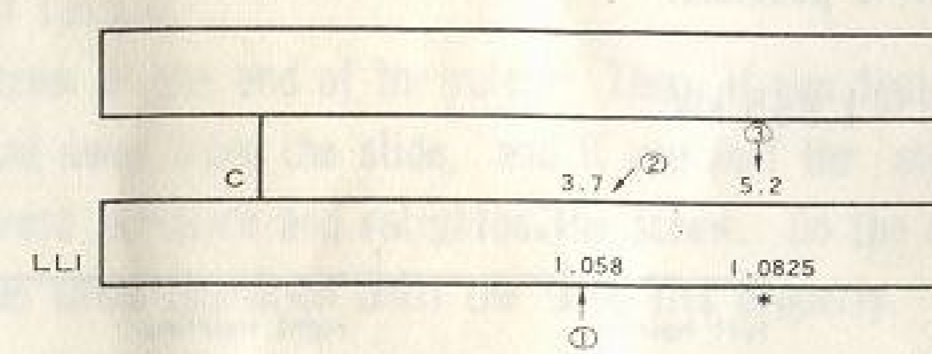
Ex. 8.11 $0.822^{1.95} = 0.682$ $0.822^{-1.95} = 1.466$



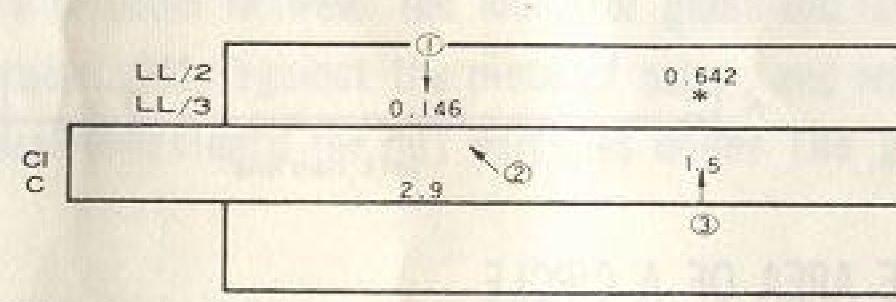
Ex. 8.12 $0.946^{26} = 0.236$ ($0.946^{2.6\times10}$ can be expressed)



Ex. 8.13 $1.058^{\frac{5.2}{3.7}} = 1.0825$



Ex. 8.14 $0.146^{\frac{1}{2.9\times1.5}} = 0.642$



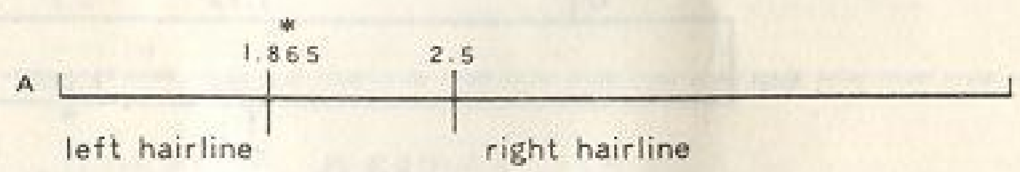
HOW TO USE THE THREE HAIRLINES ON THE INDICATOR

The indicator of the No. 260 slide rule has three hairlines, a center line and two side lines. The lines are used in the following calculation.

(1) CONVERTING HP AND kW

When the right side line is set over 1 (right index) on the A scale, 746 is found under the left side line. This shows that 1 HP = 0.746 kW. Therefore, if the right line is used for HP and the left line for kW, mutual conversion between HP and kW is possible.

Ex. 1 2.5 HP = 1.865 kW



Ex. 2 84 kW = 112.6 HP

(2) FINDING THE AREA OF A CIRCLE

Set the center hairline to a on the D scale, and read the answer $\frac{\pi a^2}{4}$ (the area of A circle whose diameter is a) on the A scale under the left side line. On the other hand, set the left side line to the area of a circle on the A scale, read the diameter on the D scale under the center hairline.

Ex. 3 Find the area of the circle whose diameter is 4.8 cm

Answer 18.1 cm²

CARE AND ADJUSTMENT OF THE SLIDE RULE.

※WHEN THE SLIDE DOES NOT MOVE EASILY;

Pull the slide out of the body and remove any dirt adhered to the sliding surfaces of the slide and the body with a toothbrush. Using a little of wax will also help.

Every Hemmi slide rule should come to you in proper adjusted condition. However, the inter-action of the slide and body, if necessary, can be adjusted to your own preference of tension.

First, loosen a screw at one end of the rule. Then, if you feel the slide fits tight, pull this end away from the slide, and if you feel the slide fits loose, push this end toward the slide and retighten the screw. Do the same at another end and repeat the same operation until the slide fits properly.

※WHEN THE INDICATOR GLASS BECOMES DIRTY;

Place a narrow piece of paper between the indicator glass and the surface of the rule, press the indicator glass against the piece of paper, and work the indicator back and force several times until the dirt particles under the glass adhere to the piece of paper.

※HOW TO ADJUST THE HAIRLINE.

The hairline should always be perpendicular to the scales. If it is not, loosen the four screws of the indicator frame and move the glass until perfect alignment is obtained and tighten the screws.

※HOW TO ADJUST THE SCALES.

When the slide is moved until the D and D scales coincide, the DF and CF or A and B scales should be coincide. However, the adjustment of the rule may be lost if the rule is dropped or severely jarred. In this case, loosen the screws at both ends of the rule and move the upper body member right or left until the DF or A scale coincides with CF or B scale, and tighten the screws.

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