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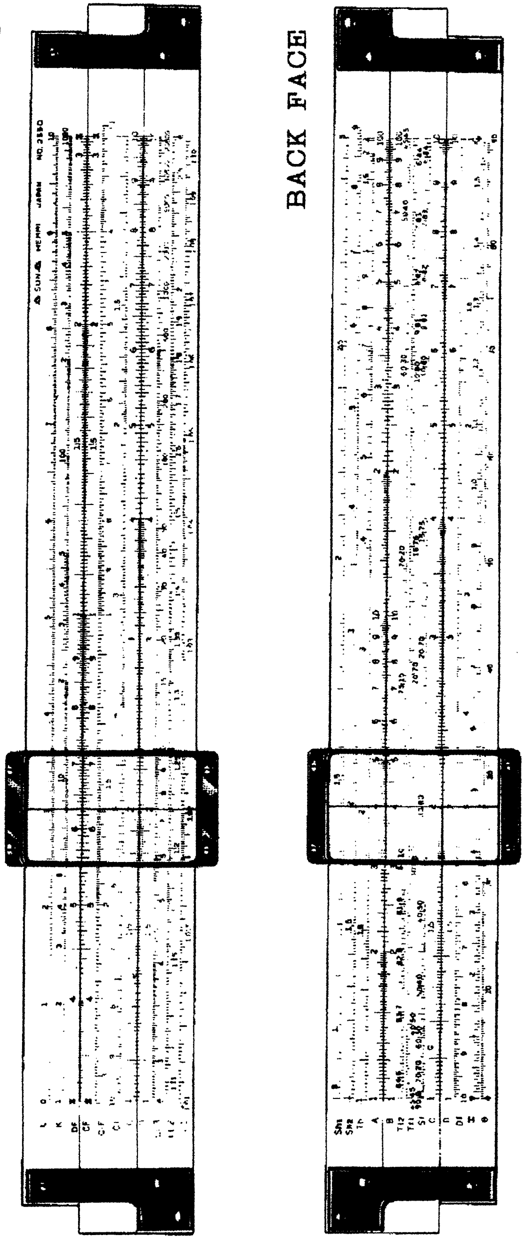
# INSTRUCTION MANUAL FOR HEMMI 255D, 275D SLIDE RULE

**HEMMI SLIDE RULE CO., LTD.**
TOKYO, JAPAN

FRONT FACE

BACK FACE



NO.255D SLIDE RULE

# INSTRUCTION MANUAL FOR HEMMI NO. 255D (25cm DUPLEX TYPE) NO. 275D (50cm DUPLEX TYPE) SLIDE RULE

This slide rule is specially designed for advanced electrical engineers and incorporates the following outstanding features.

(1) Calculation of hyperbolic function.
The rule is equipped with $Sh_1$, $Sh_2$, and Th (hyperbolic logarithm) scales, which permit the calculation of hyperbolic functions required in the design of long distance power transmission lines, etc.

(2) Angle and radian conversion as well as vector calculations can be conveniently performed. Angle and radian conversions can be calculated with the $x$ and $\theta$ scales. The utility of the SI and TI reciprocal scales is demonstrated in vector and right triangle calculations.

(3) Efficient multiplication and division. Since the DF, CF and CIF scales folded at $\pi$ are provided, "off scale" does not occur and efficient multiplications and divisions involving $\pi$ are possible.

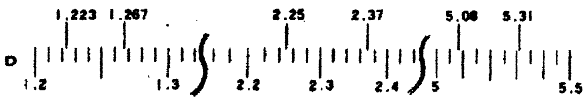
## CHAPTER 1. READING THE SCALES.

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.255D slide rule and is one used most often.

### (1) SCALE DIVISIONS

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

Between 1-2 One division is 0.01
Between 2-4 One division is 0.02
Between 4-10 One division is 0.05
Values between lines can be read by visual approximation.
An actual example is given below.




### (2) SIGNIFICANT FIGURES

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

### (3) INDEX LINES

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



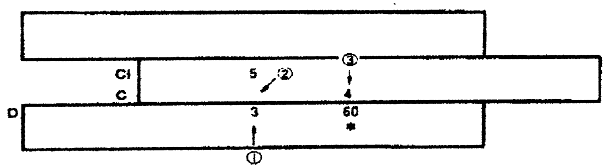
## SLIDE RULE DIAGRAM

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

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

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

(1) Set the hairline over 3 on the D scale.
(2) Move 5 on the CI scale under the hairline.
(3) Reset the hairline over 4 on the C scale and read the answer 60 on the D scale under the hairline.




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

# CHAPTER 2. MULTIPLICATION AND DIVISION. (1)

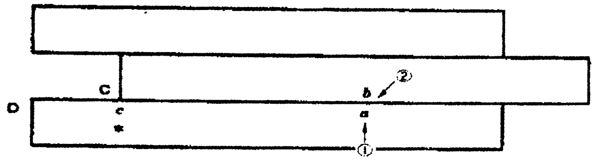
## §1. DIVISION

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

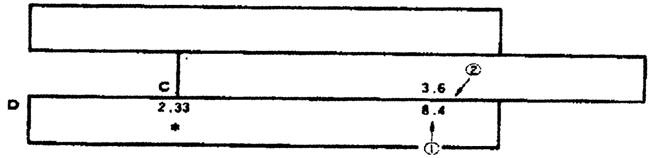
(1) Set the hairline over $a$ on the D scale,

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

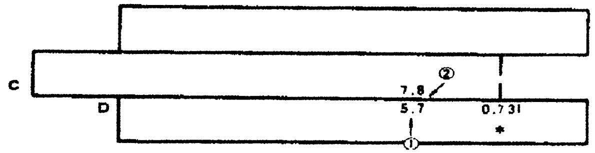
read the answer $c$ on the D scale opposite the index of the C scale.



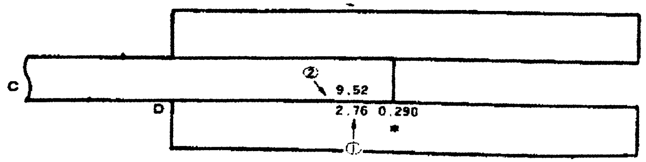

Ex. 2.1 $8.4 \div 3.6 = 2.33$




Ex. 2.2 $5.7 \div 7.8 = 0.731$




Ex. 2.3 $2.76 \div 9.52 = 0.290$





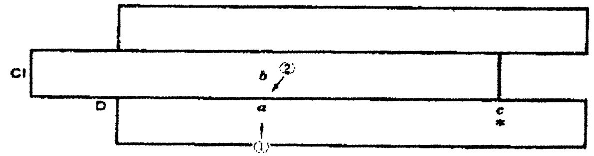

## §2. MULTIPLICATION

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

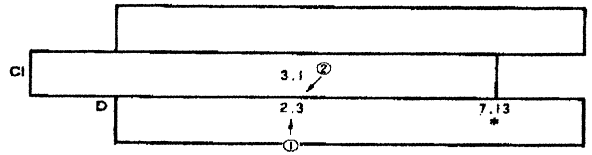
(1) Set the hairline over $a$ on the D scale,

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

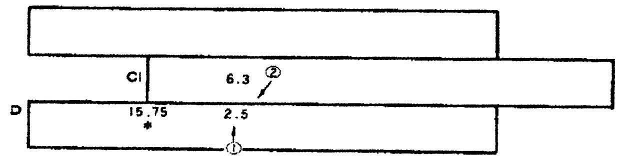
read the answer $c$ on the D scale opposite the index of the CI scale.



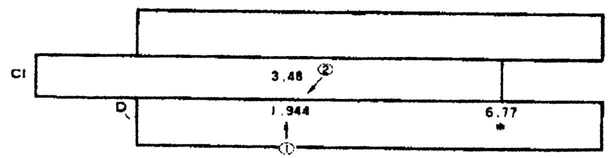

Ex. 2.4 $2.3 \times 3.1 = 7.13$




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

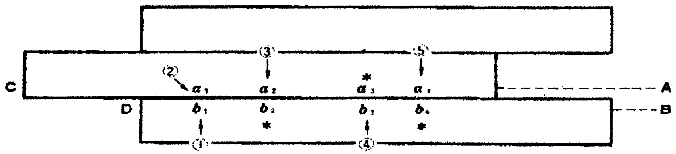
### § 1. PROPORTION

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.



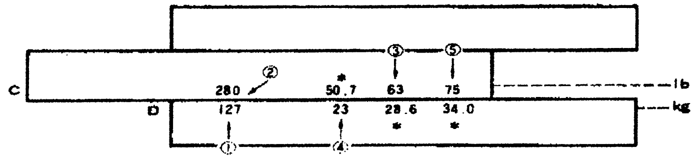

As illustrated in the above figure, when $a_1$ on the C scale is set opposite $b_1$ on the D scale the unknown quantities are all found on the C or D scales by moving the hairline.

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) |



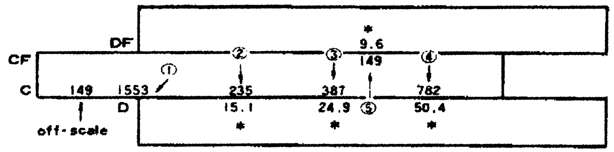



(Note) In calculating proportional problems the C scale must be used for one measurement and the D scale for the other. Interchanging the scales is not permitted until the calculation is completed. In Ex. 3.1., the C scale is used for the measurement of pounds and the D scale for that of kilo-grams.

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 |



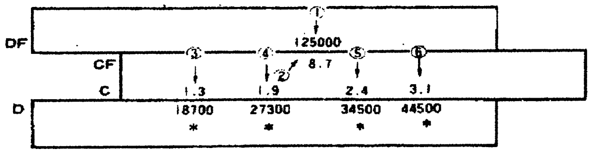

149 is on the part of the C scale which projects from the slide rule and its opposite on the D scale cannot be read. This is called "off-scale". In case of "off-scale", the CF scale is used in place of the C scale and the answer is read on the DF scale.

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

Ex. 3.3 Proportional distribution

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

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




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

## § 2. INVERSE PROPORTION

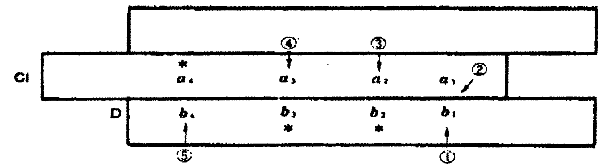
When the slide is set in any position, the product of any number on the D scale and its opposite on the CI scale is the same as the product of any other number on the D scale and its opposite on the CI scale. In other words, the D scale is inversely proportional to the CI scale. This relationship is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

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

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

( ) indicates an unknown quantity.

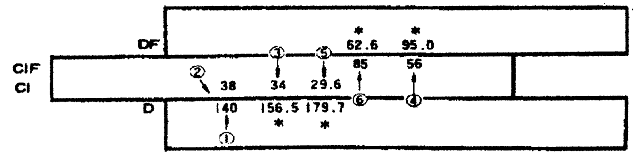





When $a_1$ on the CI scale is set opposite $b_1$ on the D scale, the product of $a_1 \times b_1$ is equal to that of $a_2 \times b_2$, that of $a_3 \times b_3$, and also equal to that of $a_4 \times b_4$. Therefore, $b_2$, $b_3$, and $a_4$ can be found by merely moving the hairline of the indicator.

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

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

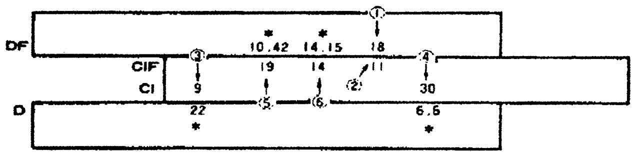



In solving inverse proportion problems, unlike proportional problems, you can freely switch the scales from one to another, but it is preferable to select and use the scales so that the answer is always read on the D or DF scale.

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

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

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




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

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



# CHAPTER 4. MULTIPLICATION AND DIVISION(2)

## § 1. MULTIPLICATION AND DIVISION OF THREE NUMBERS

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

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

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

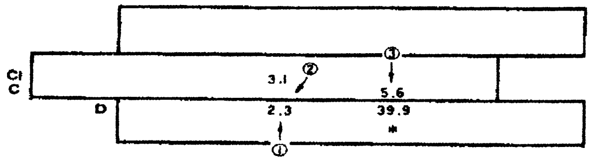
For additional multiplication to follow the calculation $(a\times b)$ or $(a\div b)$, set the hairline over $c$ on the C scale and read the answer $d$ on the D scale under the hairline.

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

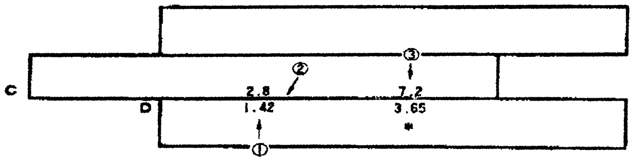
For additional division to follow the calculation $(a\div b)$ or $(a\times b)$, set the hairline over $c$ on the CI scale and read the answer $d$ on the D scale under the hairline.

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

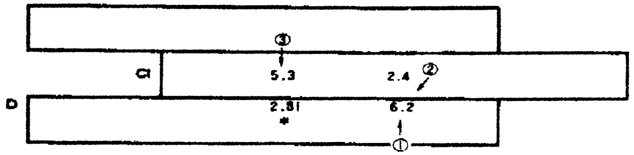
Ex. 4.1 $2.3\times3.1\times5.6=39.9$



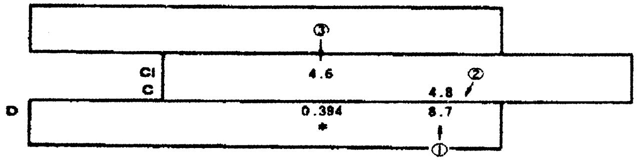
Ex. 4.2 $1.42 \div 2.8 \times 7.2 = 3.65$




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




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



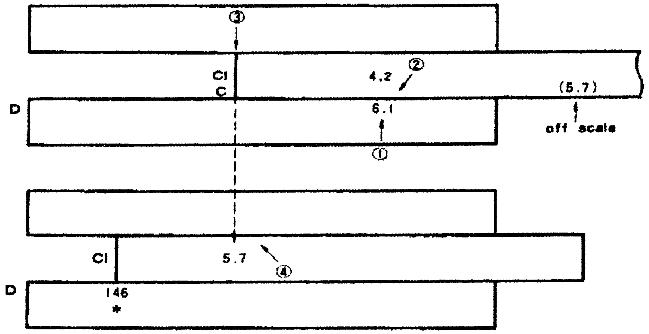

**§2. OFF SCALE**

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

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



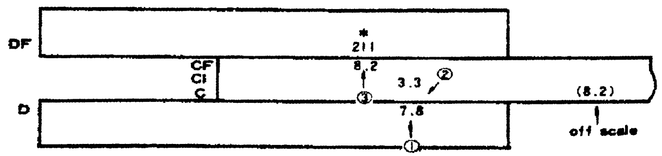
Ex. 4.5 $6.1 \times 4.2 \times 5.7 = 146$



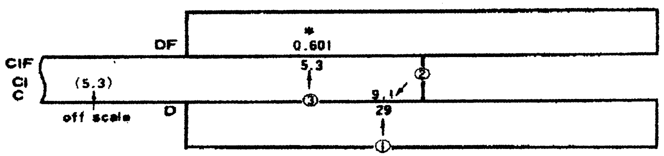

The third number 5.7 on the C scale runs off scale. Set the hairline back over the left index of the C scale and move the slide to bring 5.7 on the CI scale under the hairline. Then, read the answer 146 on the D scale opposite the index of the CI scale. In fact, selection of the scale is exactly the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

(2) Folded scales (DF, CF, and CIF)
In method (1), one more movement of the slide is necessary compared to when an off scale does not occur. However, the folded scales can be conveniently employed when an off scale occurs.
The folded scales are used in the same manner as in the case of proportion and inverse proportion problems. When an off scale occurs on the C scale the CF scale can be used, and when an off scale occurs on the CI scale the CIF scale can be used. In this case the answer appears under the hairline on the DF scale.

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

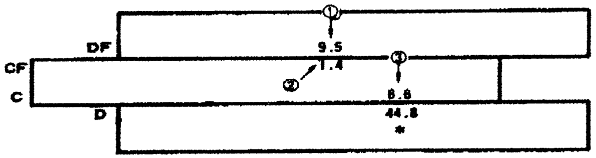


Ex. 4.7  $29 \div 9.1 \div 5.3 = 0.601$



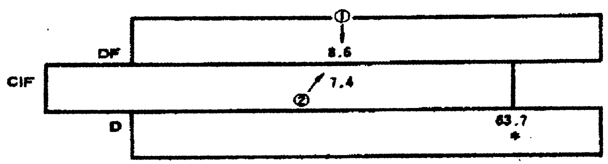

There are some problems in which an off scale will occur on both normal scale and the folded scale. In this case, interchanging the indices in method (1) will be employed; however, the method given below can be also employed.

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




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

Ex. 4.9  $8.6 \times 7.4 = 63.7$

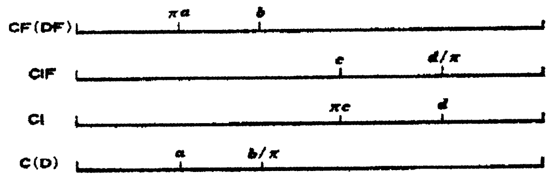



The DF and CIF scales can also be conveniently used instead of the D and CI scales to solve the above problem. The answer then appears on the D scale.



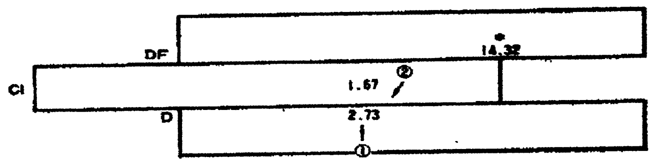
## § 3. MULTIPLICATION AND DIVISION INVOLVING $\pi$

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

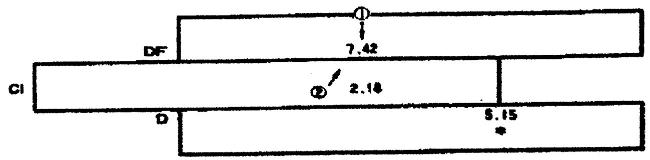



This relationship makes multiplication and division involving $\pi$ easy.

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



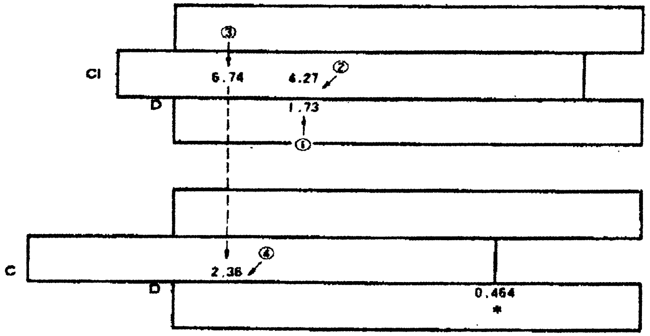

Ex. 4.11  $\dfrac{7.42 \times 2.18}{\pi} = 5.15$



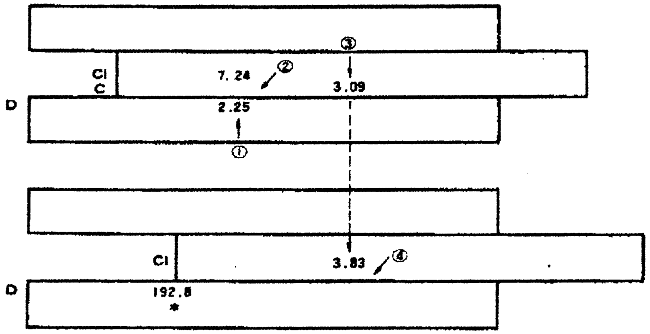

## § 4. MULTIPLICATION AND DIVISION OF MORE THAN FOUR NUMBERS

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

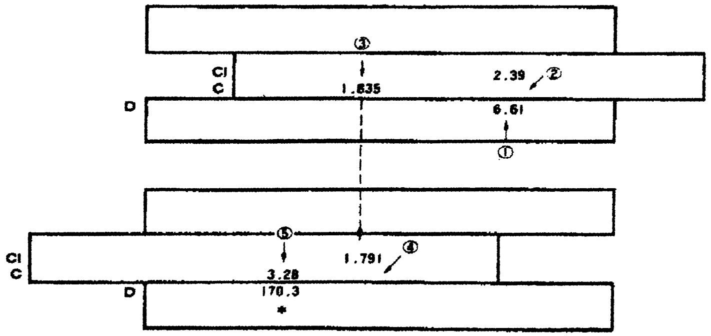
Ex. 4.12 $\frac{1.73 \times 4.27}{6.74 \times 2.36} = 0.464$




Ex. 4.13 $2.25 \times 7.24 \times 3.09 \times 3.83 = 192.8$




Ex. 4.14 $6.61 \times 2.39 \times 1.835 \times 1.791 \times 3.28 = 170.3$

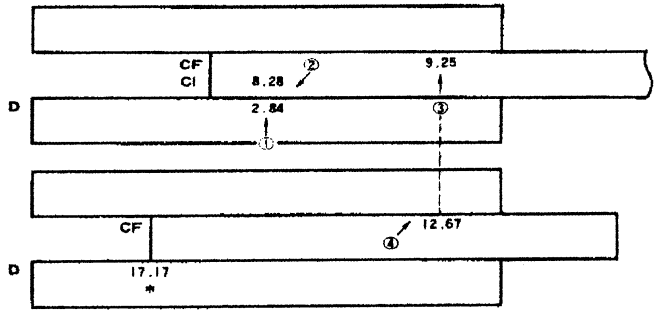




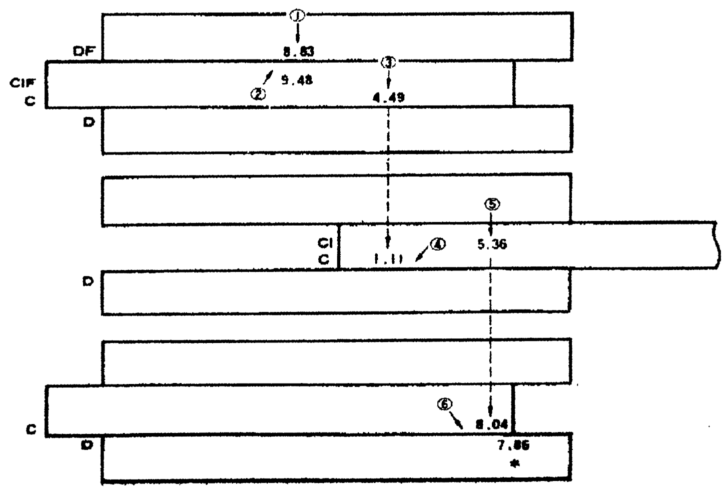

The folded scale can be conveniently used when an off scale occurs. However, once a folded scale is used, it must also be used for the next slide operation. Note that alternate use of a normal scale and a folded scale will result in an incorrect answer.

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

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




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



## § 5. PLACING THE DECIMAL POINT

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

(a) Approximation

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

Ex. $25.3\times7.15=180.9$

To get an approximate value $25.3\times7.15\rightarrow30\times7=210$. 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. $$\frac{285\times0.00875}{13.75}=0.1814$$

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.

$\frac{285\times0.00875}{13.75}$ is rewritten to $\frac{2.85\times0.875}{13.75}$ and approximated to $\frac{3\times0.9}{10}=0.27$.

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



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

$$\frac{1.346}{0.00265}\rightarrow\frac{1346}{2.65}\rightarrow\frac{1000}{3}\rightarrow300$$

(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. $$\frac{1.472\times9.68\times4.76}{1.509\times2.87}=15.66$$

$$\frac{\cancel{1.472}\times\overset{3}{\cancel{9.68}}\times4.76}{\cancel{1.509}\times\cancel{2.87}}\rightarrow3\times5=15$$

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. $$\frac{7.66\times0.423\times12.70}{0.641\times3.89}=16.50$$

$$\frac{7.66\times0.423\times12.70}{0.641\times3.89}\rightarrow\frac{\cancel{7.66}\times\cancel{4.23}\times12.70}{\cancel{6.41}\times\cancel{3.89}}\rightarrow13$$

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

(b) Exponent

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

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

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

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

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



## CHAPTER 5. SQUARES AND SQUARE ROOTS

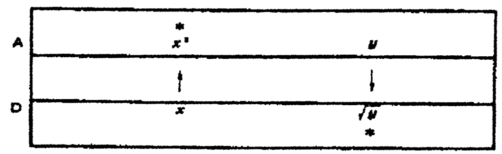
The "place number" is used to find squares and square roots as well as placing the decimal point of squares and square roots.
When the given number is greater than 1, the place number is the number of digits to the left of the decimal point. When the given number is smaller than 1, the place number is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

### § 1. SQUARES AND SQUARE ROOTS

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

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

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



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

a) When the answer is read on the left half section of the A scale $(1\sim10)$, 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$(10\sim100)$, the "place number" of $x^2 = 2$ ("place number" of $x$)

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

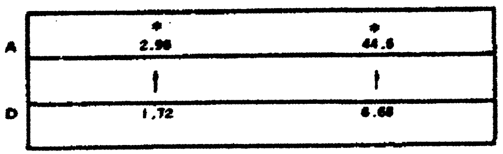
$17.2^2 = 296$ ................. The place number of 17.2 is 2. Hence, the place number in the answer is $2\times2-1=3$

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

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

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

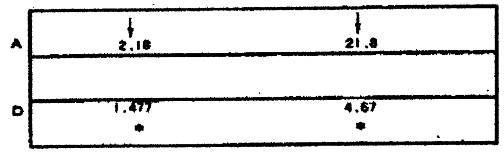
$0.0668^2 = 0.00446$ ........ The place number of 0.0668 is $-1$ Hence, the place number in the answer is $2\times(-1)=-2$






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

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




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

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

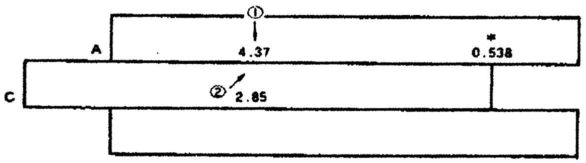
## FUNDAMENTAL OPERATION (7)

Multiplication and division involving squares

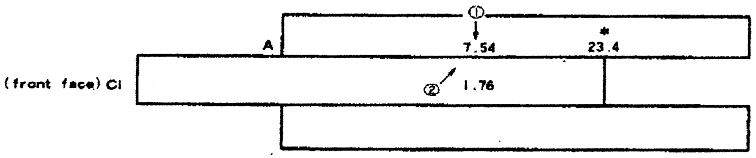
(1) Set the number to be squared on the one cycle scale (C, D, or CI) and the number not to be squared on the two cycle scale (A or B)

(2) Read the answer on the A scale.

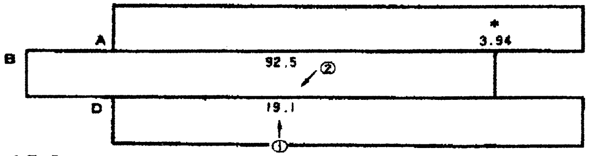
Ex. 5.4 $4.37 \div 2.85^2 = 0.538$



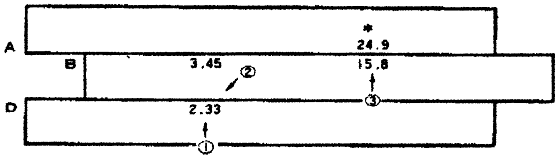

Ex. 5.5 $7.54 \times 1.76^2 = 23.4$




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




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






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

## FUNDAMENTAL OPERATION (8)

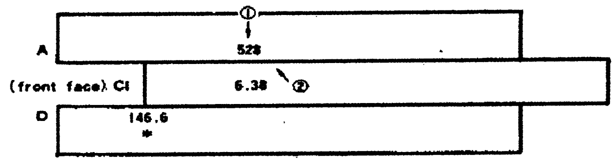
Multiplication and division involving the square roots of numbers.

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

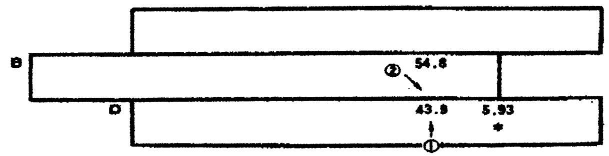
(2) Read the answer on the D scale.

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

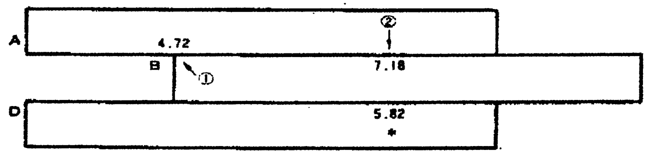
Ex. 5.8 $\sqrt{528} \times 6.38 = 146.6$



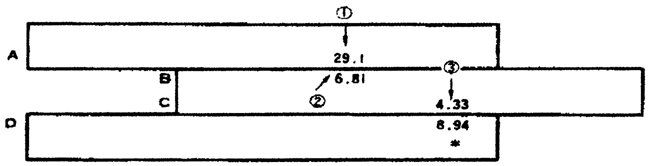

Ex. 5.9 $43.9 \div \sqrt{54.8} = 5.93$



Ex. 5.10 $\sqrt{4.72\times7.18}=5.82$




Ex. 5.11 $\dfrac{\sqrt{29.1}\times4.33}{\sqrt{6.81}}=8.94$

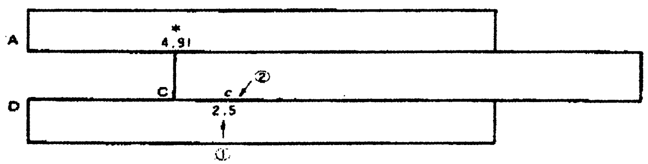



### §3. THE AREA OF A CIRCLE

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

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

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




Answer 4.91cm²



## CHAPTER 6. CUBES AND CUBE ROOTS

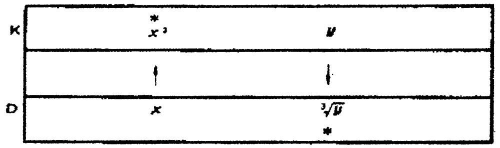
The K scale consists of three D scales connected together and reduced to exactly 1/3 of its original length. The K scale is called " three cycle scale" and is used with the C, D and CI scales to perform the calculations of the cubes and cube roots of numbers.

### §1. CUBES AND CUBE ROOTS

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

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

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




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

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

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

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

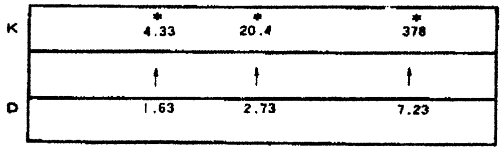
Ex. 6.1 $16.3^3=4330$ ("place number" of answer $=3\times2-2=4$)
$0.163^3=0.00433$ ("place number" of answer $=3\times0-2=-2$)

$273^3 = 20400000$ ("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 $= 3\times(-2) = -6$)
$= 3.78\times 10^{-7}$



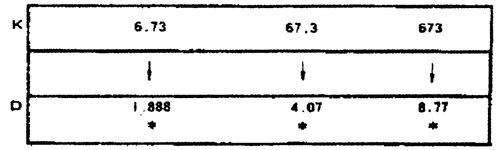

When the hairline is set over $x$ on the K scale, $\sqrt[3]{x}$ is found under the hairline on the D scale. Since the K scale consists of three identical sections, only the correct section can be used.

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.

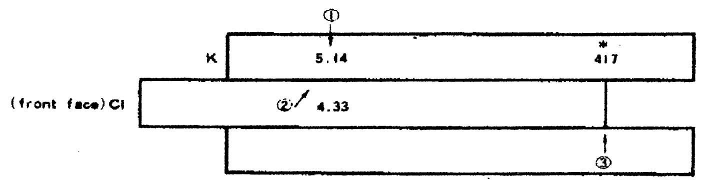
| | |
|---|---|
| 673 \| 000 (right) | Place number of the answer······ 2 |
| | $\sqrt[3]{673000} = 87.7$ |
| 67 \| 300 (center) | Place number of the answer······ 2 |
| | $\sqrt[3]{67300} = 40.7$ |
| 6 \| 730 (left) | Place number of the answer······ 2 |
| | $\sqrt[3]{6730} = 18.88$ |
| 0.673 (right) | 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. MULTIPRICATION 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 fundametal operations (7) and (8).

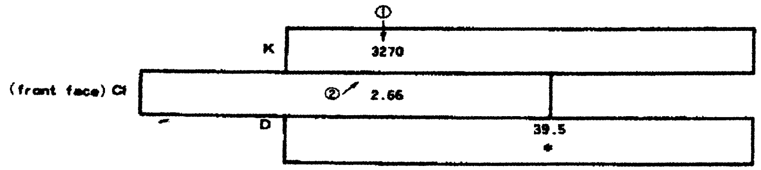
Ex. 6.3 $5.14\times 4.33^3 = 417$




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

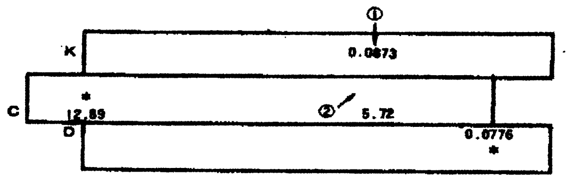
In $a^3 \div b$, first find $a^3$ and then perform division with two numbers using the C and D scales.

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




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

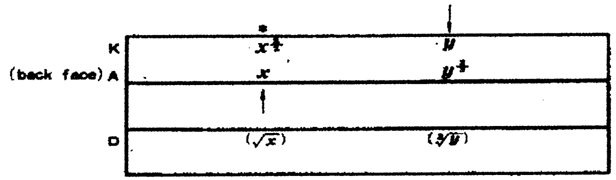
$5.72\div\sqrt[3]{0.0873} = 12.89$




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 $2.5\times 6.3$.

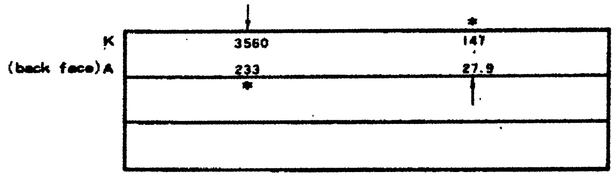
## § 3. $\frac{3}{2}$ POWER AND $\frac{2}{3}$ POWER

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

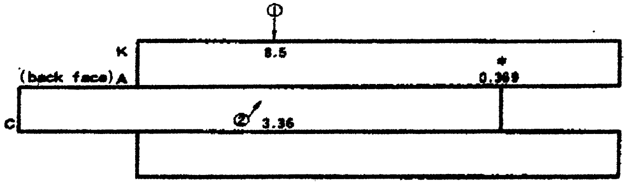



When the hairline is set over $x$ on the A scale, $x^{\frac{3}{2}}$ is read under the hairline on the K scale. When the hairline is set over $y$ on the K scale, $y^{\frac{2}{3}}$ is read under the hairline on the A scale.

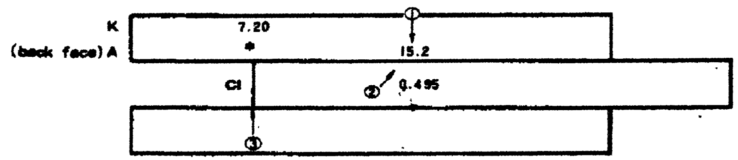
Ex. 6.6 $27.9^{\frac{3}{2}} = 147$ $3560^{\frac{2}{3}} = 233$




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



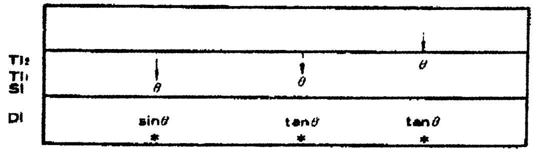

Ex. 6.8 $15.2^{\frac{3}{2}}\times 0.495^3 = 7.20$



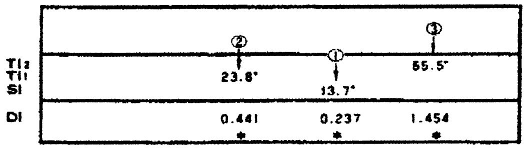
## CHAPTER 7. TRIGONOMETRIC FUNCTION

The SI scale is used to find the sine of an angle. The TI$_1$ and TI$_2$ scales are both used to find the tangent of an angle. These scales are graduated in degrees and decimals of degrees and read from right to left using the black numbers and from left to right using the red numbers.

### §1. SINE, TANGENT, COSINE

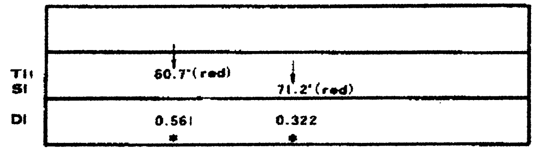
> **FUNDAMENTAL OPERATION(10)** $\sin\theta$, $\tan\theta$
>
> When the slide is closed, and
>
> (1) When the hairline is set over $\theta$ on the SI scale, $\sin\theta$ is found on the DI scale.
>
> (2) When the hairline is set over $\theta$ on the TI$_1$ or TI$_2$ scale, $\tan\theta$ is found on the DI scale. The TI$_1$ scale is used in case $\theta \leqq 45°$ and the TI$_2$ scale used in case $\theta \geqq 45°$.
>
> 
> 
>
> These scales are read using the black numbers.

Ex. 7.1 (1) $\sin 13.7° = 0.237$ (3) $\tan 55.5° = 1.454$
(2) $\tan 23.8° = 0.441$




When finding the cosine, the red numbers of the SI scale are used basing on the relation $\cos\theta = \sin(90° - \theta)$ and read the answer on the DI scale. The red numbers of the TI scales are used to find the cotangent basing on the relation $\cot\theta = \tan(90° - \theta)$.

Ex. 7.2 ① $\cos 71.2° = 0.322$ ② $\cot 60.7° = 0.561$

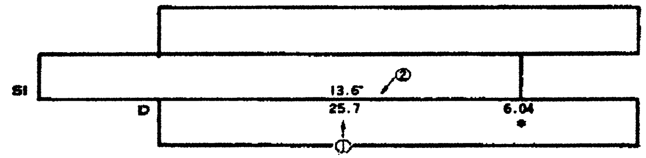



Sec $\theta$ and cosec $\theta$ are found to reciprocal of $\cos\theta$ and $\sin\theta$, respectively. Since the value under the hariline on the D scale is the reciprocal of the value under the hairline on the DI scale, this relationship can be conveniently used.

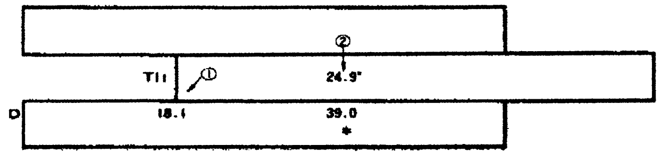
### §2. MULTIPLICATION AND DIVISION INVOLVING TRIGONOMETRIC FUNCTION

The SI, TI$_1$ and TI$_2$ scales are used for multiplication and division involving trigonometric function in the same manner as the CI scale.

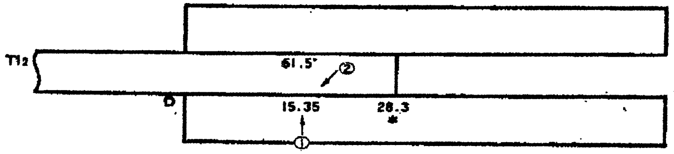
Ex. 7.3 $25.7 \times \sin 13.6° = 6.04$



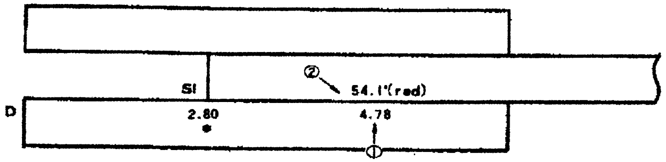

Ex. 7.4 $18.1 \div \tan 24.9° = 39.0$



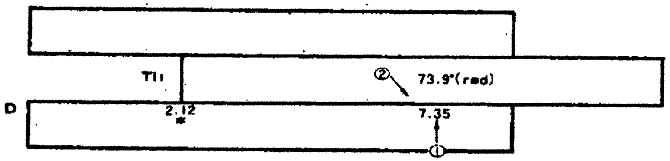
Ex. 7.5 $15.35 \times \tan 61.5° = 28.3$




Ex. 7.6 $4.78 \times \cos 54.1° = 2.80$



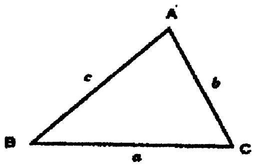

Ex. 7.7 $7.35 \times \cot 73.9° = 2.12$




## § 3. SOLUTIONS OF TRIANGLES

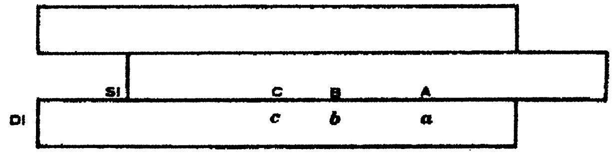
**FUNDAMENTAL OPERATION (11)** The law of sines

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




The law of sines is

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



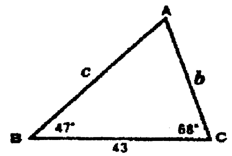

We can solve any triangle using the method solving proportional problems, when a side and its corresponding angle and another part are given.

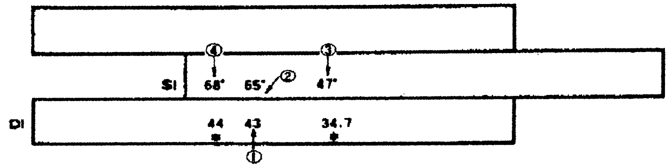
Ex. 7.8 Find $b$ and $c$.

$\angle A = 180° - (47° + 68°)$

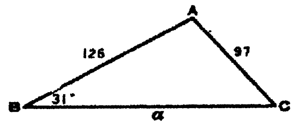
$= 65°$

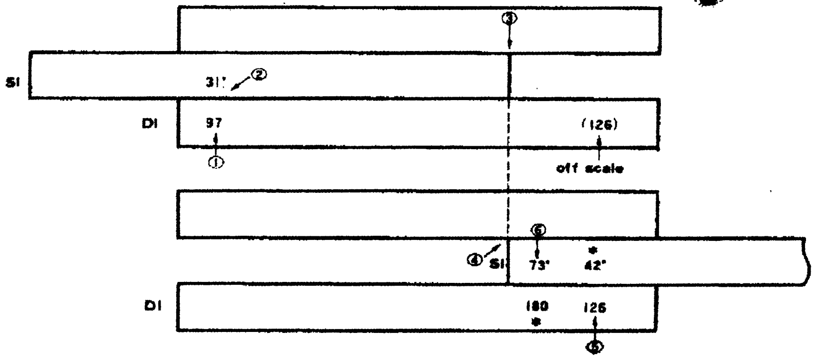
Answer $b = 34.7$, $c = 44.0$




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



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

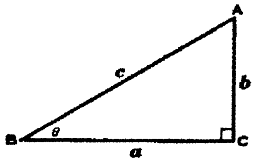
Answer $\angle A = 107°$, $\angle C = 42°$, $a = 180$

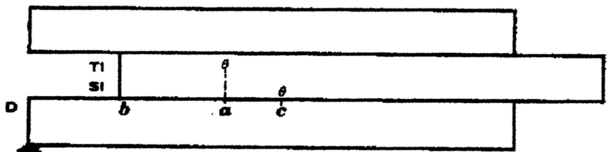
Since 126 on the DI scale runs off scale, interchanging the indices should be performed as illustrated. $\angle A$ is found as 107°, which is not shown in the SI scale. In this case, the complementary angle $180° - 107° = 73°$ is set on the SI scale basing on the relation $\sin\theta = \sin(180° - \theta)$.

## §4. SOLUTION OF RIGHT TRIANGLES

**FUNDAMENTAL OPERATION** (12) RIGHT TRIANGLES

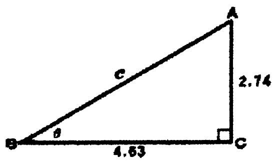
The right triangle is solved by setting the slide as illustrated in the figure below.

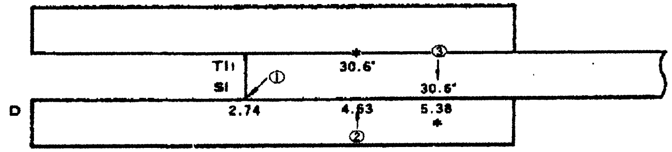



This method is used to solve right triangles, vector calculations, complex numbers, etc.

Ex. 7.10 Find $c$ and $\theta$.

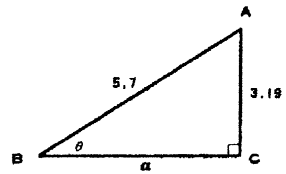


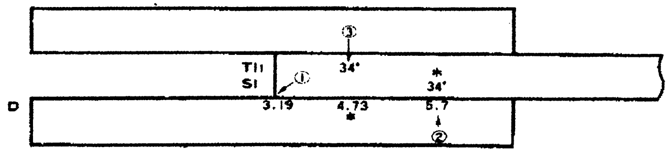




Answer $c = 5.38$, $\theta = 30.6°$

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

Ex. 7.11 Find $a$ and $\theta$.



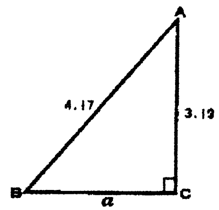




Answer $a = 4.73$, $\theta = 34°$

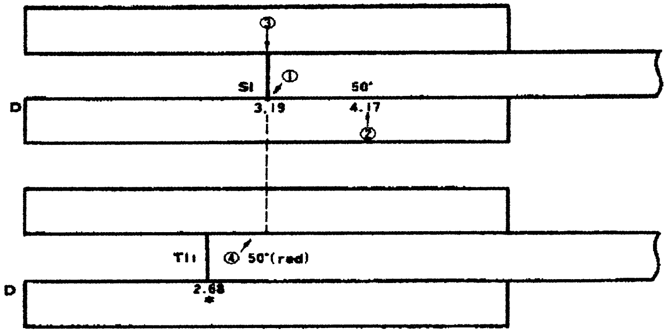
(Note) Calculating $\sqrt{5.7^2 - 3.19^2} = 4.73$ can be performed in the same manner as illustrated above.

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

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

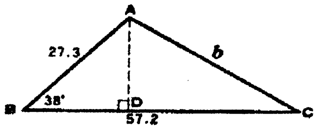


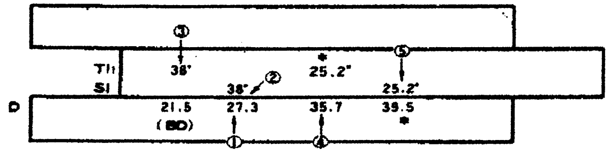

Answer 2.68




Ex. 7.13 Find $b$ and $\angle C$ of the triangle below.

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



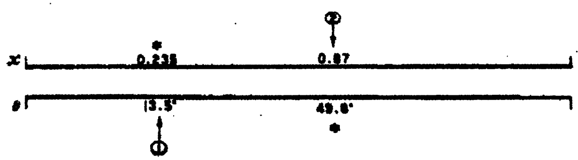




DC = 57.2 − 21.5 = 35.7  Answer $b$ = 39.5, $\angle C$ = 25.2°

## §5. DEGREE AND RADIAN CONVERSION

The slide rule is equipped with the $x$ and $\theta$ scales for conversion of degrees to radians and vice versa. The $x$ scale indicates radian measure and the $\theta$ scale indicates the angle in degrees.

Ex. 7.14 (1) 13.5° = 0.235 radian (2) 0.87 radian = 49.8°



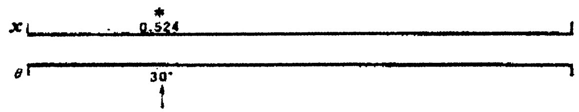



## §6. TRIGONOMETRIC FUNCTION OF VERY SMALL ANGLES

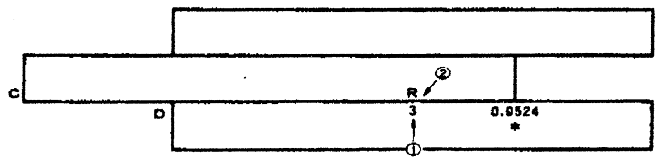
The smallest angle indicated on the SI and TI scales is 6°, therefore, these scales can not be used to find the sine or the tangent of angles less than 6°. However, since the sine and tangent of small angles very closely approximate the angle in radian measure, you can use $\theta$ radian measure for the value of sin $\theta$ and tan $\theta$.

The $x$ and $\theta$ scales can be used here again for the conversion with shifting the decimal point of the reading on these scales.

Ex. 7.15 sin 3° = 0.0524




(Note) The No. 275D slide rule has a gauge mark "R" at the position of 573 on the C scale. This indicates the relationship 1 radian = 57.3°. Therefore, an angle given in degrees can be converted to radians by dividing the angle set on the D scale by "R" on the C scale as illustrated below.



# CHAPTER 8. LOGARITHMS AND EXPONENTS

## § 1. COMMON LOGARITHMS

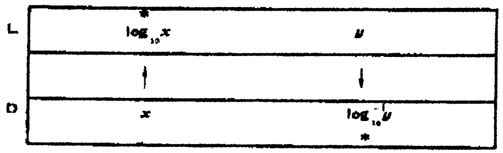
The L scale, which is a uniformly divided scale, is used with the D scale to find the mantissa of common logarithms. The characteristic of the logarithm is found by the place number of the given number. If the place number of the given number is $m$, the characteristic of the common logarithm found on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

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

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.

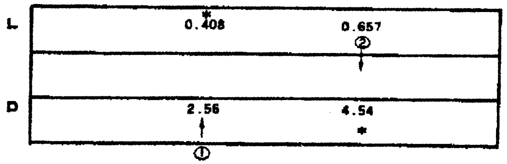
(2) When the hairline is set over the mantissa of $y$ on the L scale the significant digits of $\text{antilog}_{10}\, y$ is read under the hairline on the D scale.




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

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

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





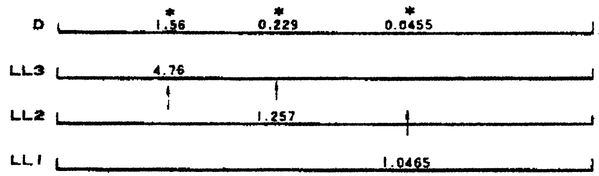

## §2. NATURAL LOGARITHMS

The log log scales LL1, LL2 and LL3 are called the LL scales and are used to obtain the natural logarithm of a numbers and powers and roots of numbers from 1.01 to 22,000. The LL scales are read with the location of the decimal point and these numbers either smaller than 1.01 or larger than 22,000 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, $\log_e x$ appears on the D scale.

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

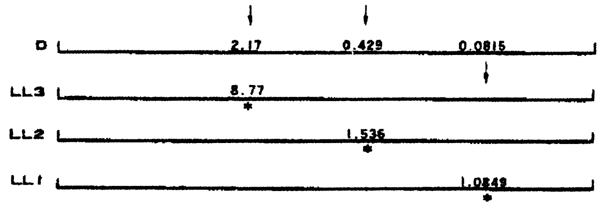



The relationship between the place number of the natural logarithm and the number (1, 2, 3) of the LL scale can be seen from the above illustration.

(b) **FINDING $e^x$**

$e^x$ is found on the LL scale when the hairline is set over $x$ on the D scale.

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



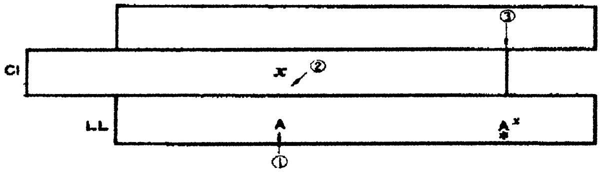

For calculating $e^{-x}$, first find $e^x$ and then find $(\frac{1}{e^x})$ by using the D and DI scales.

## § 3. EXPONENT

### FUNDAMENTAL OPERATION (14) $A^x$

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

(2) Move $x$ on the CI scale under the hairline. Read the answer on the LL scale opposite the index of the CI scale.

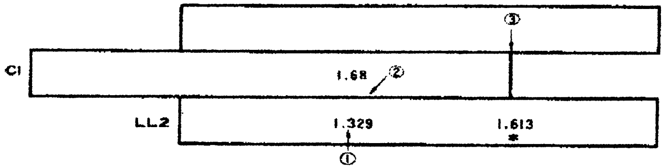



Since the slide rule has three LL scales, you must find on what LL scale the answer will appear. In the calculation of $A^x$, if $x$ is a number between 1～10, the LL scale on which the answer appears will be found as follows.

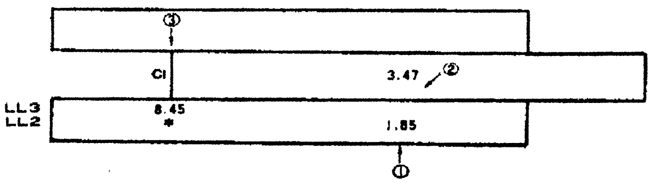
(1) When the slide protrudes to the left, the answer is found on the LL scale having the same number as the LL scale on which A is set.

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

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




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






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

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

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

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

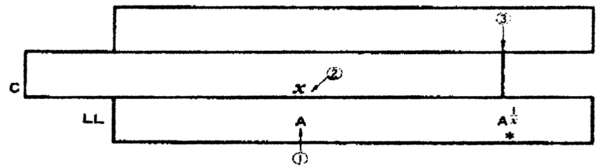
(2) Find $1.147^{2.6} = 1.428$ (The LL and CI scales are used)

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

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

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

(2) Move $x$ on the C scale under the hairline. Read the answer on the LL scale opposite the index of the C scale.

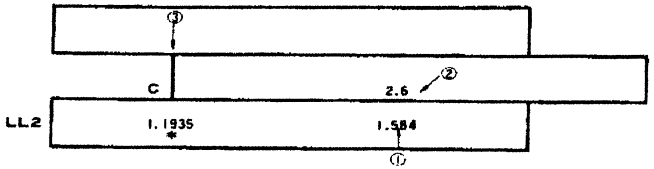



In calculating $A^{\frac{1}{x}}$, where $x$ is a number between 1 and 10, the LL scale on which the answer appears will be determined as follows.

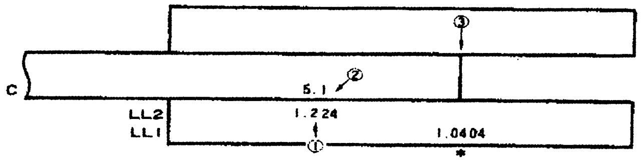
(1) If the slide protrudes to the right, the answer is found on the LL scale having the same number as the LL scale on which A is set.

(2) If the slide protrudes to the left, the answer is found on the LL scale one 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 $0.165^{\frac{1}{3.7}} = 0.615$

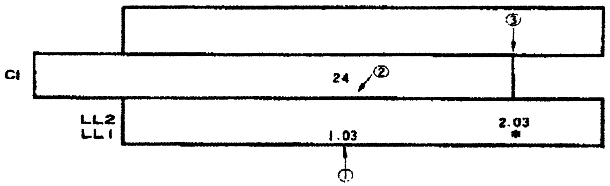
This problem is rewritten to $\frac{1}{\left(\frac{1}{0.165}\right)^{\frac{1}{3.7}}}$ and then calculated in the following manner.

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

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

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

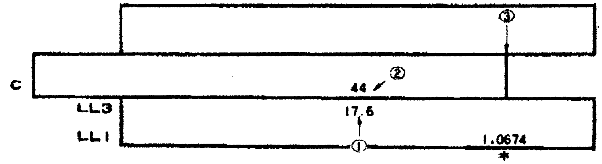
Ex. 8.10 $1.03^{24} = 2.03$






In calculating $1.03^{24} = 2.03$ since 24 is larger than 10, $1.03^{24}$ is rewritten to $1.03^{2.4\times10} = (1.03^{2.4})^{10}$ and read the answer 2.03 on the LL2 scale opposite the position you can read the answer of $1.03^{2.4}$ 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 $17.6^{\frac{1}{44}} = 1.0674$



## CHAPTER 9. HYPERBOLIC FUNCTION

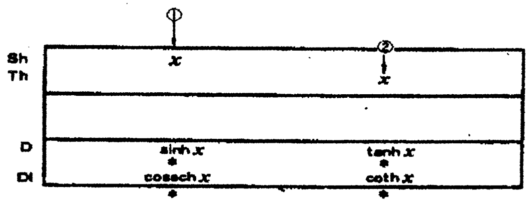
There are many occasions in which calculations of hyperbolic functions are necessary in the study of alternating current, long distance powertransmission lines, electrical engineering, etc. This slide rule is equipped with hyperbolic function scales $Sh_1$, $Sh_2$ and Th to permit convenient multiplication and division involving hyperbolic functions. Hyperbolic functions of complex arguments can be determined by using the hyperbolic scales in conjunction with the SI and TI scales.

### §1. SIN h$x$, TAN h$x$

**FUNDAMENTAL OPERATION (16)** sinh $x$, tan h$x$

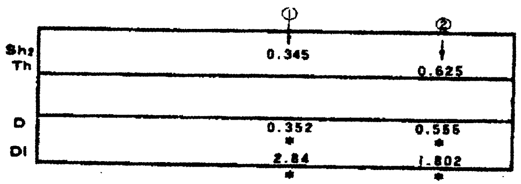
(1) When the hairline is set over $x$ on the Sh scale, sinh$x$ can be read on the D scale.

(2) When the hairline is set over $x$ on the Th scale, tanh$x$ can be read on the D scale.




Ex. 9.1 (1) sin h 0.345 = 0.352 cosec h 0.345 = 2.84

(2) tan h 0.625 = 0.555 cot h 0.625 = 1.802



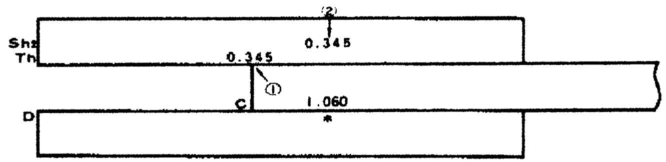



Ex. 9.2 Find cos h 0.345.

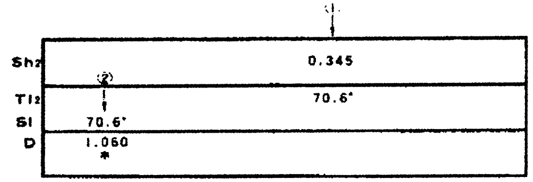
This problem can be solved by using the identity $\cos h\, x = \frac{\sin h\, x}{\tan h\, x}$.

The problem can be solved using the slide rule in the following manner.

(1)

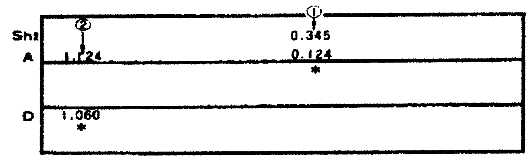



(2)



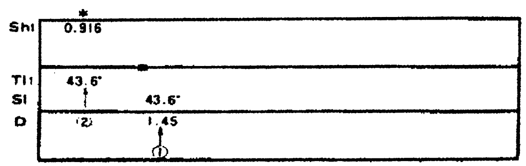

First, close the slide and read 70.6° on the $TI_2$ scale opposite 0.345 on the $Sh_2$ scale. Then, reset this value of 70.6° on the SI scale and read the answer 1.060 on the D scale opposite 70.6° on the SI scale.

(3) The answer can also be obtained from $\cos h\, x = \sqrt{1 + \sinh^2 x}$




Answer 1.060

Ex. 9.3 $\cos h^{-1}$ 1.45 = 0.916



(Note) The $Tl_1$ and $Tl_2$ scales are corresponding to the $Sh_1$ and $Sh_2$ scales, respectively.

## § 2. HYPERBOLIC FUNCTIONS OF COMPLEX NUMBERS.

Hyperbolic functions of $a+jb$ can be determined by either of the following methods (a) and (b).

(a) CALCULATION BY RECTANGULAR COORDINATES

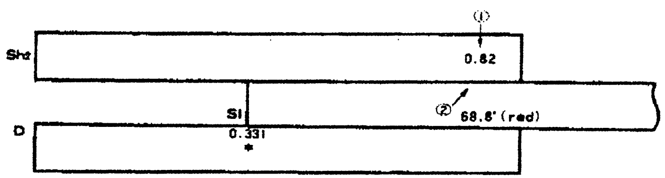
$$\sinh(x \pm jy) = \sinh x \cdot \cos y \pm j \cosh x \cdot \sin y$$
$$\cosh(x \pm jy) = \cosh x \cdot \cos y \pm j \sinh x \cdot \sin y$$

Calculation can be performed by dividing the real part and the imaginary part from the above formula.

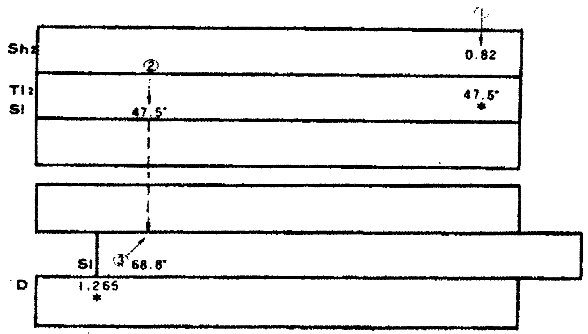
Ex. 9.4 $\sinh(0.82 + j\,1.20) = 0.331 + j\,1.265$

Since the Sl and Tl scales of this slide rule employ angles in degrees, the calculation can be performed after the given radian is converted to an angle in degrees. 1.2 radian $= 68.8°$

Calculation of the real part $\sinh 0.82 = 0.331$




Calculation of the imaginary part, $\cosh 0.82 \times \sin 68.8° = 1.265$

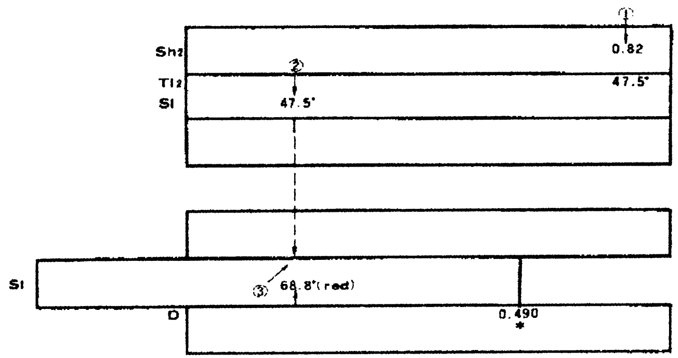





Ex. 9.5 $\cosh(0.82 + j\,1.2) = 0.490 + j\,0.853$

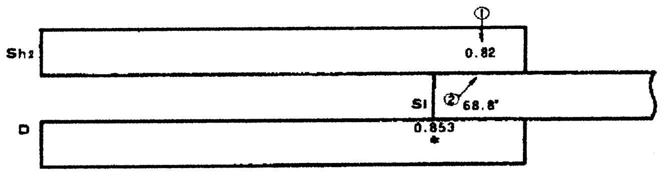
Calculation of the real part

$\cosh 0.82 \times \cos 68.8° = 0.490$




Calculation of the imaginary part

$\sinh 0.82 \times \sin 68.8° = 0.853$




Hyperbolic functions of complex numbers are complex numbers; Therefore, these functions can be expressed in polar form.

That is, $\sinh(x \pm jy) = A(\cos\theta + j\sin\theta) = (A, Q)$.

The values of A and $\theta$ can be determined from the following table:

| function | A | Q |
|---|---|---|
| $\sinh(x \pm jy)$ | $\sqrt{\sinh^2 x + \sin^2 y}$ | $\pm\tan^{-1}\left(\frac{\tan y}{\tan hx}\right)$ |
| $\cosh(x \pm jy)$ | $\sqrt{\sinh^2 x + \cos^2 y}$ | $\pm\tan^{-1}(\tan y \cdot \tanh y)$ |
| $\tanh(x \pm jy)$ | $\sqrt{\frac{\sinh^2 x + \sin^2 y}{\sinh^2 x + \cos^2 y}}$ | $\pm\tan^{-1}\left(\frac{\sin 2y}{\sinh 2x}\right)$ |

(b) CALCULATION OF $\tanh^{-1}(x+jy)$

The method illustrated can be used to find the positional angle at each point on the long distance power-transmission line in the following manner.

The formula $\tanh^{-1}(x\pm jy)= z = a\pm jb$,
can be expressed as $\tan z = x\pm jy$,
That is,

$$\frac{e^{z}-e^{-z}}{e^{z}+e^{-z}} = \frac{e^{2z}-1}{e^{2z}+1} = x\pm jy$$

$$e^{2z}= e^{-2(a\pm jb)} = \frac{1+(x\pm jy)}{1-(x\pm jy)} = (A,\theta)$$

from the above relationship, you can find

$$b=\frac{\theta}{2},\quad a=\frac{1}{2}\log_e A.$$

Ex. 9.6 $\tanh^{-1}(2.5-j\,0.57)=0.396+j\,1.672$

First calculate $e^{2z} = \frac{1+(x-jy)}{1-(x-jy)}$

$$1+(2.5-j\,0.57)=3.5-j\,0.57 = (3.54, 9.25^\circ)$$

$$1-(2.5-j\,0.57)=-1.5+j\,0.57=(1.605, \pi-20.8^\circ)$$

$$(A,\theta) = \frac{(3.54,\ 9.25^\circ)}{(1.605,\ \pi-20.8^\circ)} =(2.21, 11.55^\circ-\pi)$$

$$=(2.21,\ \pi+11.55^\circ)$$

Therefore $a=\frac{\pi+11.55^\circ}{2}=\frac{\pi}{2}+5.78^\circ=\frac{\pi}{2}+0.101=1.672$

$$b=\frac{1}{2}\log_e 2.21=\frac{0.792}{2}=0.396$$



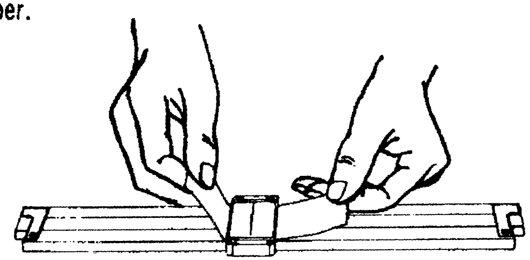
## CARE AND ADJUSTMENT OF THE SLIDE RULE.

### ※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.

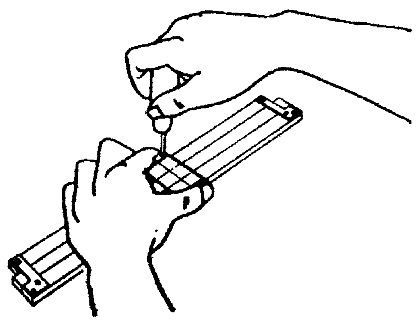
### ※WHEN THE INDICATOR GLASS BECOMES DIRTY

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



### ※HOW TO ADJUST THE HAIRLINE

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



### ※HOW TO ADJUST THE SCALES

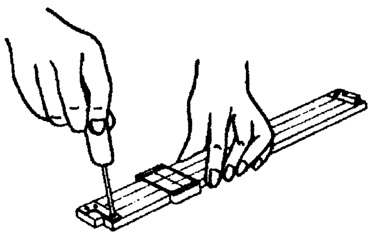
When the slide is moved until the C and D scales coincide, the DF and CF or A and B scales should be coincide. However, the adjustment of the rule may be lost if the rule is dropped or severely jarred. In this case, loosen the screws at both ends of the rule and move the upper body member right or left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

### ※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 tooth brush. Using a little of wax will also help.

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

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



### ※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.