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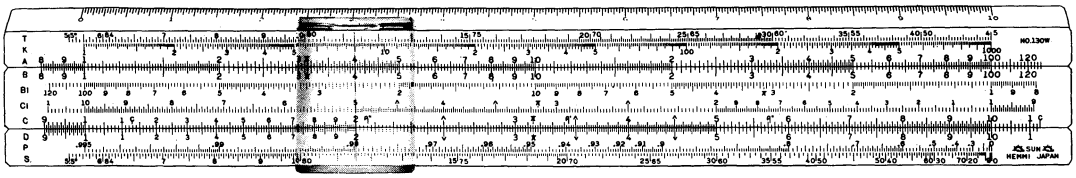
● Edition: IN-EO2-A

INSTRUCTION MANUAL FOR HEMMI 130W, 135, 136 SLIDE RULE

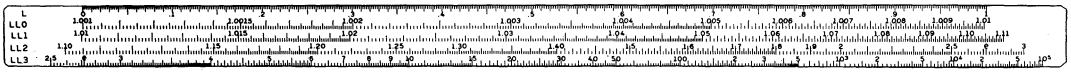
HEMMI SLIDE RULE CO., LTD.
TOKYO, JAPAN

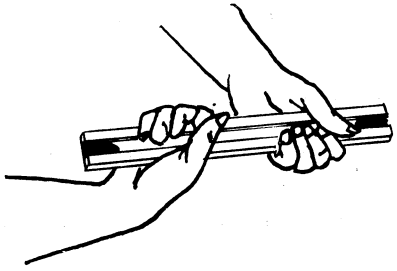
NO. 130W SLIDE RULE

FRONT FACE



BACK FACE OF SLIDE





※ 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.

INSTRUCTION MANUAL FOR HEMMI NO. 130W (25cm SINGLE TYPE) 135 (12.5cm SINGLE TYPE) 136 (15cm SINGLE TYPE) SLIDE RULE

This slide rule is an advanced "DARMSTADT" and has the following special features.

1. THE S AND T SCALES ARE ON THE BODY OF THE RULE.

The S and T scales for trigonometric functions are on the body of the rule and complementary angles are marked in red. Efficient calculation of trigonometric functions and multiplication and division involving trigonometric functions can be easily performed using these scales. At the same time, $\cos\theta$ and $\sqrt{1-x^2}$ calculations can be simplified by the use of the P scale.

2. THE BI SCALE IS EMPLOYED FOR SQUARE AND SQUARE ROOT CALCULATIONS.

The BI scale in addition to the A and B scales can be used to perform multiplication and division involving square and square root as easily as general multiplication and division.

3. EXPONENTIAL CALCULATIONS ARE POSSIBLE.

Single type slide rules are not generally equipped with LL scales, but this rule has LL scales on the back of the slide to simplify exponential calculations.

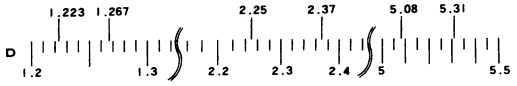
CHAPTER 1. READING THE SCALES.

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.130W 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 –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 2 3 7 (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 2 3 7 (two three seven). In 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 labeled 1 and 10 respectively are called the "fixed index lines." The corresponding lines on the C scale are called the "slide index lines".

CARE AND ADJUSTMENT OF THE SLIDE RULE.

※WHEN THE SLIDE RULE BECOMES DIRTY;

Remove the dirt with a good soft cloth dipped in vegetable oil and then use another piece of dry and soft cloth to remove remaining oil completely. The use of sandpaper, cleanser, benzene or other alcoholic solution is strictly prohibited.

※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.

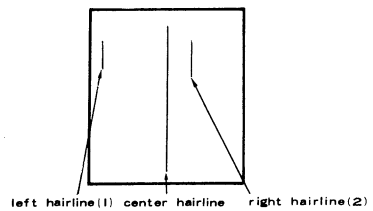
If you feel the slide fits tightly, you will pull the silde out and hold the body members giving the slight outward bending effect to the metal strip.

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.

HOW TO USE THE THREE HAIRLINES ON THE INDICATOR.

The indicator of this slide rule has three hairlines, a center line and two side lines. The lines are used in the following calculation.

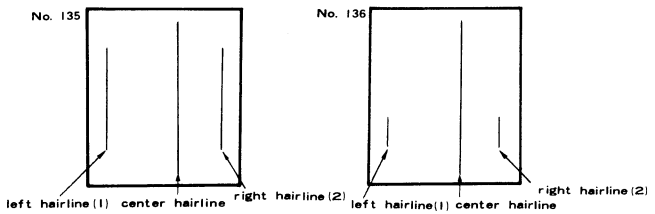
(1) No. 130W



(a) When the center hairline is set over a (diameter) on the D scale, $\frac{\pi a^2}{4}$ (area of a circle) is found on the A scale under line 1.

(b) Setting line 2 over 100 (right index) on the A scale, 746 is found under line 1. This shows the 1 HP = 0.746 kW relationship. Therefore, setting HP on the right and kW on the left of the hairline permits to perform mutual conversion merely by indicator operation.

(2) No. 136 and No. 135



(a) Setting the line 2 over a on the D scale, $\frac{\pi a^2}{4}$ is found under the hairline on the A scale.

(b) Setting the line 2 over 1 (right index), 746 is found. Accordingly, mutual conversion HP ↔ kW can be performed.

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:

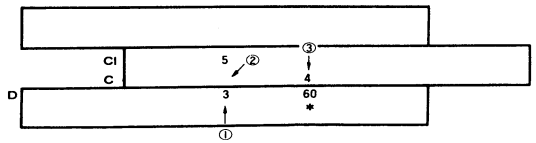
Slide Operation — Moving the slide to the position of the arrow with respect to the body of the rule.

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.

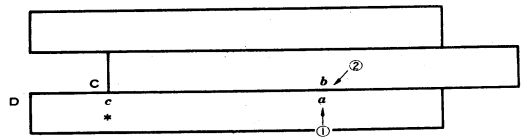
CHAPTER 2. MULTIPLICATION AND DIVISION. (1)

§ 1. DIVISION

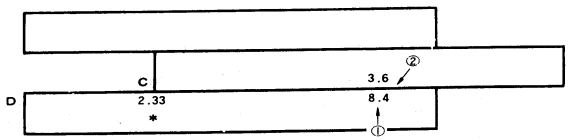
FUNDAMENTAL OPERATION (1) $a \div b = c$

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

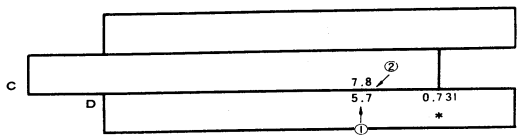
(2) Move b on the C scale under the hairline,
read the answer c on the D scale opposite the index of the C scale.



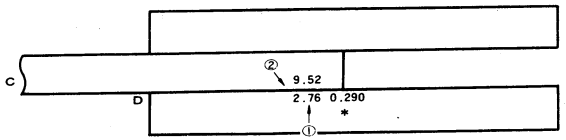
Ex. 2.1 $8.4 \div 3.6 = 2.33$



Ex. 2.2 $5.7 \div 7.8 = 0.731$

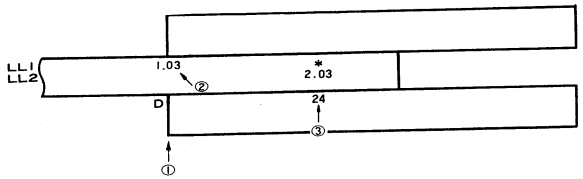


Ex. 2.3 $2.76 \div 9.52 = 0.290$



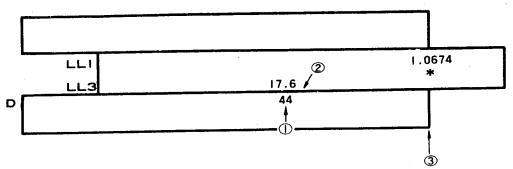
Find $\frac{1}{1.627} = 0.615$ as the answer (The C and CI scales are used)

Ex. 8.10 $1.03^{24} = 2.03$



In calculating $1.03^{24} = 2.03$ since 24 is larger than 10, 1.03^{24} is rewritten to $1.03^{2.4 \times 10} = (1.03^{2.4})^{10}$ and read the answer 2.03 on the LL2 scale opposite the position you can read the answer of $1.03^{2.4}$ 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.

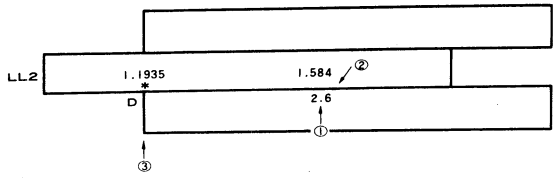
Ex. 8.11 $17.6^{\frac{1}{44}} = 1.0674$



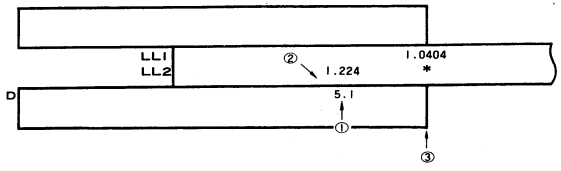
In calculating $A^{\frac{1}{x}}$, if x is a number between 1 and 10, the LL scale on which the answer appears will be determined as follows.

(1) If the slide protrudes to the left, the answer is found on the LL scale having the same number as the LL scale on which A is set.
(2) If the slide protrudes to the right, the answer is found on the LL scale 1 number lower than the LL scale on which A is set.

Ex. 8.7 $1.584^{\frac{1}{2.6}} = 1.1935$



Ex. 8.8 $1.224^{\frac{1}{5.1}} = 1.0404$



To calculate $A^{-\frac{1}{x}}$, first calculate $A^{\frac{1}{x}}$ and then find its reciprocal $\frac{1}{A^{\frac{1}{x}}}$ as the answer.

Ex. 8.9 $0.165^{\frac{1}{3.7}} = 0.615$

This problem is rewritten to $\frac{1}{\left(\frac{1}{0.165}\right)^{\frac{1}{3.7}}}$ and then calculated in the following manner.

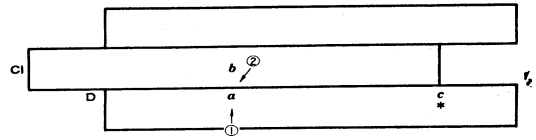
Find $\frac{1}{0.165} = 6.06$ (The C and CI scales are used)

Find $6.06^{\frac{1}{3.7}} = 1.627$ (The LL and D scales are used)

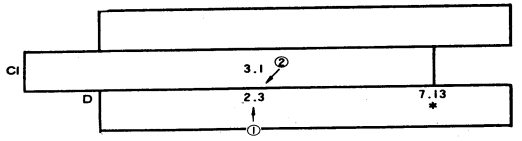
§ 2. MULTIPLICATION

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

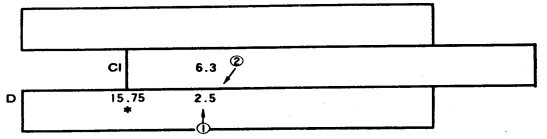
(1) Set the hairline over a on the D scale,
(2) Move b on the CI scale under the hairline,
read the answer c on the D scale opposite the index of the CI scale.



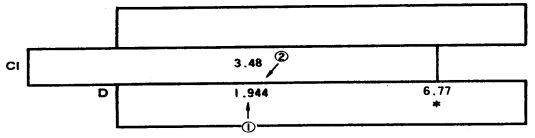
Ex. 2.4 $2.3 \times 3.1 = 7.13$



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

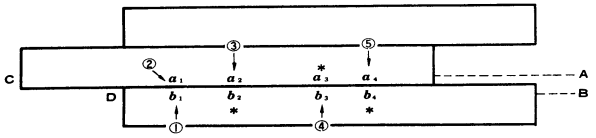
§ 1. PROPORTION

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.



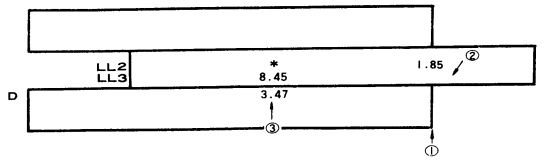
As illustrated in the above figure, when a_1 on the C scale is set opposite b_1 on the D scale the unknown quantities are all found on the C or D scales by moving the hairline.

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)

Ex. 8.5 $1.85^{3.47} = 8.45$



In calculating A^{-x}, find A^x first, and then calculate the reciprocal $\frac{1}{A^x}$.

Ex. 8.6 $0.872^{2.6} = 0.700$

This problem can be converted to $\frac{1}{(\frac{1}{0.872})^{2.6}}$ and calculated in the following manner.

(1) Find $\frac{1}{0.872} = 1.147$ (The C and CI scales are used)

(2) Find $1.147^{2.6} = 1.428$ (The LL and D scales are used)

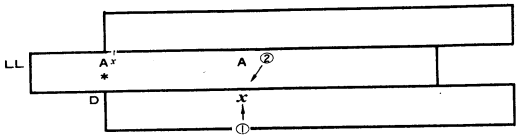
(3) Find $\frac{1}{1.428} = 0.700$ (The C and CI scales are used)

FUNDAMENTAL OPERATION (15) $A^{\frac{1}{x}}$

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

(2) Move A on the LL scale under the hairline.

Read the answer on the LL scale opposite the index of the D scale.



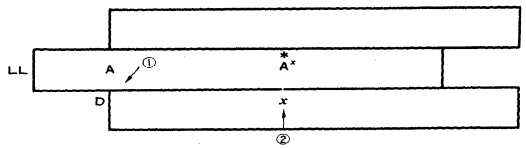
In calculating e^{-x}, find e^{x} first, and then calculate the reciprocal $\frac{1}{e^{x}}$

§ 3. EXPONENT

FUNDAMENTAL OPERATION (14) A^{x}

(1) Set A on the LL scale opposite the index of the D scale.

(2) Set the hairline over x on the D scale.
Read the answer on the LL scale under the hairline.

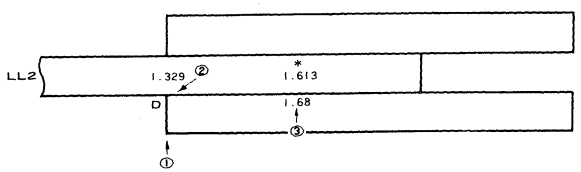


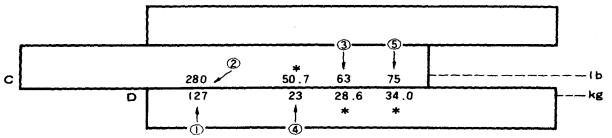
Since the slide rule has four LL scales, you must find on what LL scale the answer will appear. In the calculation of A^{x}, if x is a number between 1~10, the LL scale on which the answer appears will be determined as follows.

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

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

Ex. 8.4 $1.329^{1.68} = 1.613$





(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.

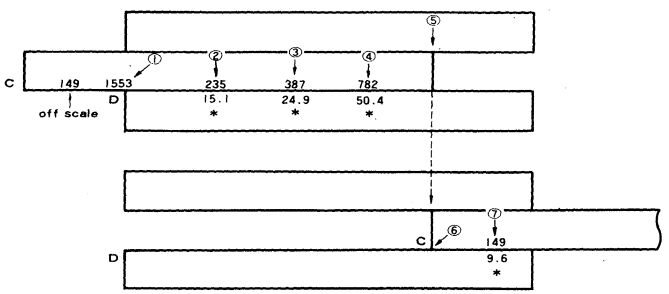
Ex. 3.2 Percentages.

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".

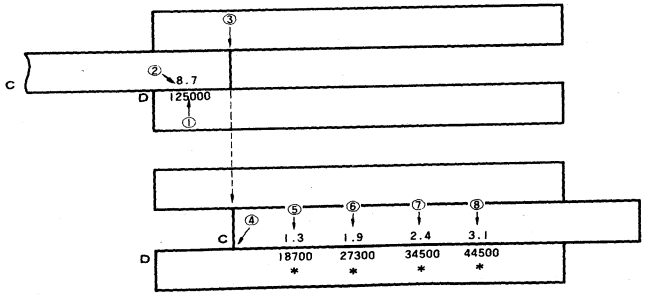


Ex. 3.3 Proportional Distribution.
Distribute a sum of $125,000 in proportion to each rate specified below.

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.

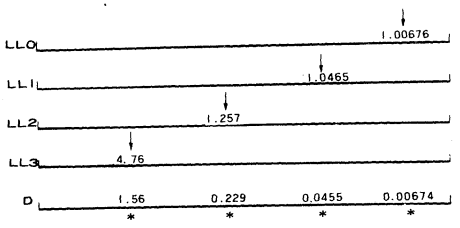
§ 2. NATURAL LOGARITHMS

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 10^5. The LL scales are read with the location of the decimal point and these numbers either smaller than 1.001 or larger than 10^5 can not be direct obtained on the log log scales.

(a) HOW TO FIND NATURAL LOGARITHMS

When the hairline is set over x on the LL scale, $\log_e x$ is read on the D scale.

Ex. 8.2 $\log_e 4.76 = 1.56$ $\log_e 1.257 = 0.229$
$\log_e 1.0465 = 0.0455$ $\log_e 1.00676 = 0.00674$

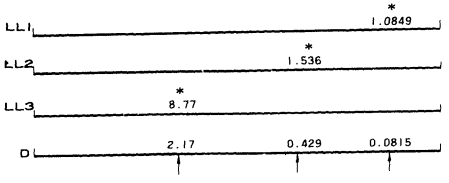


The relationship between the place number of natural logarithms and the number (0, 1, 2, 3,) of the LL scale can be seen from the above illustration.
(Note) The No. 135 and No. 136 have no LLO scale.

(b) HOW TO FIND e^x

e^x is found on the LL scale by moving the hairline over x on the D scale.

Ex. 8.3 $e^{2.17} = 8.77$ $e^{0.429} = 1.536$ $e^{0.0815} = 1.0849$



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 $m-1$.

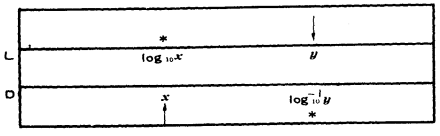
(Note) The No. 136 slide rule has the L scale on the body of the rule.

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

Remove and place the slide with the L scale on the front and close the slide rule.

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

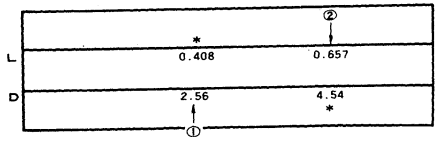
(2) When the hairline is set over the mantissa of y on the L scale, the significant digits of $\text{antilog}_{10} y$ is read under the hairline on the D scale.

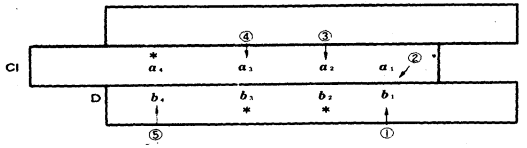


Ex. 8.1 (1) $\log_{10} 2.56 = 0.408$ (2) $\text{antilog}_{10} 0.657 = 4.54$

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

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



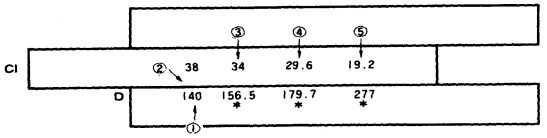


When a_1 on the CI scale is set opposite b_1 on the D scale, the product of $a_1 \times b_1$ is equal to that of $a_2 \times b_2$, that of $a_3 \times b_3$, and also equal to that of $a_4 \times b_4$. Therefore, b_2, b_3, a can be found by merely moving the hairline of the indicator.

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.

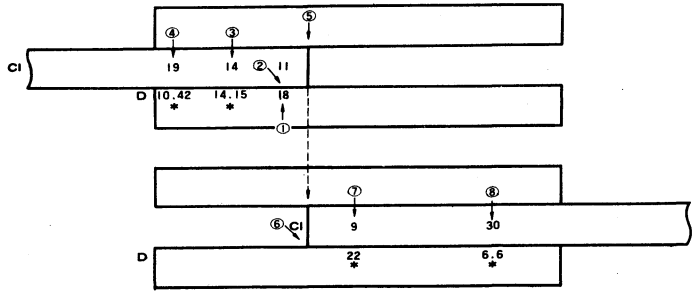
Speed	38 km	34	29.6	19.2
Time required	140 min.	(156.5)	(179.7)	(277)



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.

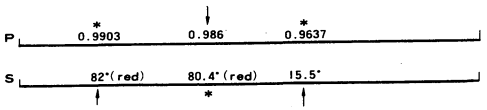
Ex. 3.5 A job which requires 11 men 18 days to complete. How many days will it take if the job is done by 9 men, 30 men, 19 men and 14 men?

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



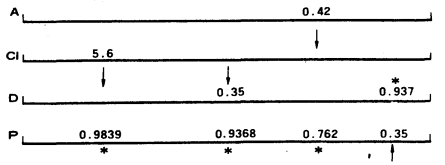
In this exercise 9 and 30 run "off scale". In this case it is more efficient to calculate the figures (19 and 14) which are inside the rule before interchanging the indices.

Ex. 7.15 $\cos 15.5° = 0.9637$ $\sin 82° = 0.9903$
$\arcsin 0.986 = 80.4°$



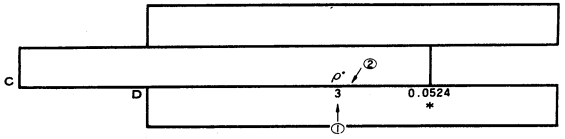
As the above examples show, $\cos\theta$ (when θ is smaller than 45°) and $\sin\theta$ (when θ is greater than 45°) can be more accurately found using the P scale than using the D scale.

Ex. 7.16 $\sqrt{1-0.35^2} = 0.9368$
$\sqrt{1-0.42} = 0.762$ $\sqrt{1-\frac{1}{5.6^2}} = 0.9839$

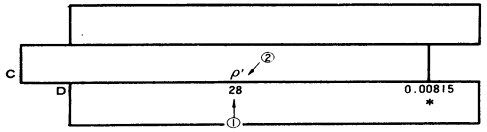


mark, the angle (θ) is converted to its equivalent (θ radians). For the location of the decimal point you will use these values sin 1' = 0.0003 and sin 1" = 0.000005.

Ex. 7.13 sin 3° = 0.0524



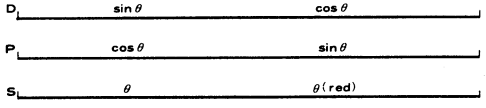
Ex. 7.14 tan 28' = 0.00815



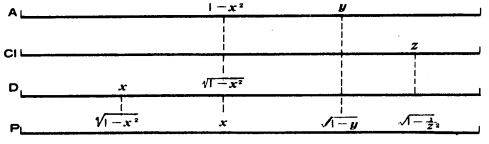
§ 6. HOW TO USE THE P SCALE

This slide rule is equipped with the P. scale. This scale provides cos θ corresponding with 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 with the S scale.



(2) Corresponding with the A, D and CI 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) $(a\times b)\times c = d$, $(a\div b)\times c = d$

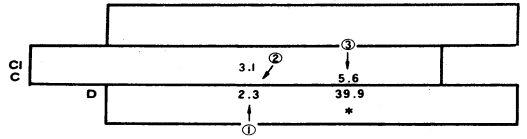
For additional multiplication to follow the calculation $(a\times b)$ or $(a\div b)$, set the hairline over c on the C scale and read the answer d on the D scale under the hairline.

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

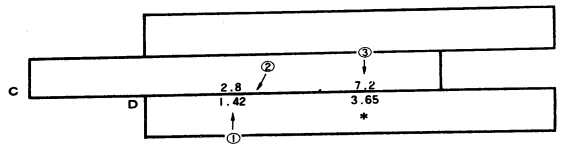
For additional division to follow the calculation $(a\div b)$ or $(a\times b)$, set the hairline over c on the CI scale and read the answer d on the D scale under the hairline.

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.

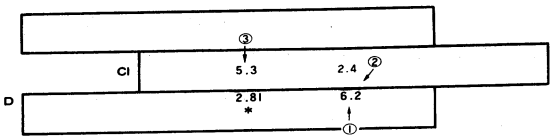
Ex. 4.1 $2.3\times 3.1\times 5.6 = 39.9$



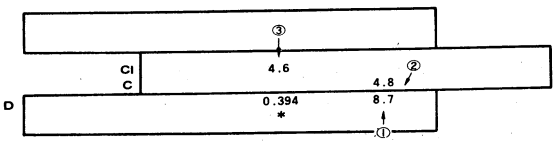
Ex. 4.2 $1.42 \div 2.8 \times 7.2 = 3.65$



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



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



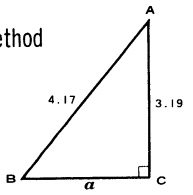
§ 2. OFF SCALE

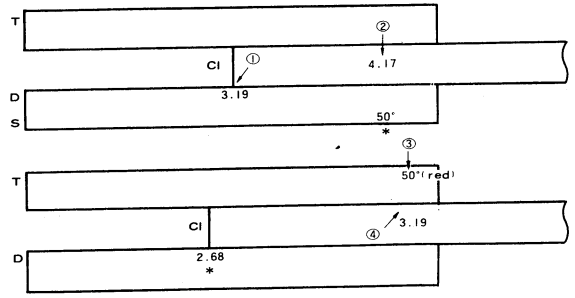
When multiplications and divisions of three numbers are performed by an indicator operation, a position on the C or CI scale over which the hairline is to be set may occasionally run off scale. In this case you once set the hairline over the position on which you read the answer of the first two numbers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

Ex. 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 $\angle B = 50°$.

Answer 2.68.





§ 5. SINE AND TANGENT OF VERY SMALL ANGLES

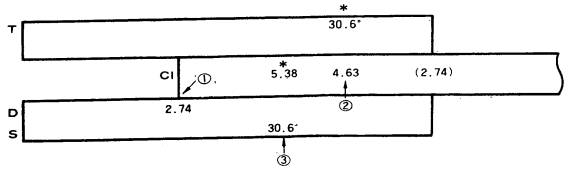
The S and T scales are graduated in angle larger than 5.5.° When the angle (θ) is very small and smaller than 5.5,° θ radians $\fallingdotseq \sin\theta \fallingdotseq \tan\theta$, and $\sin\theta$ and $\tan\theta$ can be found by means of converting the angle (θ) to its radian equivalents (θ radians).

$$1 \text{ radian} = \frac{180^\circ}{\pi} = 57.29^\circ \ldots\ldots \rho^\circ$$

$$= \frac{180 \times 60'}{\pi} = 3437.75' \ldots\ldots \rho'$$

$$= \frac{180 \times 60 \times 60''}{\pi} = 206265'' \ldots\ldots \rho''$$

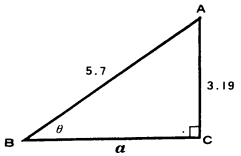
The gauge marks ρ°, ρ' and ρ'' on the C scale of the No. 130W indicate the above values. Therefore, by dividing the angle (θ) on the D scale by the gauge

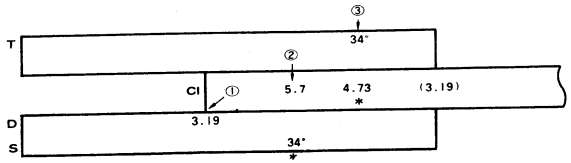


Answer $c = 5.38$, $\theta = 30.6°$

(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 a and θ.

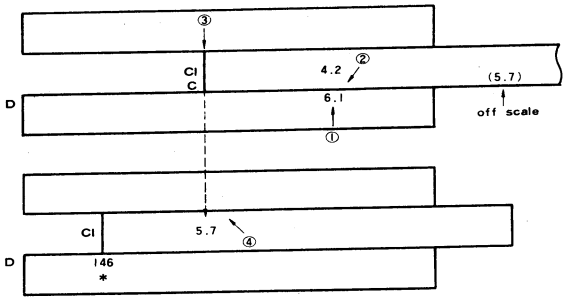




Answer $a = 4.73$, $\theta = 34°$

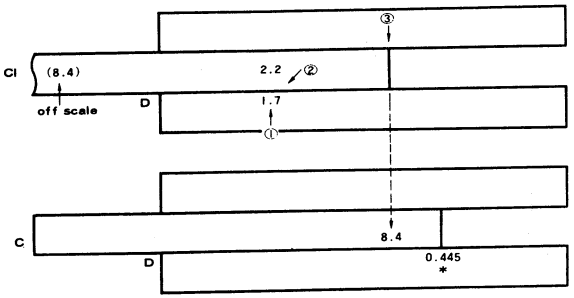
(Note) Calculating $\sqrt{5.7^2 - 3.19^2} = 4.73$ can be performed in the same manner as illustrated above.

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

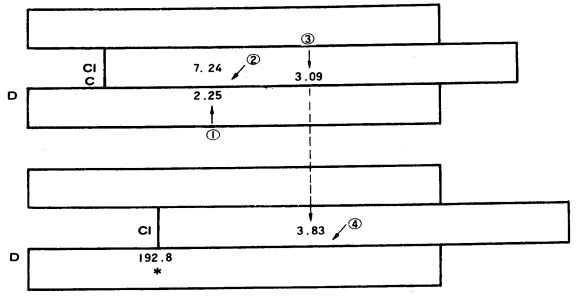


§ 3. MULTIPLICATION AND DIVISION OF MORE THAN FOUR NUMBERS.

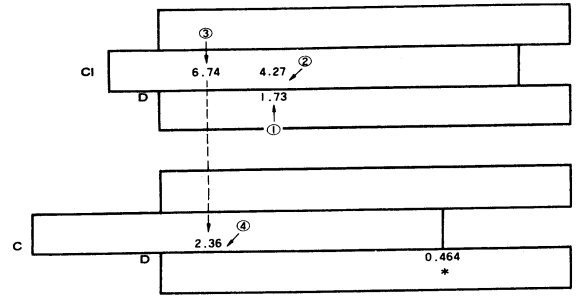
When the multiplication and division of three numbers, such as $a \times b \times c = d$ is completed, the answer (d) is found under the hairline on the D scale.

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



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

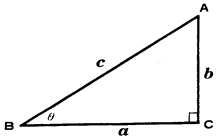
Answer $\angle A = 107°$, $\angle C = 42°$, $a = 180$

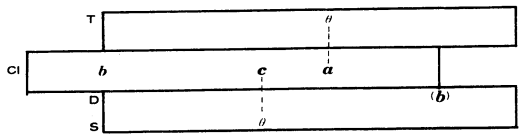
Since 126 on the C scale runs off scale, interchanging the indices should be performed as illustrated. $\angle A$ is found as 107°, which is not shown on the S scale. In this case, the complementary angle $180° - 107° = 73°$ is set on the S scale basing on the relation $\sin\theta = \sin(180° - \theta)$.

§ 4. SOLUTION OF RIGHT TRIANGLES

FUNDAMENTAL OPERATION (12) RIGHT TRIANGLES

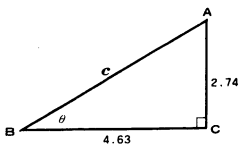
The right triangle is solved by setting the slide as illustrated in the figure below.

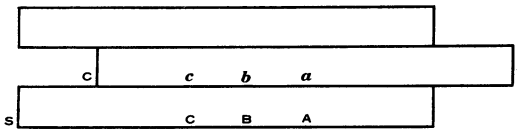




This method is used to solve right triangles, vector calculations, complex numbers, etc.

Ex. 7.10 Find c and θ.



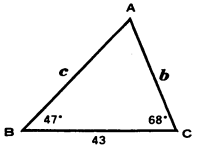


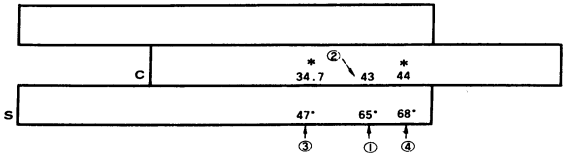
We can solve any triangle using the method solving proportional problems, when a side and its corresponding angle and another part are given.

Ex. 7.8 Find b and c.

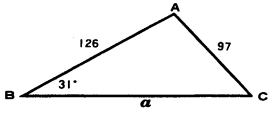
$\angle A = 180° - (47° + 68°)$
$= 65°$

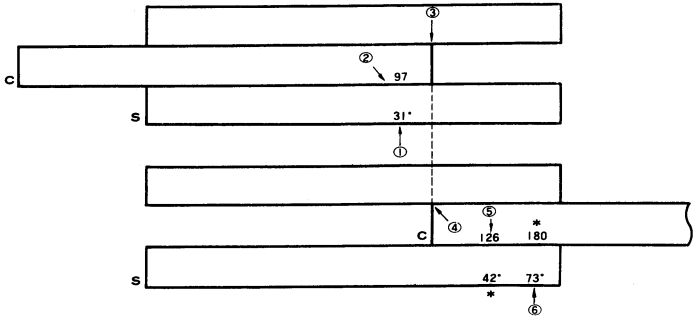
Answer: $b = 34.7$, $c = 44.0$



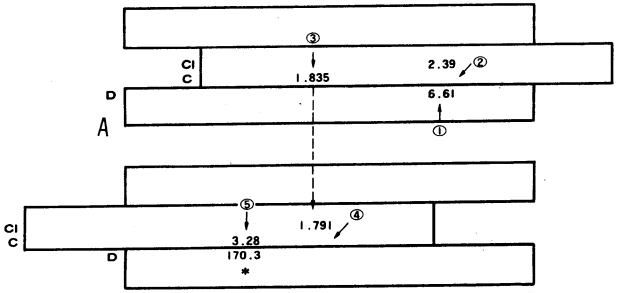


Ex. 7.9 Find $\angle A$, $\angle C$ and a.

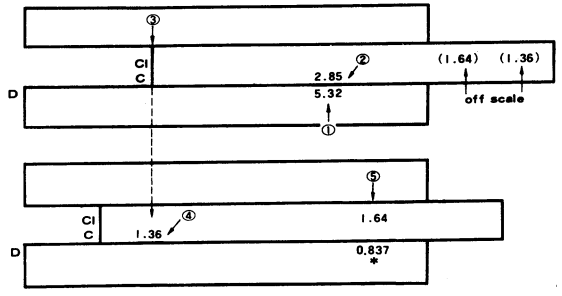




Ex. 4.9 $6.61 \times 2.39 \times 1.835 \times 1.791 \times 3.28 = 170.3$



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



§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

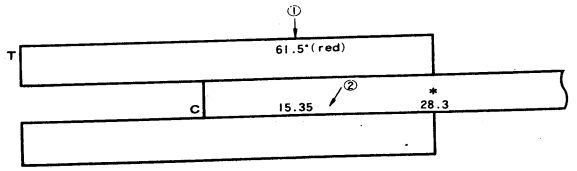
Ex. $\dfrac{285 \times 0.00875}{13.75} = 0.1814$

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.

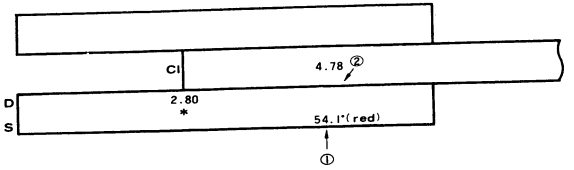
$\dfrac{285 \times 0.00875}{13.75}$ is rewritten to $\dfrac{2.85 \times 0.875}{13.75}$ and approximated to $\dfrac{3 \times 0.9}{10} = 0.27$.

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

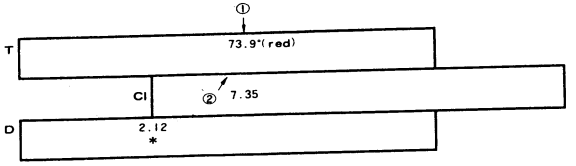
Ex. 7.5 $15.35 \times \tan 61.5^\circ = 28.3$



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



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

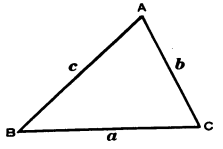


§3. SOLUTIONS OF TRIANGLES

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

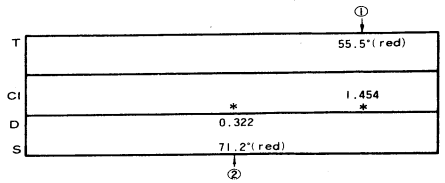
$$\frac{a}{\sin A} = \frac{b}{\sin B} = \frac{c}{\sin C}$$



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 CI scale.

When finding the cosine, the red numbers of the S scale are used basing on the relation $\cos\theta = \sin(90° - \theta)$ and read the answer on the D scale.

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

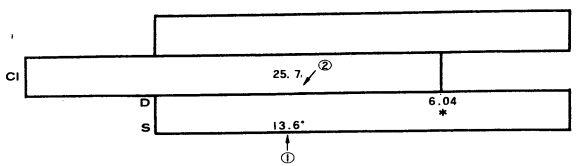


cot θ, sec θ and cosec θ are found to reciprocal of tan θ, cos θ and sin θ, respectively. Since a value on the hairline the CI scale is the reciprocal of the value under the hairline on the C scale, this relationship can be conveniently used.

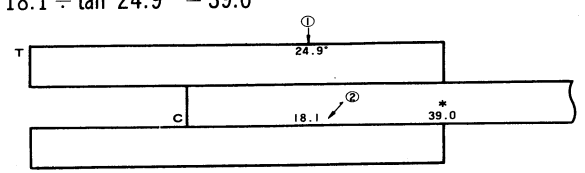
§2. MULTIPLICATION AND DIVISION INVOLVING TRIGONOMETRIC FUNCTIONS

The S and T scales, in conjunction with the C and CI scales, permit multiplication and division involving trigonometric functions.

Ex. 7.3 $25.7 \times \sin 13.6° = 6.04$



Ex. 7.4 $18.1 \div \tan 24.9° = 39.0$



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

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

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 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.

(Note) On the No. 136 slide rule, the SIN scale on the side of the rule corresponds to the S scale and the tg scale corresponds to the T scale.

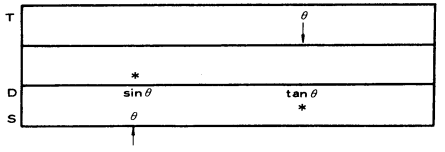
§1. SINE, TANGENT, COSINE

FUNDAMENTAL OPERATION (10) Sin θ, Tan θ

When the slide is closed, and

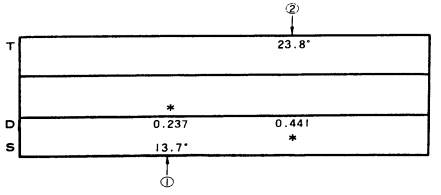
(1) When the hairline is set over θ on the S scale, sin θ is read under the hairline on the D scale.

(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.

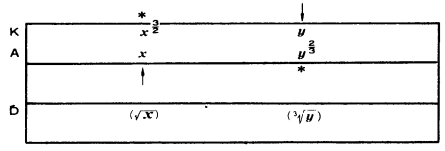
Ex. 7.1 (i) sin 13.7°= 0.237 (ii) tan 23.8°= 0.441



When the T scale is read from left to right using the black numbers angles

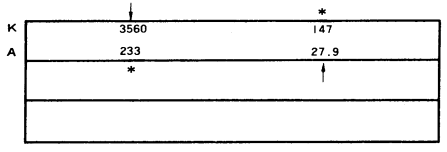
§ 3. $\frac{3}{2}$ POWERS AND $\frac{2}{3}$ POWERS

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

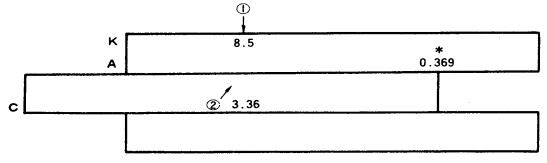


When the hairline is set over x on the A scale, $x^{\frac{3}{2}}$ is read under the hairline on the K scale. When the hairline is set over y on the K scale, $y^{\frac{2}{3}}$ is read under the hairline on the A scale.

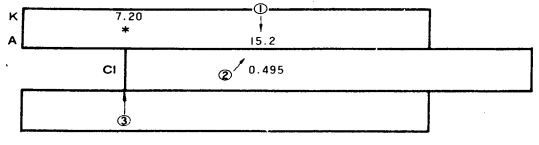
Ex. 6.6 $27.9^{\frac{3}{2}} = 147$ $3560^{\frac{2}{3}} = 233$



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 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.

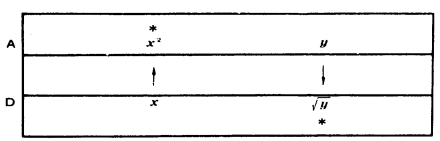
§ 1. SQUARES AND SQUARE ROOTS

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, B and BI scales are called "two cycyle 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 $2 \times 3 - 1 = 5$

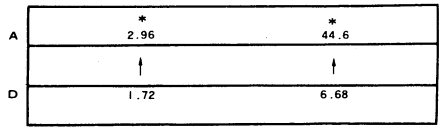
$17.2^2 = 296$ ····· The place number of 17.2 is 2. Hence, the place number in the answer is $2 \times 2 - 1 = 3$

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

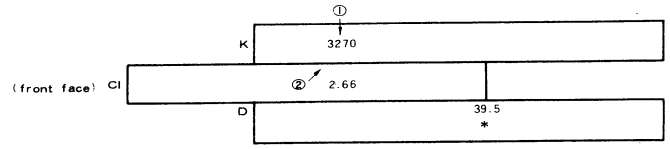
Ex. 5.2 $668^2 = 446000$ ····· The place number of 668 is 3
$= 4.46 \times 10^5$ Hence, the place number in the answer is $2 \times 3 = 6$

$0.668^2 = 0.446$ ····· 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 $2 \times (-1) = -2$

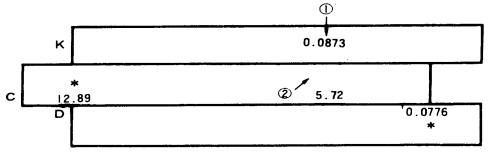


Ex. 6.4 $\sqrt[3]{3270} \times 2.66 = 39.5$



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

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



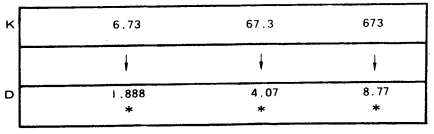
In Ex. 6.5, the equation $\sqrt[3]{0.0873} \div 5.72 = 0.0776$ is the reciprocal of the second equation $5.72 \div \sqrt[3]{0.0873} = 12.89$, and 0.0776 is read on the D scale opposite the index of the C scale, and at the same time, 12.89 is read on the C scale opposite the index of the D scale. From 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 $\frac{1}{2.5 \cdot 6.3}$ 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.

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
$\sqrt[3]{0.00673} = 0.1888$

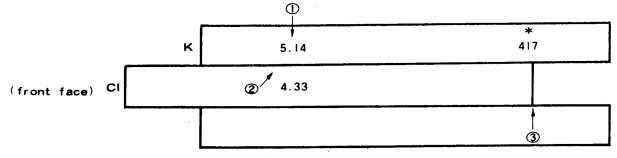
0.000 | 673 (right) Place number of the answer··· −1
$\sqrt[3]{0.000673} = 0.0877$



§ 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.

When the hairline is set over x on the A scale, $\sqrt{x}$ appears under the hairline on the D scale. Since the 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 if the number. It 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 $\sqrt{2180} = 46.7$

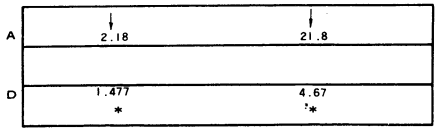
2 | 18 (left half) Place number·····2 $\sqrt{218} = 14.77$

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 OF NUMBERS.

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

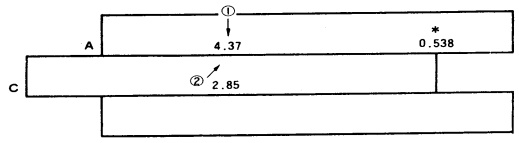
FUNDAMENTAL OPERATION (7)

MULTIPLICATION AND DIVISION INVOLVING SQUARES

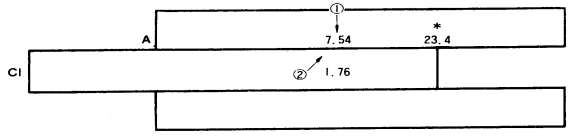
(1) Set the number to be squared on the one cycle scale (C, D, or CI) and the number not to be squared on the two cycle scale (A, B or BI).

(2) Read the answer on the A scale.

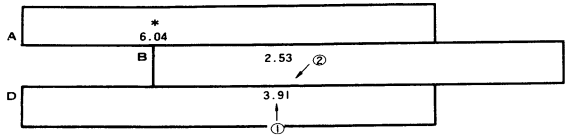
Ex. 5.4 $4.37 \div 2.85^2 = 0.538$



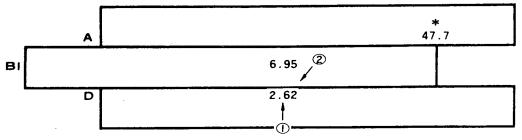
Ex. 5.5 $7.54 \times 1.76^2 = 23.4$



Ex. 5.6 $3.91^2 \div 2.53 = 6.04$



Ex. 5.7 $2.62^2 \times 6.95 = 47.7$

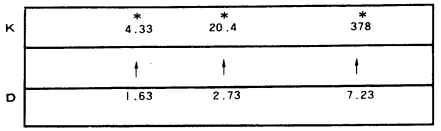


$273^3 = 20400000$ ("place number" of answer $= 3 \times 3 - 1 = 8$)
$= 2.04 \times 10^7$

$0.0273^3 = 0.0000204$ ("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
$\sqrt[3]{6730} = 18.88$

CHAPTER 6. CUBES AND CUBE ROOTS

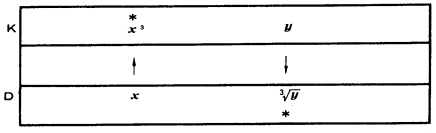
The K scale consists of three D scales connected together and reduced to exactly 1/3 of its original length. The K scale is called " three cycle scale" and is used with the C, D and CI scales to perform the calculations of the cubes and cube roots of numbers.

§ 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) $- 2$.

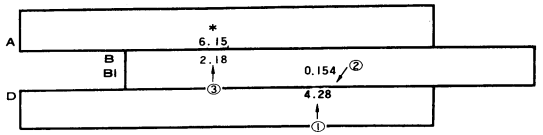
b. When the answer is read on the center section of the K scale (10 ~ 100), "place number" of $x^3 = 3$ ("place number" of x) $- 1$.

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).

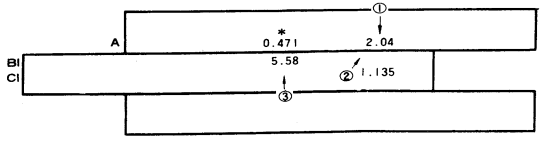
Ex. 6.1 $16.3^3 = 4330$ ("place number" of answer $= 3 \times 2 - 2 = 4$)

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

Ex. 5.8 $4.28^2 \times 0.154 \times 2.18 = 6.15$



Ex. 5.9 $\dfrac{2.04 \times 1.135^2}{5.58} = 0.471$



If the hairline is set over 2.04 on the left half of the A scale, the slide will extremely protrude to left from the slide rule when setting 1.135 on the CI scale under the hairline. Therefore, set the hairline over 2.04 on the right half of the A scale disregarding the place number of the reading. In multiplication or division involving squares you can freely use either half section of the A, B or BI scale to minimize the distance the slide must be moved.

FUNDAMENTAL OPERATION (8)

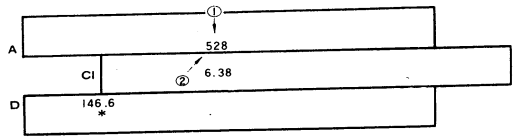
MULTIPLICATION AND DIVISION INVOLVING SQUARE ROOTS.

(1) Set the number to be square rooted on the two cycle scales (A, B or BI) and the number not to be square rooted on the one cycle scales (C, D or CI).

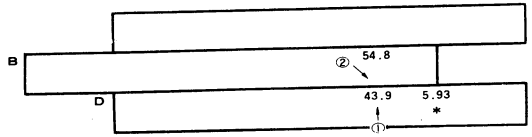
(2) Read the answer on the D scale.

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

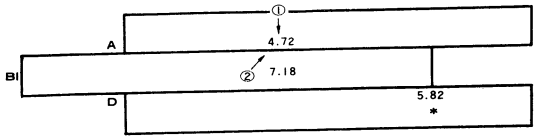
Ex. 5.10 $\sqrt{528} \times 6.38 = 146.6$



Ex. 5.11 $43.9 \div \sqrt{54.8} = 5.93$

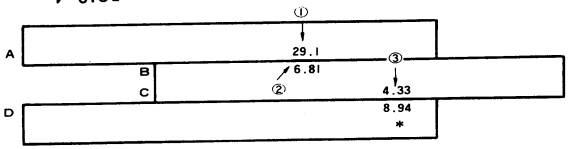


Ex. 5.12 $\sqrt{4.72 \times 7.18} = 5.82$

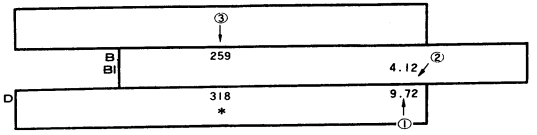


In Ex. 5.12., $\sqrt{4.72 \times 7.18}$ can be broken down into the form $\sqrt{4.72} \times \sqrt{7.18}$. Therefore, both numbers are set on the two cycle scales.

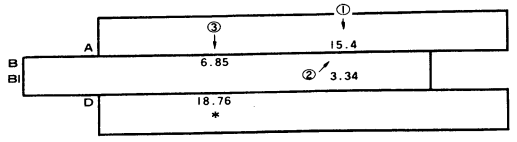
Ex. 5.13 $\dfrac{\sqrt{29.1} \times 4.33}{\sqrt{6.81}} = 8.94$



Ex. 5.14 $9.72 \times \sqrt{4.12} \times \sqrt{259} = 318$



Ex. 5.15 $\sqrt{15.4 \times 3.34 \times 6.85} = 18.76$

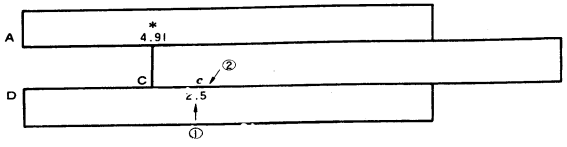


§ 3. THE AREA OF A CIRCLE

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.

(Note) The No. 135 has no gauge mark "c".

Ex. 5.16 Find the area of a circle having a diameter of 2.5cm.



Answer 4.91 cm^2