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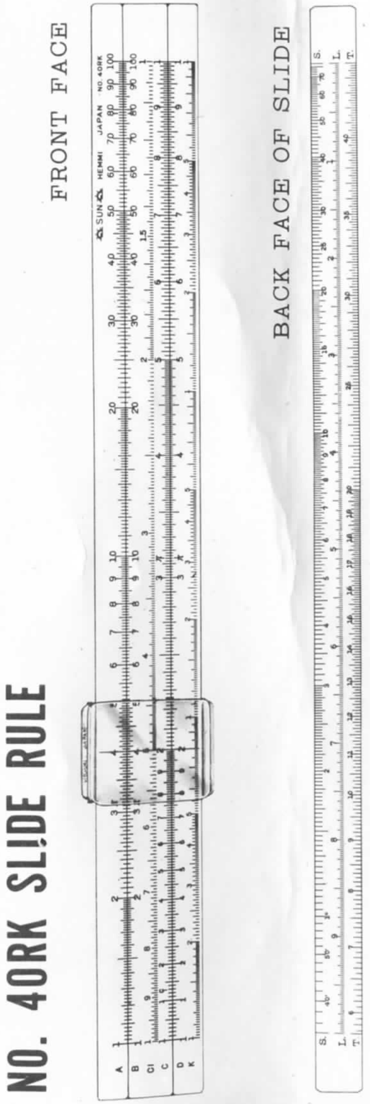
INSTRUCTION MANUAL FOR HEMMI 30, 32, 34RK, 40RK, 50W SLIDE RULE

HEMMI SLIDE RULE CO., LTD.
TOKYO, JAPAN



INSTRUCTION MANUAL

FOR HEMMI NO. 30 (10cm SINGLE TYPE) NO. 32 (10cm SINGLE TYPE) NO. 34RK (12.5cm SINGLE TYPE) NO. 40RK (25cm SINGLE TYPE) NO. 50W (25cm SINGLE TYPE) SLIDE RULE

This type of slide rule was originally designed by a Frenchman Mannheim and is the traditional Mannheim type slide rule.

(1) STANDARD SCALE ARRANGEMENT.

The A, B, CI, C, D and K scales are equipped on the front face and the S, L and T scales on the back face. This is the most common scale arrangement and permits calculation of multiplication, division, proportion, square, cube, trigonometric function and logarithm.

(2) THE S SCALE IS IN CONJUNCTION WITH THE A SCALE AND THE T SCALE IS WITH THE D SCALE.

The graduations on the S scale cover angles from approximately 35′ to 90°, and the sine of angles in this range is directly read on the A scale, and tangent of angles is also directly read on the D scale.

(Note) Since the No. 30 and 32 are not equipped with the K scale, the No. 34RK is recommendable if you need to calculate cube root explained in Chapter 6.

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. 50W slide rule and is one most often used.

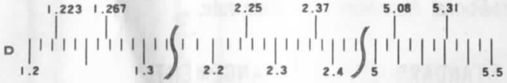
(1) SCALE DIVISIONS

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

Between 1 — 2	one division is 0.01
Between 2 — 5	one division is 0.02
Between 5 — 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 it 2 3 7 (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 labelled 1 and 10 respectively are called the "fixed index lines."

The corresponding lines on the C scale are called the "slide index lines"

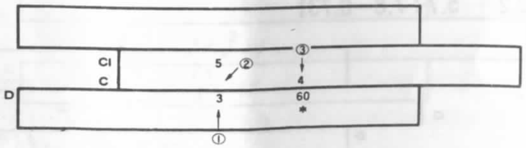
SLIDE RULE DIAGRAM

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)

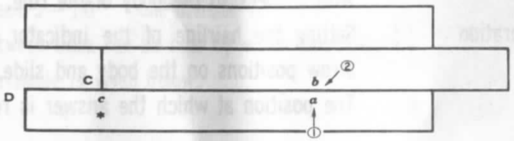
§ 1. DIVISION

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

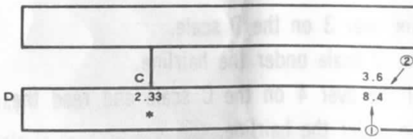
(1) Set the hairline over a on the D scale,

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

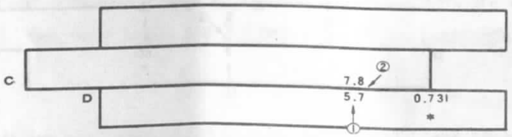
read the answer c on the D scale opposite the index of the C scale.



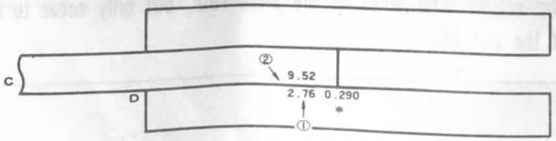
Ex. 2.1 $8.4 \div 3.6 = 2.33$



Ex. 2.2 $5.7 \div 7.8 = 0.731$



Ex. 2.3 $2.76 \div 9.52 = 0.290$



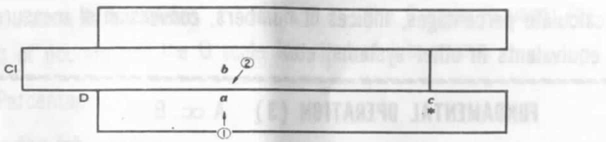
§ 2. MULTIPLICATION

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

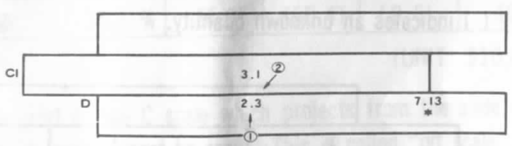
(1) Set the hairline over a on the D scale,

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

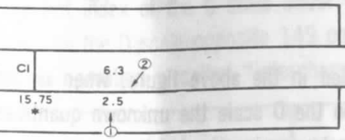
read the answer c on the D scale opposite the index of the CI scale.



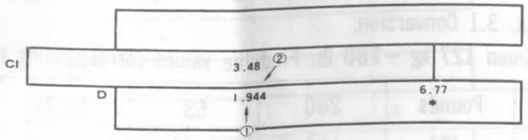
Ex. 2.4 $2.3 \times 3.1 = 7.13$



Ex. 2.5 $2.5 \times 6.3 = 15.75$



Ex. 2.6 $1.944 \times 3.48 = 6.77$



CHAPTER 3. PROPORTION AND INVERSE PROPORTION

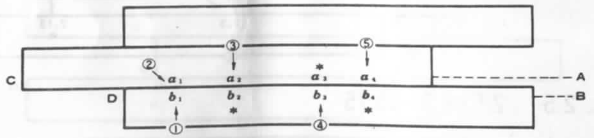
§ 1. PROPORTION

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 $\propto$ B

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

( ) indicates an unknown quantity.

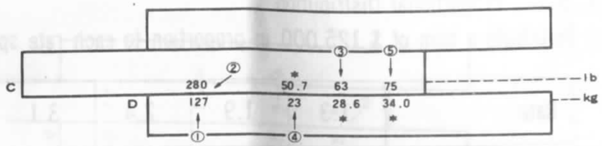


As illustrated in the above figure, when a_1 on the C scale is set opposite b_1 on the D scale the unknown quantities are all found on the C or D scales by moving the hairline.

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 proportion, the C scale must be used for one measurement and the D scale for the other. Interchanging 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.

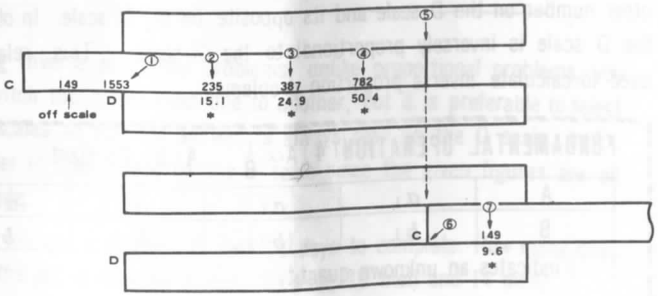
Ex. 3.2 Percentages.

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

(UNIT: $10,000)

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 the case of an "off scale", move the hairline to the right index of the C scale and move the slide to bring the left index of the C scale under the hairline. The answer 9.6 can then be read on the D scale opposite 149 on the C scale which is now inside the rule. This operation is called "interchanging the indices".



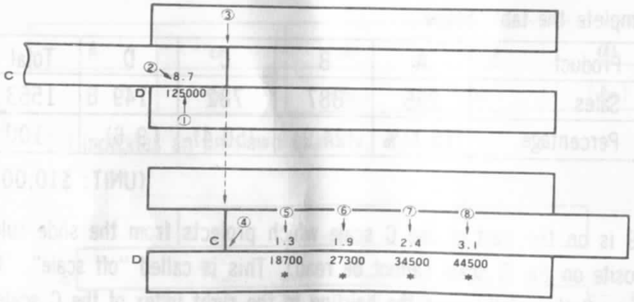
Ex. 3.3 Proportional Distribution.

Distribute a 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

(UNIT: $)

When 8.7 on the C scale is set opposite 125000 on the D scale, 1.3, 1.9, 2.4, and 3.1 on the C scale run "off scale". Therefore interchanging the indices is immediately required.



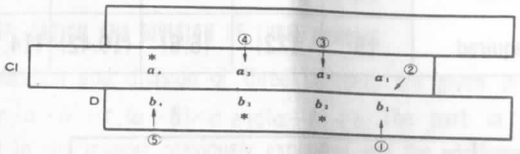
§ 2. INVERSE PROPORTION

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 relationship 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.

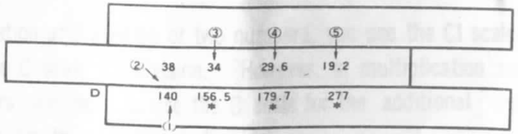


When a_1 on the CI scale is set opposite b_1 on the D scale, the product of $a_1 \times b_1$ is equal to that of $a_2 \times b_2$, that of $a_3 \times b_3$, and also equal to that of $a_4 \times b_4$. Therefore, b_2, b_3, a can be found by merely moving the hairline of the indicator.

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, 29.6 km per hour or 19.2 km per hour.

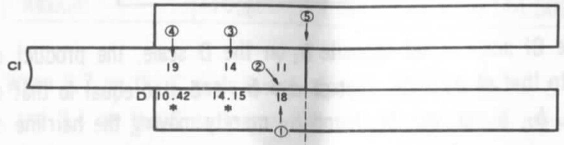
Speed	38 km	34	29.6	19.2
Time required	140 min.	(156.5)	(179.7)	(277)

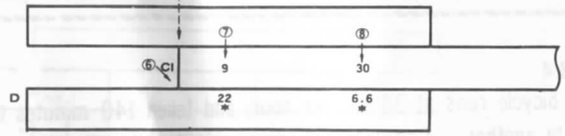


In solving inverse proportion problems, unlike proportional problems, you can freely switch the scales from one to another, but it is preferable to select and use the scales so that the answer is always read on the D scale. In Ex. 3.1 the answer is always read on the D scale since the given figures are all set on the slide.

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 this example 9 and 30 run "off scale". In this case it is more efficient to calculate the figures (19 and 14) which are inside the rule before interchanging the indices.

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

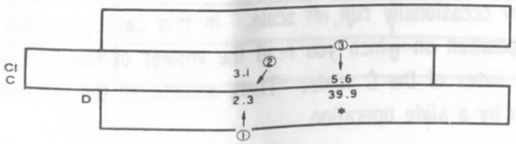
For additional multiplication to follow the calculation $(a\times b)$ or $(a\div b)$, set the hairline over c on the C scale and read the answer d on the D scale under the hairline.

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

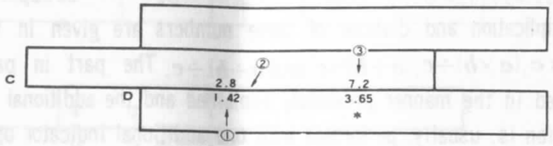
For additional division to follow the calculation $(a\div b)$ or $(a\times b)$, set the hairline over c on the CI scale and read the answer d on the D scale under the hairline.

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.

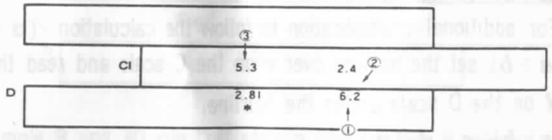
Ex. 4.1 $2.3\times 3.1\times 5.6=39.9$



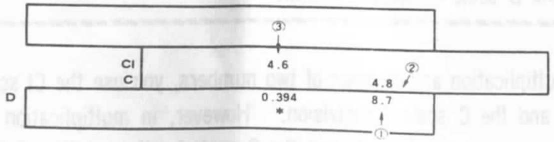
Ex. 4.2 $1.42 \div 2.8 \times 7.2 = 3.65$



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



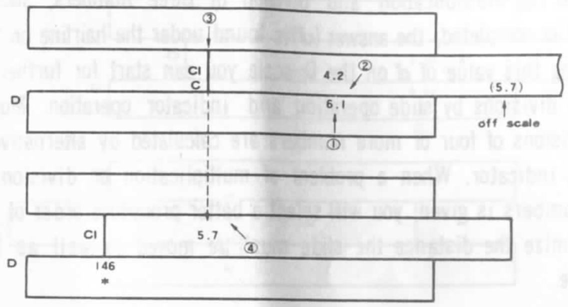
Ex. 4.4 $8.7 \div 4.8 \div 4.6 = 0.394$



§ 2. OFF SCALE

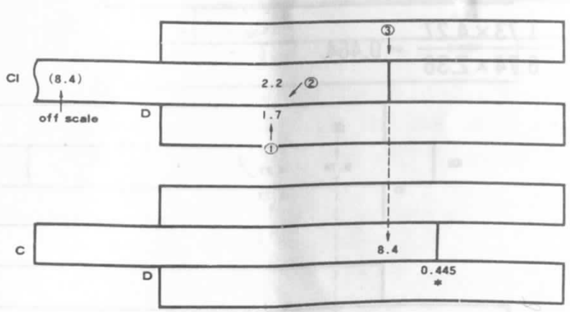
When multiplications and divisions of three numbers are performed by an indicator operation, a position on the C or CI scale over which the hairline is to be set may occasionally run off scale. In this case you once set the hairline over the position on which you read the answer of the first two numbers (opposite the index of the C scale). Then, accomplish the remaining multiplication or division by a slide operation.

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



The above operations mean that the problem of $a \times b \times c = x$ is solved in such a manner as $a \times b = y$ and $y \times c = x$. Therefore, the third number 5.7 is to be set on the CI scale basing on the principle of multiplication and division of two numbers. If the third operation is a division as the problem of Ex. 4.6, set the third number on the C scale.

Ex. 4.6 $1.7 \times 2.2 \div 8.4 = 0.445$

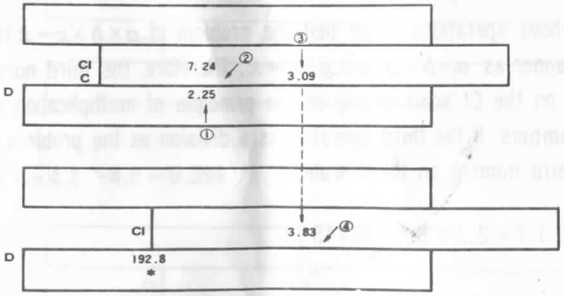


§ 3. MULTIPLICATION AND DIVISION OF MORE THAN FOUR NUMBERS.

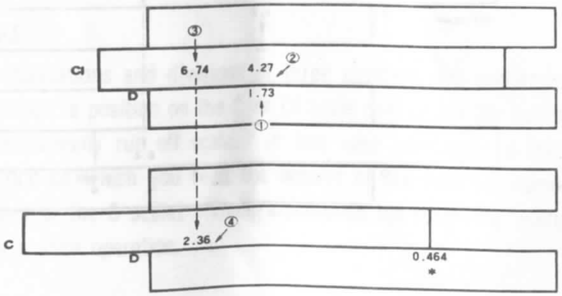
When the multiplication and division of three numbers, such as $a \times b \times c = d$ is completed, the answer (d) is found under the hairline on the D scale.

Using this value of d on the D scale you can start for further multiplications or divisions by slide operation and indicator operation. Multiplications and divisions of four or more numbers are calculated by alternative operations of slide-indicator. When a problem of multiplication or division of four or more numbers is given, you will select a better procedure order of calculations to minimize the distance the slide must be moved as well as to avoid the off scale.

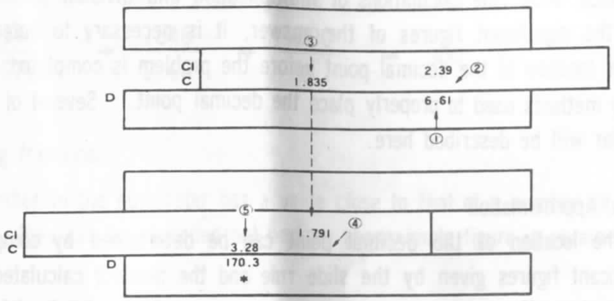
Ex. 4.7 $2.25 \times 7.24 \times 3.09 \times 3.83 = 192.8$



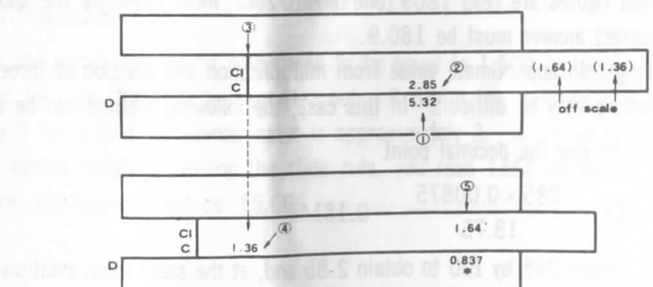
Ex. 4.8 $\dfrac{1.73 \times 4.27}{6.74 \times 2.36} = 0.464$



Ex. 4.9 $6.61 \times 2.39 \times 1.835 \times 1.791 \times 3.28 = 170.3$



Ex. 4.10 $\dfrac{5.32}{1.36 \times 1.64 \times 2.85} = 0.837$



§4. 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. $$\frac{285 \times 0.00875}{13.75} = 0.1814$$

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.

$\frac{285 \times 0.00875}{13.75}$ is rewritten to $\frac{2.85 \times 0.875}{13.75}$ and approximated to $\frac{3 \times 0.9}{10} = 0.27$.

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

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

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

(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. $$\frac{1.472 \times 9.68 \times 4.76}{1.509 \times 2.87} = 15.66$$

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

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

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

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 $N\times10^{P}$ 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. $\dfrac{1587\times0.0503\times0.381}{0.00815}=3730$

$$\frac{1587\times0.0503\times0.381}{0.00815}=\frac{1.587\times10^{3}\times5.03\times10^{-2}\times3.81\times10^{-1}}{8.15\times10^{-3}}$$

$$=\frac{1.587\times5.03\times3.81}{8.15}\times10^{3-2-1-(-3)}$$

$$=\frac{2\times5\times4}{8}\times10^{3-2-1-(-3)}=5\times10^{3}=5000$$

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

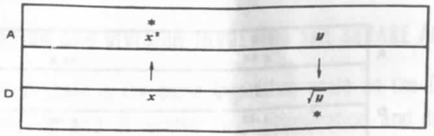
The A scale, which is identical to the B scale, consists of two D scales connected together and reduced to exactly 1/2 of their original length. The A scale is used with the C, D or CI scale to perform the calculations of the square and square root of numbers.

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 ($1 \sim 10$), 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($10 \sim 100$), 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 $2 \times 3 - 1 = 5$

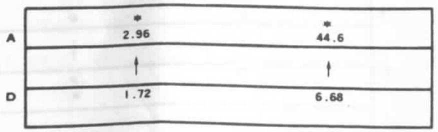
$17.2^2 = 296$ ················ The place number of 17.2 is 2. Hence, the place number in the answer is $2 \times 2 - 1 = 3$

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

Ex. 5.2 $668^2 = 446000 = 4.46 \times 10^5$ ············ The place number of 668 is 3 Hence, the place number in the answer is $2 \times 3 = 6$

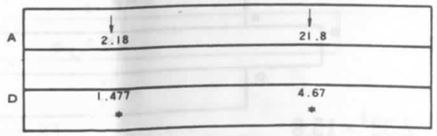
$0.668^2 = 0.446$ ············ The place number of 0.668 is 0. Hence, the place number in the answer is $2 \times 0 = 0$

$0.0668^2 = 0.00446$ ······· 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 $\sqrt{0.000218} = 0.01477$



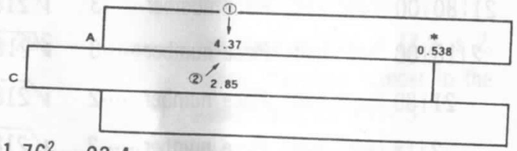
§2. MULTIPLICATION AND DIVISION INVOLVING THE SQUARE AND SQUARE ROOT

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.

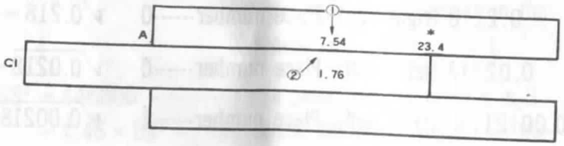
FUNDAMENTAL OPERATION (7)
Multiplication and division involving squares

(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.

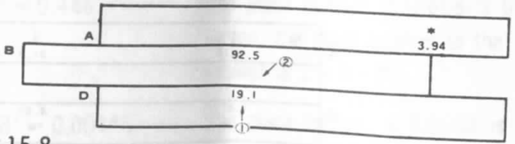
Ex. 5.4 $4.37 \div 2.85^2 = 0.538$



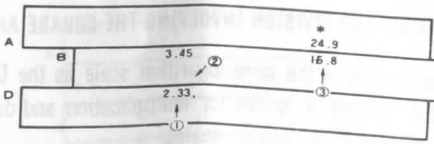
Ex. 5.5 $7.54 \times 1.76^2 = 23.4$



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



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



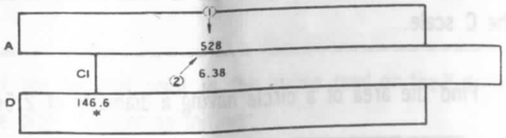
(Note) In multiplication or division involving squares, you can freely use either half section of the A or B scale to minimize the distance the slide must be moved.

FUNDAMENTAL OPERATION (8)
Multiplication and division involving the square roots of numbers.

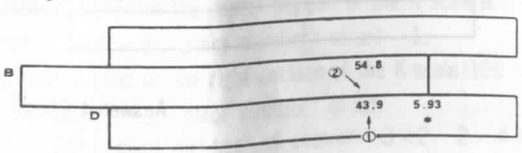
(1) The number whose square root is to be found should always be set on the two cycle scale (A or B), and the number whose square root is not to be found should be set on the one cycle scale (C, D or CI).
(2) Read the answer on the D scale.

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.

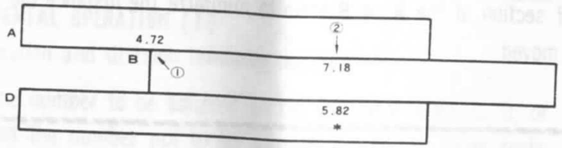
Ex. 5.8 $\sqrt{528} \times 6.38 = 146.6$



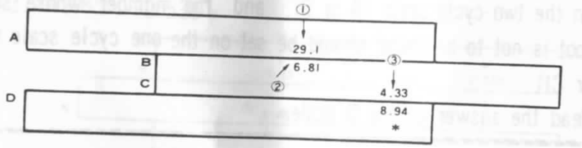
Ex. 5.9 $43.9 \div \sqrt{54.8} = 5.93$



Ex. 5.10 $\sqrt{4.72 \times 7.18} = 5.81$



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

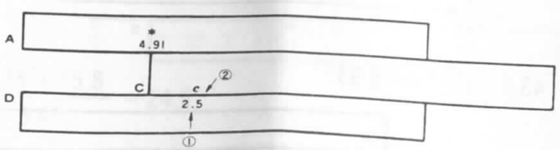


§ 3. THE AREA OF A CIRCLE

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 4.91cm^2

CHAPTER 6. CUBES AND CUBE ROOTS

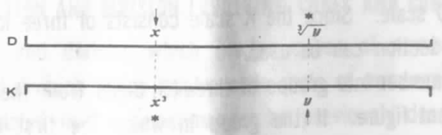
The K scale consists of three D scales connected together and reduced to exactly 1/3 of its original length. The K scale is called " three cycle scale" and is used with the C, D and CI scales to perform the calculations of the cubes and cube roots of numbers.

§ 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 ($1 \sim 10$), "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 ($10 \sim 100$), "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 ($100 \sim 1000$), "place number" of $x^3 = 3$ ("place number" of x).

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

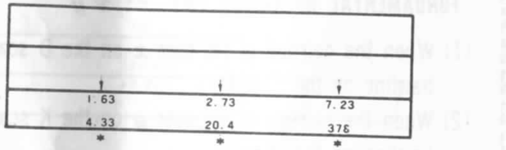
$0.163^3 = 0.00433$ ("place number" of answer $= 3 \times 0 - 2 = -2$)

$273^3 = 20400000$ ("place number" of answer $= 3\times 3 - 1 = 8$)
$= 2.04\times 10^7$

$0.0273^3 = 0.0000204$ ("place number" of answer $= 3\times(-1) - 1 = -4$)
$= 2.04\times 10^{-5}$

$72.3^3 = 378000$ ("place number" of answer $= 3\times 2 = 6$)
$= 3.78\times 10^5$

$0.00723^3 = 0.000000378$ ("place number" of answer $= 3\times(-2) = -6$)
$= 3.78\times 10^{-7}$



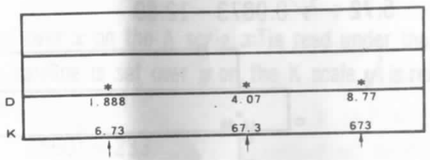
When the hairline is set over x on the K scale, $\sqrt[3]{x}$ is found under the hairline on the D scale. Since the K scale consists of three identical sections, only the correct section can be used.

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.

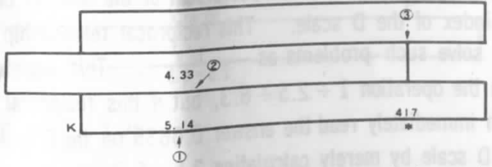
673 | 000 (right)	Place number of the answer...... 2 $\sqrt[3]{673000} = 87.7$
67 | 300 (center)	Place number of the answer...... 2 $\sqrt[3]{67300} = 40.7$
6 | 730 (left)	Place number of the answer...... 2 $\sqrt[3]{6730} = 18.88$
0.673 (right)	Place number of the answer...... 0 $\sqrt[3]{0.673} = 0.877$
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).

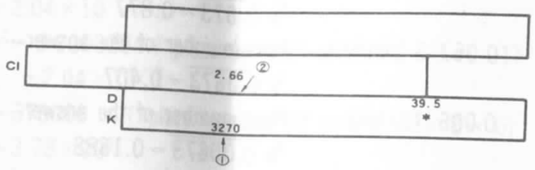
Ex. 6.3 $5.14\times 4.33^3 = 417$



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

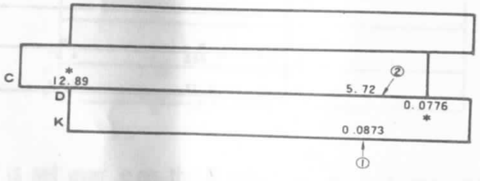
In $a^3 \div b$, first find a^3 and then perform division with two numbers using the C and D scales.

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



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

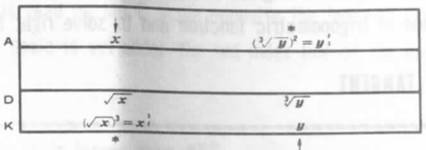
$5.72\div\sqrt[3]{0.0873}=12.89$



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.

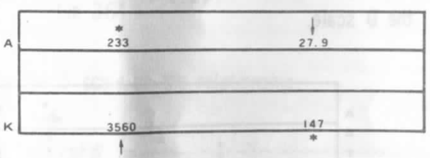
§ 3. $\frac{3}{2}$ POWER AND $\frac{2}{3}$ POWER

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

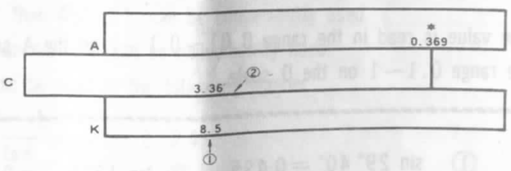


When the hairline is set over x on the A scale, $x^{\frac{3}{2}}$ is read under the hairline on the K scale. When the hairline is set over y on the K scale, $y^{\frac{2}{3}}$ is read under the hairline on the A scale.

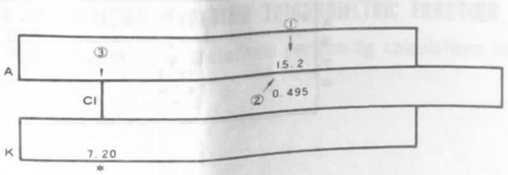
Ex. 6.6 $27.9^{\frac{3}{2}}=147$ $3560^{\frac{2}{3}}=233$



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 FUNCTION.

The S and T scales are equipped on the back of the slide. You will pull out the slide and reset it with the S and T scales on the front for the calculations of the sine and the tangent of angles. These scales also permit to calculate multiplication and division of trigonometric function and to solve right triangles.

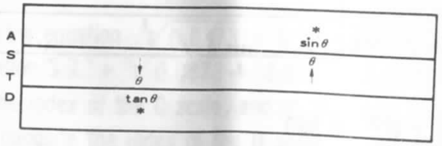
§ 1. SINE, TANGENT

FUNDAMENTAL OPERATION (10) $\sin\theta$, $\tan\theta$

When the slide rule is closed, and,

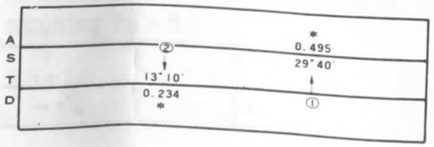
(1) When the hairline is set over θ on the S scale, $\sin\theta$ is read on the A scale.

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



The value is read in the range $0.01 \sim 0.1 \sim 1$ on the A scale and in the range $0.1 \sim 1$ on the D scale.

Ex. 7.1 ① $\sin 29°40' = 0.495$ ② $\tan 13°10' = 0.234$



(Note) 1

It is not always necessary to turn over the slide in finding the sine and the tangent. You can find $\sin\theta$ on the B scale opposite the index of the A scale when the angle θ on the S scale is set under the red index line of the back face. In the same manner $\tan\theta$ is read on the C scale opposite the index of the D scale when the angle θ on the T scale is set under the red index line of the back face.

(Note) 2

(1) How to find $\tan\theta$ when θ is larger than 45°

This can be performed by using the formula:

$$\tan\theta = \frac{1}{\tan(90° - \theta)}$$

For example, $\tan 54° = \frac{1}{\tan 36°} = 1.377$

(2) $\cos\theta$, $\cot\theta$

$\cos\theta$ can be found by using the S scale on the relationship:

$$\cos\theta = \sin(90° - \theta)$$

$\cot\theta$ can be found from either $\cot\theta = \frac{1}{\tan\theta}$ .... (1)

or $\cot\theta = \tan(90° - \theta)$ .... (2)

When θ is smaller than 45°, (1) can be conveniently used.

When θ is larger than 45° (2) can be conveniently used.

For example, they can be used in the following manner:

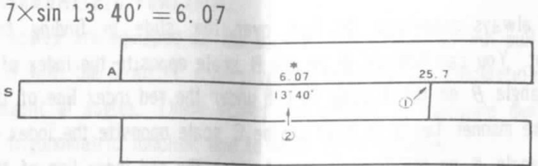
$$\cot 24° = \frac{1}{\tan 24°} = 2.24$$

$$\cot 63° = \tan(90° - 63°) = 0.510$$

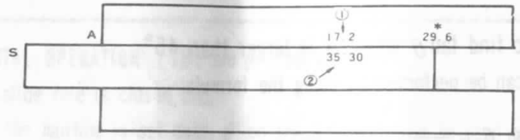
§ 2 MULTIPLICATION AND DIVISION INVOLVING TRIGONOMETRIC FUNCTION.

The following example illustrate the operations performing calculations involving trigonometric function.

Ex. 7.2 　25.7×sin 13° 40′ = 6. 07



Ex. 7.3 　17.2÷sin 35° 30′ = 29.6



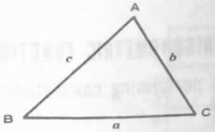
When multiplying tan θ, operate the rule in the same manner as in Ex. 7.2 and 7.3 but use the T scale instead of the S scale in conjunction with the D scale For multiplication and division involving cos θ, the answer can be found from the formula: $\cos\theta = \sin(90° - \theta)$ by using the S scale in conjunction with the A scale. Multiplication and division involving cot θ can be performed by converting

$$\cot\theta = \frac{1}{\tan\theta} \text{ and } a \times \cot\theta = a \div \tan\theta,\ \ a \div \cot\theta = a \times \tan\theta.$$

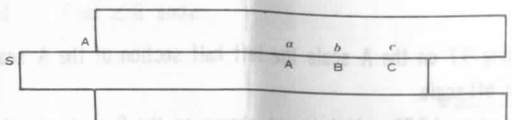
§ 3. SOLUTION OF TRIANGLES BY THE LAW OF SINES.

FUNDAMENTAL OPERATION (11) THE LAW OF SINES.

Given triangle A B C, a is the side corresponding to A, b is the side corresponding to B, and c to C. The law of sine is



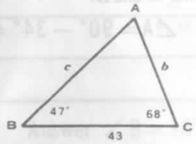
$$\frac{a}{\sin A} = \frac{b}{\sin B} = \frac{c}{\sin C}$$

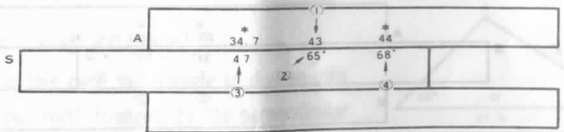


We can solve any triangle using the method solving proportional problems, when a side and its corresponding angle and another part are given.

Ex. 7.4 Find b and c.

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

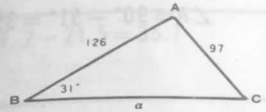


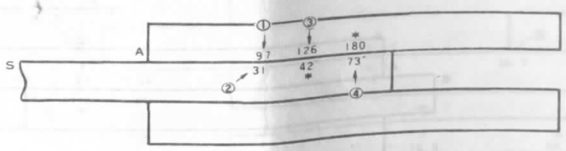


Answer $b = 34.7$, $c = 44$

Ex. 7.5 Find ∠A, ∠C and a.

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





Answer ∠A = 107°, ∠C = 42°. a = 180

(Note)

(1) When setting 97 on the A scale the left half section of the A scale is used to prevent an off-scale.

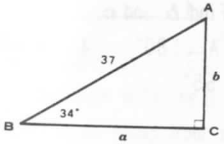
(2) ∠A is found as 107°, which is not shown on the S scale. In this case, its complimentary angle $180° - 107° = 73°$ is set on the S scale.

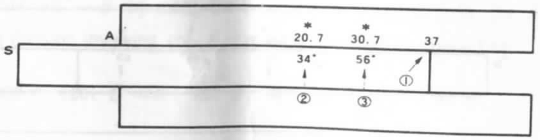
§ 4. SOLUTION OF RIGHT TRIANGLES

Right triangles can be also solved by using the law of sines.

Ex. 7.6 Find a and b.

$\angle A = 90° - 34° = 56°$

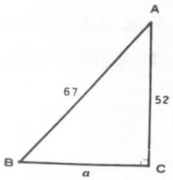


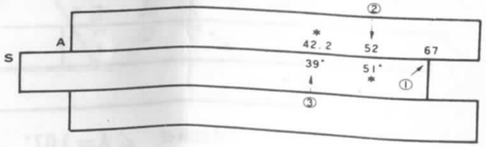


Answer $a = 30.7$, $b = 20.7$

Ex. 7.7 Find ∠B and a.

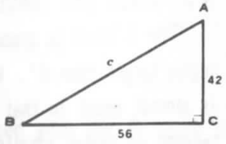
$\angle A = 90° - 51° = 39°$

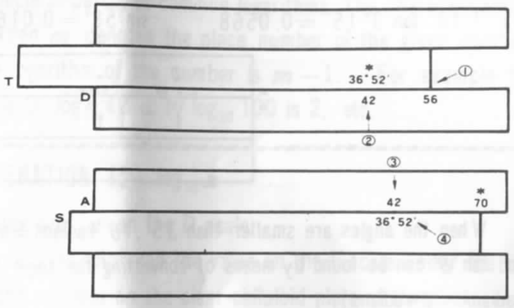




Answer $\angle B = 51°$; $a = 42.2$

Ex. 7.8 Find ∠B and c.

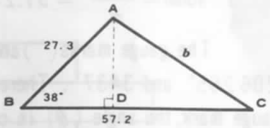


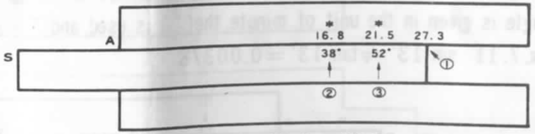


Answer $\angle B = 36° 52'$, $c = 70$

Ex. 7.9 Find ∠C and b.

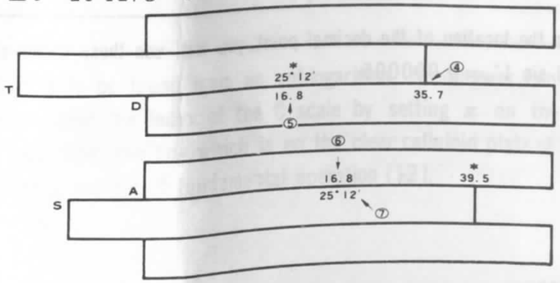
In this case, the triangle is divided into two right triangles by the perpendicular





AD = 16.8, BD = 21.5, CD = 57.2 − 21.5 = 35.7

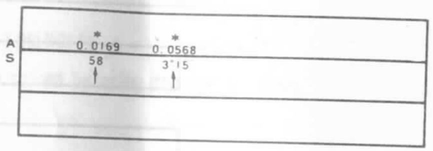
Answer $\angle C = 25°12'$, $b = 39.5$



§ 5. SINES AND TANGENT OF VERY SMALL ANGLES.

The S scale is graduated in angles larger than 35′, while the T scale covers angles larger than 6°. When the angle (θ) is smaller than 6°, the value of $\sin\theta$ is almost equal to that of $\tan\theta$, therefore, the S scale is used to find the value of tangent of angles smaller than 6°

Ex. 7.10 $\tan 3°15' = 0.0568$ $\sin 58' = 0.0169$

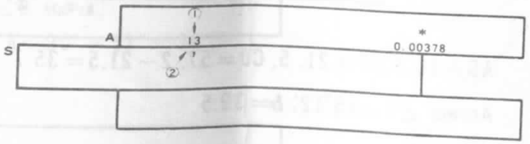


When the angles are smaller than 35′, θ radians $\fallingdotseq \sin\theta \fallingdotseq \tan\theta$, and $\sin\theta$ and $\tan\theta$ can be found by means of converting the angle (θ) to its equivalent radian (θ radians).

$$1 \text{ radian} = \frac{180°}{\pi} = 57.29° = 3437' = 206265''$$

The gauge marks(″) and(′) on the S scale indicate the above values of 206 265″ and 3437′. Therefore, by dividing the angle (θ) on the A scale by the gauge mark, the angle (θ) is converted to its equivalent (θ radians). When the angle is given in the unit of minute, the(′) is used, and(″) in the unit of second.

Ex. 7.11 $\sin 13' \fallingdotseq \tan 13' = 0.00378$



For the location of the decimal point, you will use these values $\sin 1' = 0.0003$ and $\sin 1'' = 0.000005$.

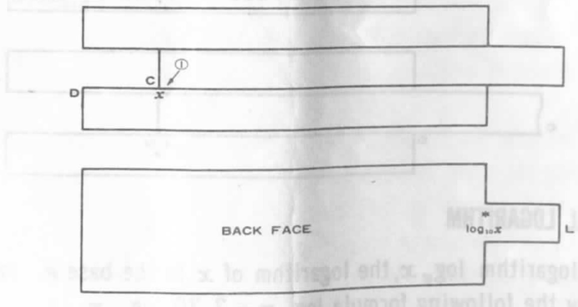
CHAPTER 8. LOGARITHMS AND EXPONENTS

§ 1. COMMON LOGARITHM

The L scale, which is a uniformly divided scale is used with the D scale to find the mantissa (the decimal parts) of common logarithms. The characteristic is mentally determined. When m denotes the place number of the given number, the characteristic of the logarithm of the number is $m-1$. For example the characteristic of $\log_{10} 1$ is 0, $\log_{10} 10$ is 1, $\log_{10} 100$ is 2, etc.

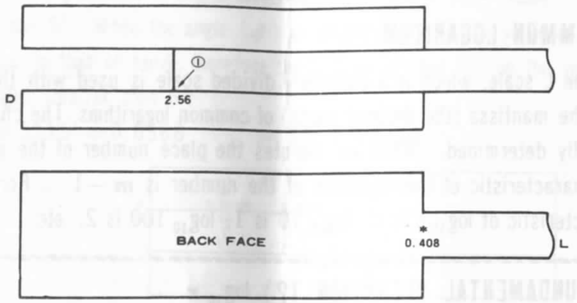
FUNDAMENTAL OPERATION(12) $\log_{10} x$

(1) Set the slide index over x on the D scale.
(2) Turn the slide rule over and read the value on the L scale under the red index line (the red line on the clear celluloid plate of the back face.)

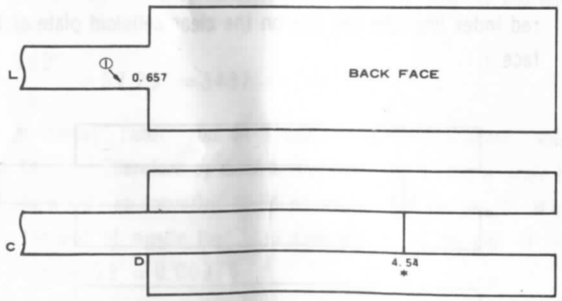


When a logarithm is to be found from an antilogarithm, the answer can be found on the D scale under the index of the C scale by setting x on the L scale over the red index line (the line which is on the clear celluloid plate of the back face) in the reverse manner of fundamental operation (12).

Ex. 8.1 $\log_{10} 2.56 = 0.408$ $\log_{10} 0.0256 = \bar{2}.408$



Ex. 8.2 $\text{antilog}_{10} 0.657 = 4.54$ $\text{antilog}_{10} 1.657 = 45.4$



§ 2. NATURAL LOGARITHM

Natural logarithm $\log_e x$, the logarithm of x to the base e, can be expressed by the following formula $\log_e x = 2.30 \log_{10} x$.
First find the common logarithms $\log_{10} x$ and then multiply it by 2.30.

§ 3. EXPONENT

Calculations of A^n are performed in a following manner.
The formula $\log_{10} A^n = (n \log_{10} A)$

(1) Calculate $\log_{10} A$ (Using the D and L scales)
(2) Calculate $n \times \log_{10} A$ (Using the D and CI scales) and
(3) Read the answer $\text{antilog}_{10} (n \times \log_{10} A)$ (Using the L and D scales)

Ex. 8.3 $16.8^{2.15} = 427$

$\log_{10} 16.8 = 1.225$ (D, L)

$1.225 \times 2.15 = 2.63$ (D, CI)

$\text{antilog}_{10} 2.63 = 427$ (L, D)

Ex. 8.4 $\sqrt[1.48]{0.763} = 0.833$

$\log_{10} 0.763 = \bar{1}.882 = -0.118$ (D, L)

$-0.118 \div 1.48 = -0.0798 = \bar{1}.9202$ (D, C)

$\text{antilog}_{10} (\bar{1}.920) = 0.833$ (L, D)

CARE AND ADJUSTMENT OF THE SLIDE RULE.

※ 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.

※ 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. The metal strip which is inset into the back of the rule insures the proper tension for constant smooth inter-action of slide and body. However, the inter-action of the slide and body, if necessary, can be adjusted to your own preference of tension.

If you feel the slide fits tightly, you will pull the silde out and hold the body members giving the slight outward bending effect to the metal strip.

It will give more openings to the sliding surfaces. If you feel the slide fits loose, you will pull the slide out and grip the rule to give the slight inward bending effect to the metal grip.

※ CAREFUL TREATMENT.

Do not expose the slide rule to direct sunlight for prolonged periods of time. In addition, never leave the rule near steam pipes or radiators. If the indicator glass is broken, replace it immediately. Otherwise, it will damage the rule. Not in use, place the slide rule back into the case provided with the rule.