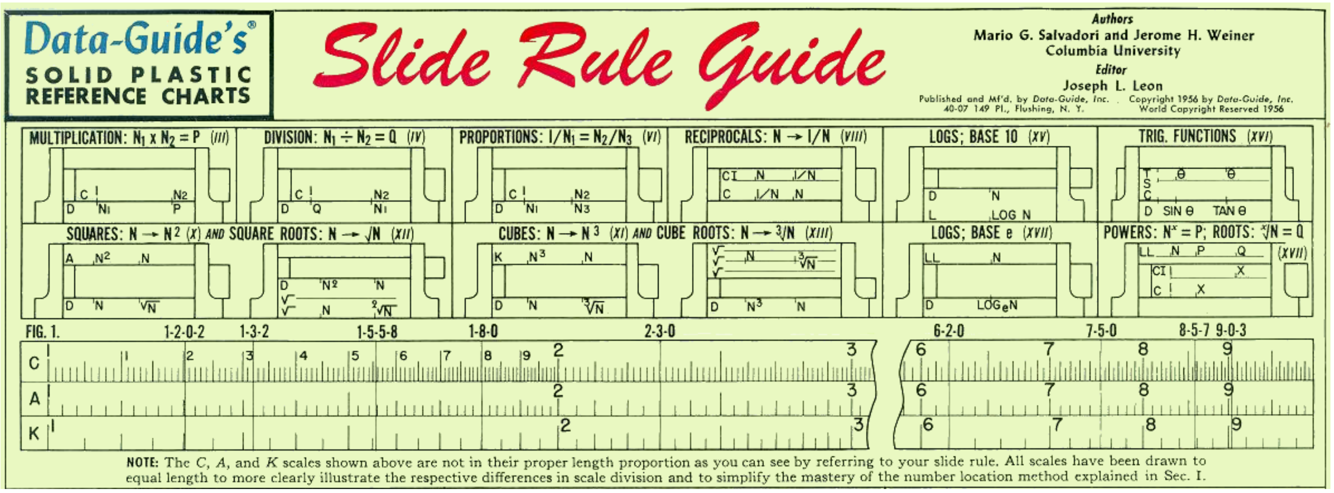

Slide Rule Guide

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Contents

Preface

This is a reformatted version of a document which was copyrighted in 1956. There is no record in the U.S. Copyright Office of this copyright being updated. The original company's phone number is disconnected, and the original editor and owner of the company has passed away. So far as we can tell, this document is now in the public domain.

This reformatted version is based on a low resolution scan. Image processing enhancements were performed to ready the image for optical character recognition software. Sections at a time were isolated and fed to the OCR software. The resulting text was assembled into one document. OCR mistakes were then located and corrected. Original text was preserved in almost every instance.

The layout has been changed to a much more readable format. Mathematics were typeset with small modifications to improve clarity, such as the use of powers of ten notation. A few typographic flaws in the original were corrected, such as square-root symbols which did not always extend as far as necessary. Finally, two transposed digits were found and corrected in the answers in the log-log section.

For a list of abbreviations, see Appendix A.

For a grayscale version of the original document, see Appendix B.

Chapter I

READING THE SLIDE RULE SCALES

I-A THE DECIMAL POINT (d.p.)

There is no way of indicating the position of the d.p. in a number read on a slide rule scale. Only the sequence of significant digits is indicated.

I-B SIGNIFICANT DIGITS (s.d.'s)

in a number are the first non-zero digit and those following it, up to and including the last non-zero digit.

Ex: s.d.'s in italics: *6*00, *45*0, *405*00, 0.0*6*00. 0.*602*0, 0.00*16006*0.

Thus the numbers 10,500, 1,050, and .00105 are treated as the same number consisting only of the three s.d.'s 1-0-5. Likewise .002, .02, 2, 200, 2,000, etc. are treated as a number with the single s.d. "2".

NOTE: Numbers may be expressed to three places using zeros when necessary since slide rule scales can usually be read accurately to just three places.

Ex: 2 may be written 2-0-0; 69 as 6-9-0; etc.

For the location of the d.p. in the answer see Section II on page 5.

I-C PRIMARY MARKS

PRIMARY MARKS AND THE FIRST SIGNIFICANT DIGIT

The ten primary marks on each of the scales in Fig. 1 are labeled with the largest numbers (1, 2, 3, 4, 5, 6, 7, 8, 9, 1) and divide the length of a scale into nine primary spaces. The scale may run the length of the rule (*C* scale) or may be repeated several times (*A* and *K* scales) as seen on your slide rule.

A NUMBER WITH ONE SIGNIFICANT DIGIT

A number with one significant digit is located at the corresponding primary mark.

Ex: No.s 1-0-0, 2-0-0, 3-0-0, etc. are located at primary marks 1. 2, 3, etc.

I-D SECONDARY MARKS

SECONDARY MARKS AND THE SECOND SIGNIFICANT DIGIT

Secondary marks (the heavy lines in Fig. 1) form the major divisions of the space between two consecutive primary marks and may vary in number. Note in Fig. 1 and on your slide rule that nine secondary marks form ten secondary spaces. Each space is then equal to one unit in the second place of a number and s.d.'s 1 to 9 can be located on secondary marks. Four marks form only five secondary spaces, each space representing two units in the second place. This means that even digits (2, 4, 6, 8) are located on marks and odd digits (1, 3, 5, 7, 9) are located midway between marks.

A NUMBER WITH TWO SIGNIFICANT DIGITS

A number with two significant digits is located at the secondary mark or in the secondary space representing the second digit following the primary mark that represents the first digit.

Ex: 1. No. 1-8-0 is located on each scale at the eighth secondary mark following primary mark 1.

Ex: 2. No. 2-3-0 is located on each scale at the third secondary mark after primary mark 2.

Ex: 3. No. 6-2-0 on scale *K* is located at the first secondary mark after primary mark 6.

Ex: 4. 7-5-0 on scale *K* is located halfway between second secondary mark (7-4-0) and third secondary mark (7 -6-0).

I-E TERTIARY MARKS

TERTIARY MARKS AND THE THIRD DIGIT

Tertiary marks (the thin lines in Fig. 1) divide the space between two consecutive secondary marks.

A NUMBER WITH THREE SIGNIFICANT DIGITS

A number with three significant digits is located at the corresponding tertiary mark or in the tertiary space following the second digit position.

Ex: 5. No. 1-3-2. On scale *C* it is located at the second tertiary mark following position 1-3-0. On scale *A* it is located at the first tertiary mark following position 1-3-0, since each space is valued two units. On scale *K*, 1-3-2 is estimated two-fifths of the way between 1-3-0 and the next tertiary mark 1-3-5.

Ex: 6. No. 8-5-7. On scale *C* it is located two-fifths of the way between the center tertiary mark 8-5-5 and mark 8-6-0. On scale *A*, 8-5-7 is estimated at a point seven-tenths of the way between 8-5-0 and 8-6-0 since the entire space is equivalent to 10 units in the third place. On scale *K* first locate 8-5-0 midway between marks 8-4-0 and 8-6-0. Then estimate a point seven-tenths of the way between 8-5-0 and 8-6-0 to locate 8-5-7.

Ex: 7. No. 9-0-3. NOTE: When the second digit is zero the number is always located in the space between the appropriate primary mark and first secondary mark following it. No. 9-0-3. On scale *C*, located three-fifths of the way between primary mark 9 (9-0-0) and the first tertiary mark (9-0-5). On scale *A*, since there are no tertiary marks, it is located three-tenths of the way between primary mark 9 (9-0-0) and the first secondary mark (9-1-0). On scale *K*. first estimate 9-1-0; then estimate 9-0-3 at a point three-tenths of the distance between 9-0-0 and 9-1-0.

I-F THE FOURTH DIGIT OF A NUMBER

can be located only on that portion of a scale containing ten tertiary spaces.

Ex: 8. No. 1-5-5-8 is located on scale *C* eight-tenths of the way between 1-5-5-0 and 1-5-6-0.

Ex: 9. No. 1-2-0-2. NOTE: When the third digit is zero, the number is always located in the space between the appropriate secondary mark and the first tertiary mark following it. No. 1-2-0-2 on scale *C* is two-tenths of the way between 1-2-0-0 and 1-2-1-0.

I-G IF A NUMBER HAS MORE SIGNIFICANT DIGITS THAN CAN BE LOCATED ACCURATELY ON A GIVEN SCALE

it is first rounded off. See Section II on page 5.

Table I.1: SUMMARY OF VARIATIONS IN SLIDE RULE SCALE DIVISIONS

MARKS	SPACES	SPACE / VALUE	DIGIT LOCATION
9	10	1 unit	All digits located on marks.
4	5	2 units	2, 4, 6, 8 on marks; 1, 3, 5, 7, 9 half-way between marks.
1	2	5 units	5 on the mark; 1 to 4 and 6 to 9 estimated in space left or right of the mark.
0	1	10 units	All digits estimated by approximate division of the space into ten parts.

Chapter II

LOCATION OF THE DECIMAL POINT IN THE ANSWER

Found by obtaining an approximate answer (AA) as follows:

1. ROUND OFF. Set all s.d.'s but the first equal to "0".

   Ex: 1340 becomes 1000; .0609$\rightarrow$.06; 53.65$\rightarrow$50; .003006$\rightarrow$.003

   NOTE: Increase the first s.d. by one unit if the second is five or more.

   Ex: 4.62$\rightarrow$5; .987$\rightarrow$1.0

2. CONVERT TO POWERS OF TEN.

   POWERS OF TEN:
   $10^0 = 1$; $10^1 = 10$; $10^2 = 100$; $10^3 = 1000$; $10^{-1} = 0.1$; $10^{-2} = 0.01$; $10^{-3} = 0.001$; etc.
   NOTE: Negative powers of ten are the reciprocals of the corresponding powers of ten.

   Ex: $10^{-2} = 1/10^2 = 1/100 = .01$

   CONVERSION FORM:
   Numbers are written with one (or two) s.d.'s to the left of the d.p.

   Ex: $300 = 3 \times 10 \times 10 = 3 \times 10^2$

   The integer is called the multiplier. The exponent of ten is the power.

   Numbers $>$ 10: Shift the d.p. "m" places left, multiply by 10.

   Ex: $500 = 5 \times 10^2$, $6000 = 6 \times 10^3$

   Numbers $<$ 1: Shift the d.p. "m" places right and multiply by 10^{-m}.

   Ex: $0.06 = 6 \times 10^{-2}$, $0.0030 = 3 \times 10^{-3}$

3. PERFORM INDICATED OPERATIONS.

   MULTIPLICATION:
   $(N_1 \times 10^x)(N_2 \times 10^y) = (N_1 \times N_2)(10^{x+y})$.
   Exponents are added algebraically.

Ex: $(6 \times 10^2)(3 \times 10^3) = (18 \times 10^5)$

Ex: $(4 \times 10^3)(3 \times 10^{-2}) = (12 \times 10^1)$

Ex: $(7 \times 10^1)(2 \times 10^{-4}) = (14 \times 10^{-3})$

DIVISION:

$(N_1 \times 10^x) \div (N_2 \times 10^y) = (N_1 \div N_2)(10^{x-y})$.
Exponents are subtracted algebraically.

Ex: $(6 \times 10^3) \div (3 \times 10^2) = (2 \times 10^1)$

Ex: $(8 \times 10^4) \div (4 \times 10^4) = (2 \times 10^0) = 2$

Ex: $(9 \times 10^1) \div (3 \times 10^{-5}) = (3 \times 10^{1-(-5)}) = (3 \times 10^6)$

POWERS:

$(N \times 10^x)^y = (N^y)(10^{xy})$.
Exponents are multiplied algebraically.

Ex: $(2 \times 10^3)^2 = (2^2 \times 10^{3\times 2}) = (4 \times 10^6)$

Ex: $(2 \times 10^{-3})^3 = (8 \times 10^{-9})$

ROOTS:

$\sqrt[y]{(N \times 10^x)} = (\sqrt[y]{N} \times 10^{x/y})$.
Exponents are divided algebraically.

Ex: $\sqrt{400} = \sqrt{4 \times 10^2} = \sqrt{4} \times 10^{2/2} = 2 \times 10^1$

Ex: $\sqrt{.0004} = \sqrt{(4 \times 10^{-4})} = (2 \times 10^{-2})$

Ex: $\sqrt[3]{27,000} = \sqrt[3]{(27 \times 10^3)} = (3 \times 10^1)$

4. CONVERT ANSWERS BACK TO DECIMAL NOTATION.

$(N \times 10^m)$**:** Shift the decimal point "m" places right.

Ex: $(6 \times 10^3) = 6000$

Ex: $(5.4 \times 10^1) = 54$

$(N \times 10^{-m})$**:** Shift decimal point “m” places left.

Ex: $(7.14 \times 10^{-2}) = 0.0714$

Ex: $(.0600 \times 10^{-1}) = .006$

COMBINED OPERATIONS:

Ex:

$$\frac{3.02 \times 120 \times \sqrt{392}}{1.15 \times (30.6)^2}$$

AA:

$$\begin{aligned}
\frac{(3 \times 10^0)(1 \times 10^2)(\sqrt{(4 \times 10^2)})}{(1 \times 10^0)(3 \times 10^1)^2} &= \\
\frac{3 \times 1 \times 2}{1 \times 9} \times 10^{(0+2+\frac{2}{2}-0-(1\times 2))} &= \\
(\frac{2}{3} \times 10^1) &= 6.67
\end{aligned}$$

Chapter III

MULTIPLICATION

III-A SCALES USED

The *C* on the slide and the *D* on the body extend the length of the rule. The left and right "1" marks are called the left and right *C* and *D* indices. (*LC1* , *RC1* ; *LD1* , *RD1*)

III-B SLIDE RULE OPERATION (SRO)

$N_1 \times N_2 = P$**:** Set the left *C* index over the first number N_1 on the *D* scale. Move the hairline (*HLN*) to the second number N_2 on the *C* scale. Read the product P under the hairline on the *D* scale.

Ex: 2×3

SRO: Set *LC1* over *D*2. Move *HLN* to *C*3. Read product under the *HLN* at *D*6.

ANS: 6.

NOTE: If in the second step, N_2 cannot be positioned on the *C* scale, set the right *C* index over N_1 instead.

Ex: 2×9

SRO: If *LC1* is set over *D*2, *C*9 is off scale; therefore, set *RC1* over *D*2. Move *HLN* to *C*9. Read product under *HLN* at *D*1-8.

ANS: 18

III-C COMPLETE OPERATION

Ex: 21×320

AA: Round off and express as powers of ten; $21 \to 20 = (2 \times 10^1)$; $320 \to 300 = (3 \times 10^2)$. Perform the indicated operation; multiply: $(2 \times 10^1) \times (3 \times 10^2) = (6 \times 10^3) = 6000$.

SRO: Set *LC1* on *D*2-1. Move *HLN* to *C*3-2. Read the product under the *HLN* at *D*6-7-2.

ANS: Since AA = 6000, the true answer is 6,720.

Ex: 0.0855×4120

AA: $(9 \times 10^{-2}) \times (4 \times 10^3) = (36 \times 10^1) = 360$

SRO: *RC1* on *D*8-5-5, *HLN* to *C*4-1-2. Product under *HLN* at *D*3-5-2.

ANS: 352

Ex: 0.442×11.6

AA: $(4 \times 10^{-1}) \times (1 \times 10^1) = (4 \times 10^0) = 4$

SRO: *LC1* on *D*4-4-2, *HLN* to *C*1-1-6. Product under *HLN* at *D*5-1-2.

ANS: 5.12

III-D PERCENTAGES

x% of $N = (x) \times (N) \times (10^{-2})$.

Ex: 50% of $12 = 50 \times 12 \times 10^{-2} = 600 \times 10^{-2} = 6$

Ex: 6.4% of .036

AA: $6 \times (4 \times 10^{-2}) \times 10^{-2} = (24 \times 10^{-4}) = .0024$

SRO: Set *RC1* over *D*6-4. Move *HLN* to *C*3-6. Read under *HLN*, *D*2-3.

ANS: 0.0023

III-E CONTINUED PRODUCTS

$N_1 \times N_2 \times N_3 = P$.

SRO: Multiply the first two factors $(N_1 \times N_2 = P_a)$. Multiply this partial product by the next factor $(P_a \times N_3 = P_b)$. Continue multiplying each partial product by the next factor until the final product is obtained.

Ex: $6.4 \times .088 \times 12.3$

AA: $6 \times (9 \times 10^{-2}) \times (1 \times 10^{1})) = 5.4$

SRO: It is not necessary to read any of the partial products. Set *RC1* over *D*6-4. Move *HLN* to *C*8-8. Bring *LC1* under the *HLN*. Move *HLN* to *C*1-2-3. The final product is under *HLN* at *D*6-9.

ANS: 6.9

Chapter IV

DIVISION

IV-A SCALES USED

are *C* and *D*.

IV-B SRO

$N_1 \div N_2 = Q$**.** Set hairline over the numerator N_1 on *D* scale. Bring the denominator N_2 on the *C* scale under the hairline. Read quotient Q under whichever *C* index falls on the *D* scale.

Ex: $6 \div 3$

SRO: Set *HLN* on *D*6. Bring *C*3 under *HLN*. Read quotient under *LC1* at *D*2.

ANS: 2

Ex: $62 \div 305$

AA: $(6 \times 10^1) \div (3 \times 10^2) = (2 \times 10^{-1}) = 0.2$

SRO: Set *HLN* on 05.2. Bring *C*3-0-5 under *HLN*. Read quotient under *LC1* at *D*2-0-3.

ANS: 0.203

Ex: $17.55 \div 0.00203$

AA: $(2 \times 10^1) \div (2 \times 10^{-3}) = (1 \times 10^4) = 10,000$

SRO: *HLN* on *D*1-7-5-5. Bring *C*2-0-3 under *HLN*. Under *RC1* read *D*8-6-4.

ANS: 8,640

Chapter V

COMBINED MULTIPLICATION AND DIVISION

V-A ONE FACTOR IN NUMERATOR OR DENOMINATOR

Perform sequence multiplication then division.

Form: $N_1 \times N_2 \times N_3 \times \cdots \div N_d$

Or: $(N_n \div N_1) \times N_2 \times N_3 \ldots$

V-B SEVERAL FACTORS IN NUMERATOR AND DENOMINATOR

Perform multiplication and division operations alternately whenever possible since the least number of slide rule motions will then be required.

Form:

$$\frac{N_1 \times N_2}{N_3 \times N_4}$$

Perform as: $N_1 \div N_3 \times N_2 \div N_4$

Form:

$$\frac{N_1 \times N_2 \times N_3 \times N_4}{N_5 \times N_6}$$

Perform as: $N_1 \times N_2 \div N_5 \times N_3 \div N_6 \times N_4$

Form:

$$\frac{N_1 \times N_2}{N_3 \times N_4 \times N_5}$$

Perform as: $N_1 \div N_3 \times N_2 \div N_4 \div N_5$

Ex:

$$\frac{2.02 \times 120 \times 0.0925}{1.15 \times 0.81}$$

AA:

$$\frac{2 \times (1 \times 10^2) \times (9 \times 10^{-2})}{1 \times (8 \times 10^{-1})} = 18 \div 8 \times 10^1 \cong 20$$

SRO: It is not necessary to read any intermediate results. Perform as 2-0-2 $\div$ 1-1-5 $\times$ 1-2-0 $\div$ 8-1 $\times$ 9-2-5.

1. Divide: Set *HLN* on *D*2-0-2. Bring *C*1-1-5 under *HLN*.
2. Multiply: Move *HLN* to *C*1-2-0.
3. Divide: Bring *C*8-1-0 under *HLN*.
4. Multiply: Move bin to *C*9-2-5.
5. Read under *HLN*, *D*2-4-1.

ANS: 24.1

(See also Section VII on page 16.)

Chapter VI

PROPORTIONS ON THE SLIDE RULE

VI-A PRINCIPLE

Any pair of numbers set opposite each other on the *C* and *D* (or *CF* and *DF*) scales are in the same proportion as any other pair of numbers found opposite each other along the entire length of the scales.

Ex: Set *C*1 over *D*2; the proportion is 1 to 2 (written also 1/2 or 1:2); read on the scales *C*2 opposite *D*4, *C*3 opposite *D*6, etc.

VI-B FORMATION OF PROPORTIONS

A whole number may be divided by 1.

Ex: $6 = 2.6/x$ solve as $6/1 = 2.6/x$

Any factor in the numerator (denominator) of one ratio may be transferred to the denominator (numerator) of the other.

Ex: $6 = \frac{2.4 \times 9.4}{x}$ solve as $\frac{6}{9.4} = \frac{2.4}{x}$ or $\frac{x}{2.4} = \frac{9.4}{6}$; etc.

VI-C MULTIPLE PROPORTIONS

Ex:

$$\frac{.0202}{.182} = \frac{x}{.3} = \frac{4.5}{y} \qquad \frac{(\text{Set numerators on } \boldsymbol{C})}{(\text{Set denominators on } \boldsymbol{D})}$$

AA:

$$x = (2 \times 10^{-2}) \times (3 \times 10^{-1}) \div (2 \times 10^{-1}) = (3 \times 10^{-2}) = .03$$
$$y = (5) \times (2 \times 10^{-1}) \div (2 \times 10^{-2}) = (5 \times 10^{1}) = 50$$

SRO: Set *C*2-0-2 over *D*1-8-2. Move *HLN* to *D*3; read *C*3-3-3. Move *HLN* to *C*4-5; read *D*4-0-5.

ANS: x = .0333; y = 40.5

Chapter VII

FOLDED SCALES

VII-A SCALES

The *CF*, a folded *C* scale is on the slide; the *DF*, a folded *D* scale, is on the body. Both scales have a single index in the center. Their extreme right and left ends are labeled π.

VII-B PRINCIPLE

Operations performed on the *C* and *D* scales are simultaneously being performed on the *CF* and *DF* scales.

VII-C APPLICATIONS

When numbers can not be conveniently matched because of their position on the *C* and *D* scales: the operation can be transferred to the folded scales. The calculation can either be completed on the folded scales or returned to the *C* and *D* scales at will.

NOTE: When the answer is to be found under an index, it can be read under either the *CF* or *C* indices; but when the answer is to be found under the hairline, it must be read on the scale concerned.

Ex: $(18 \div 4) \times 11$

AA: $(20 \div 4) \times 10 = 50$

SRO:

1. Divide: Over *D*1-8 set *C*4; quotient is then under *RC1* at *D*4-5.
2. Multiply: Move hairline to *C*1-1; since 1-1 is off scale, it would be necessary to switch *LC1* over 4-5 to bring 1-1 back on scale. Instead, note that *DF*4-5 is over *CF1*. Then, merely move *HLN* to *CF*1-1 and read under *HLN*, *DF*4-9-5.

ANS: 49.5

Multiplication by π:

SRO: Set N on D under HLN, read $\pi \times N$ on DF.

Ex: Opposite 3 on D read $3\pi = 9.42$ on DF.

Division by π:

SRO: Set N on DF under HLN, read $N \div \pi$ on D.

Ex: Opposite 4 on DF read $4 \div \pi = 1.273$ on D.

NOTE: Circumference (on DF) = $\pi \times$ diameter (on D); diameter (on D) = circumference (on DF)$/\pi$

Chapter VIII

RECIPROCAL (or INVERSE) SCALES

VIII-A SCALES

The *CI*, on the slide, is an inverted *C* scale, and reads from right to left. The *CIF* (above the *CI*) is a folded *CI* scale having a single index in the center of the scale.

VIII-B RECIPROCALS

Definition:

The reciprocal of the number N equals 1/N; also written as N^{-1}.

Ex: $5^{-1} = 1/5 = .200$

Properties:

Division by N can be replaced by multiplication by 1/N, $a \div N = a \times 1/N$.

Ex: $6 \div 3 = 6 \times 1/3 = 2$

Multiplication by N can be replaced by division by $1/N$. $a \times N = a \div 1/N$.

Ex: $4 \times 2 = 4 \div 1/2 = 8$

VIII-C USING THE RECIPROCAL SCALES

To obtain a reciprocal:

SRO: Set N on scale *C* under the hairline, read 1/N on the scale *CI*. If N is on the *CF*, $1/N$ is read from the *CIF* scale.

Ex: Find $1/246$

AA: $1/246 \rightarrow 1/200 = (1/2 \times 10^{-2}) = (.5 \times 10^{-2}) = .005$

SRO: Set *C*2-4-6 under *HLN* and read *CI*4-0-6

ANS: 0.00406

To reduce slide motions in multiply and divide when factors are widely separated:

Remember: When using the *CI* answers are read on *D*; with the *CIF*, answers are read on the *DF*.

Ex: $12 \div 7.5$ **— Perform as** 12×7.5^{-1}

SRO: Set *LC1* over *D*1-2. Move *HLN* to *CI*7-5. Read under *HLN*, *D*1-6.

ANS: 1.6

Ex: 12×9.1 **— Perform as** $12 \div 9.1^{-1}$

SRO: Set *HLN* over *D*1-2. Bring *CI*9-1 under *HLN*. Read under *RC1* , *D*1-0-9-2.

ANS: 109.2

NOTE: 12×9.1 could also have been calculated with the *CF* and *DF*.

To simplify combined operations by permitting complete alternation of multiply and divide operations:

NOTE: The proficient use of the *CI* and *CIF* scales is of fundamental importance in fast computation.

Ex: $2.1 \times 14 \times 6.6 \div 0.073$

AA: $(2 \times 10 \times 7) \div (7 \times 10^{-2}) = 140 \div (7 \times 10^{-2}) = (20 \times 10^{2}) = 2000$

SRO: Perform as $2.1 \times 1.4 \div 6.6^{-1} \times 7.3^{-1}$

1. Multiply: Set *LC1* over *D*2-1, move *HLN* to *C*1-4.
2. Divide: Bring *CI*6-6 under *HLN*.
3. Multiply: Set *HLN* on *CI*7-3. Read under *HLN*, *D*2-6-6.

ANS: 2660

Chapter IX

COMBINED OPERATIONS — FOLDED AND INVERSE SCALES

NOTE: With the combined use of folded and inverse scales, a minimum number of slide and *HLN* shifts is required.

Ex: $2 \times 1.4 \times 6.2 \times 7 \times 0.51$

AA: $2 \times 1 \times 6 \times 7 \times (5 \times 10^{-1}) = 42$

SRO: Perform as $2 \times 1.4 \div 6.2^{-1} \times 7 \div 0.51^{-1}$

1. Multiply: Set *LC1* on *D*2, *HLN* on *C*1-4.
2. Divide: Bring *CI*6-2 under *HLN*.
3. Multiply. Since *C*7 is off scale, set *HLN* on *CF*7.
4. Divide: Bring *CIF*5-1 under *HLN*. Read under *CF* index, *DF*6-2.

ANS: 62

Ex: $6.04 \times .051 \times 86 \div 2.64$

AA: $6 \times (5 \times 10^{-2}) \times 8 \times 10 \div 2 = 12$

SRO: Perform as $6.04 \times .051 \div 86^{-1} \times 2.64^{-1}$

1. Multiply. Set *LC1* at *D*6-0-4, *HLN* on *C*5-1.
2. Divide: Bring *CI*8-6 under *HLN*.
3. Multiply: Set *HLN* on *CIF*2-6-4. Read under *HLN*, *DF*1-0-0-2.

ANS: 10.02

Chapter X

SQUARES

X-A SCALES USED

D and *C* with the *A* and *B* (or $\sqrt{\ }$) scales. The *A* on the body and *B* on the slide each contain two scales, similar to, but 1/2 the length of the *D*. (Two full-length scales may replace the *A* and *B*.)

X-B SRO

$N \to N^2$. Set hairline over N on *D* scale and read N^2 under hairline on *A* scale (or set hairline over N on *C* scale and read N^2 under hairline on *B* scale).

Ex: 3^2

SRO: Set him over *D*3, read under *HLN*, *A*9.

ANS: 9

Ex: $(41)^2$

AA: $(4 \times 10^1)^2 = (16 \times 10^2) = 1600$

SRO: *HLN* on *D*4-1, read under *HLN*, *A*1-6-8.

ANS: 1680

Ex: $(.115)^2$

AA: $(1 \times 10^{-1})^2 = (1 \times 10^{-2}) = .01$

SRO: *HLN* on *D*1-1-5: read under *HLN*, *A*1-3-2.

ANS: 0.0132

Ex: $(613)^2$

AA: $(6 \times 10^2)^2 = (36 \times 10^4) = 360,000$

SRO: *HLN* on *D*6-1-3; read under *HLN*, *A*3-7-6.

ANS: 376,000

X-C SRO

Set hairline on N on $\sqrt{}$ scale. Read N^2 on *D*.

Ex: $(6.1)^2$

SRO: Set *HLN* on 6-1 on $\sqrt{}$ scale; read *D*3-7-2.

ANS: 37.2

Chapter XI

CUBES

XI-A SCALES USED

The *D* with *K* (or $\sqrt[3]{\ }$ scales. The *K* on the body is composed of three scales. similar to, but each 1/3 the length of the *D*. (Three full-length scales may replace the *K*.)

XI-B SRO

$N \to N^3$. Set hairline over N on *D* scale; read N^3 under hairline on *K* scale.

Ex: 2^3

SRO: Set *HLN* over *D*2; read under *HLN*, *K*8.

ANS: 8

Ex: $(0.117)^3$

AA: $(0.117)^3 \cong (1 \times 10^{-1})^3 = .001$

SRO: *HLN* on *D*1-1-7, read under *HLN*, *K*1-6-1

ANS: .00161

Chapter XII

SQUARE ROOTS

XII-A SCALES USED

Same as for squares.

XII-B FORM OF N

Must have either one or two digits left of the d.p. Otherwise, re-write N with an even power of ten

$$\cdots, 10^{-4}, 10^{-2}, 10^{0}, 10^{2}, 10^{4}, \cdots$$

such that one or two digits are placed left of the d.p. in the multiplier. Then, take the square root of this power of ten.

Ex: $\sqrt{400} = \sqrt{(4 \times 10^2)} = \sqrt{4} \times 10^1$

Ex: $\sqrt{0.00225} = \sqrt{(22.5 \times 10^{-4})} = (\sqrt{22.5} \times 10^{-2})$

The square root of the multiplier is found on the slide rule as follows:

XII-C SRO

$N \to \sqrt{N}$ — Set the hairline over N located on the proper section of the *A* or *B* scales as shown:

No. of digits left of the d.p. in the multiplier	1	2
Root location on section of *A* or *B* scale	left (1st)	right (2nd)

Read $\sqrt{N}$ under the hairline on the *D* scale if N is set on *A* (or on the *C* scale is N is set on *B*).

XII-D SRO

Set hairline on N on *D*.

Read $\sqrt{N}$ on upper or lower $\sqrt{\ }$ scale if N has one or two digits left of the d.p.

XII-E DECIMAL POINT LOCATION

Always place the d.p. after the first digit of the number read from the slide rule. When the square root is multiplied by a power of ten, move the d.p. the indicated number of places.

Ex: $\sqrt{900}$

Form: $\sqrt{900} = \sqrt{(9 \times 10^2)} = (\sqrt{9} \times 10^1)$

SRO: *HLN* on *A*9 (left section). Read under *HLN* *D*3-0-0.

D.P.: (3.0×10^1)

ANS: 30

Ex: $\sqrt{25}$

Form: $\sqrt{25}$ is already in the proper form.

SRO: Set *HLN* on *A*2-5 (right section). Read under *HLN*, *D*5-0-0.

D.P.: 5.0

ANS: 5.0

Ex: $\sqrt{415} = \sqrt{(4.15 \times 10^2)} = (\sqrt{4.15} \times 10^1)$

SRO: Set *HLN* on *A*4-1-5 (left section). Read under *HLN*, *D*2-0-4.

D.P.: (2.04×10^1)

ANS: 20.4

Ex: $\sqrt{0.00365} = \sqrt{(36.5 \times 10^{-4})} = (\sqrt{36.5} \times 10^{-2})$

SRO: Set *HLN* on *A*3-6-5 (right section). Read under *HLN*, *D*6-0-4.

D.P.: (6.04×10^{-2})

ANS: 0.0604

Ex: $\sqrt{52.4}$

SRO: Set *HLN* on *D*5-2-4; read 7 2-4 on lower $\sqrt{\ }$ scale.

ANS: 7.24

Chapter XIII

CUBE ROOTS

XIII-A SCALES USED

Same as for cubes.

XIII-B FORM OF N

Must have either one, two, or three digits to the left of the d.p. Otherwise, rewrite N with a power of ten that is a multiple of three

$$\cdots, 10^{-6}, 10^{-3}, 10^{0}, 10^{3}, 10^{6}, \cdots$$

such that one, two, or three digits are placed to the left of the d.p. in the multiplier. Then, take the cube root of this power of ten.

Ex: $\sqrt[3]{27000} = \sqrt[3]{(27 \times 10^3)} = (\sqrt[3]{27} \times 10^1)$

Ex: $\sqrt[3]{.0000157} = \sqrt[3]{(15.7 \times 10^{-6})} = (\sqrt[3]{15.7} \times 10^{-2})$

The cube root of the multiplier is found on the slide rule as follows:

XIII-C SRO

$N \to N^3$ — Set the hairline over N on the proper section of the K scale as shown:

No. of digits left of the d.p. in the multiplier	1	2	3
Root location on section of L scale	left (1st)	middle (2nd)	right (3rd)

Read $\sqrt[3]{N}$ under the hairline on the D scale.

XIII-D SRO

Set N on D.

Read $\sqrt[3]{N}$ on upper, middle or lower $\sqrt[3]{\ }$ scale if N has one, two, or three digits left of the d.p.

XIII-E THE LOCATION OF THE DECIMAL POINT

Always place the d.p. after the first digit of the number read from the slide rule.

When the cube root is multiplied by a power of ten, move the d.p. the indicated number of places.

Ex: $\sqrt[3]{4150}$

Form: $\sqrt[3]{4150} = \sqrt[3]{(4.15 \times 10^3)} = (\sqrt[3]{4.15} \times 10^1)$

SRO: Set hairline on K4-1-5 (left section). Read under hlm, D1-6-0-5.

D.P.: (1.605×10^1)

ANS: 16.05

Ex: $\sqrt[3]{0.000068}$

Form: $\sqrt[3]{0.000068} = \sqrt[3]{(68.0 \times 10^{-6})} = (\sqrt[3]{68.0} \times 10^{-2})$.

SRO: Set *HLN* on K6-8-0 (middle section). Read under *HLN*, D4-0-8.

D.P.: $(4.08 \times 10^{-2}) = 0.0408$

Ex: $\sqrt[3]{47.3}$

SRO: Set *HLN* on D4-7-3; read 3-6-1-5 on middle $\sqrt[3]{\ }$ scale.

ANS: 3.615

Chapter XIV

COMBINED OPERATIONS: SQUARES OR SQUARE ROOTS

These problems can be solved without first finding the required roots or powers using the following methods.

XIV-A SQUARE ROOTS

Write all roots in the proper form (see Section XII on page 24). Perform the multiply and divide operations in the usual manner on the scales previously described but when the square root of a number N is needed: on the *C* (moving) scale, set the hairline over N on the proper section of the *B* (moving) scale; on the *D* (fixed) scale, set the hairline over N on the proper section of the *A* (fixed) scale.

Ex: $2 \times \sqrt{9}$

SRO: Set *LC1* at *D*2. Since the root is required on the *C* scale set *HLN* on *B*9 (left section). Read under *HLN*, *D*6.

ANS: 6

Ex: $\sqrt{16} \div 2$

SRO: Since root is required on the *D* scale set *HLN* on *A*1-6 (right section). Bring *C*2 under *HLN*. Read under *LC1* , *D*2.

ANS: 2

Ex: $2.06 \times \sqrt{.062} \div \sqrt{916}$

Form: $2.06 \times \sqrt{(6.2 \times 10^{-2})} \div \sqrt{(9.16 \times 10^{2})}$

AA: $2 \times (2 \times 10^{-1}) \div (3 \times 10^{1}) \cong .01$

SRO: Set *LC1* at *D*2-0-6. Set *HLN* over *B*6-2 (left section). Bring *B*9-1-6 (left section) under *HLN*. Read under *LC1* , *D*1-6-9-5.

ANS: 0.01695

XIV-B SQUARES

Multiply and divide may be performed on the *A* and *B* scales exactly as on the *C* and *D* scales. When the square of a number N is needed: on the *B* (moving) scale, set the hairline over N on the *C* (moving) scale; on the *A* (fixed) scale, set the hairline over N on the *D* (fixed) scale.

Ex: 2×3^2

SRO: Set *LB1* at *A*2. Set *HLN* on *C*3. Read under *HLN*, *A*1-8.

ANS: 18

Ex: $6^2 \div 4$

SRO: Set *HLN* on *D*6. Bring *B*4 under *HLN*. Read under *B*1, *A*9.

ANS: 9

Ex: $(4.1)^2 \div (6.8)^2 \times 2$

AA: $20 \div 50 \times 2 = 0.800$

SRO: Set *HLN* on *D*4-1. Bring *C*6-8 under *HLN*. Set *HLN* on *B*2 and read under *HLN* *A*7-2-7.

ANS: 0.727

XIV-C MIXED SQUARE ROOTS AND SQUARES

For the roots, use the rules in Section XIV-A, but compute the squares as a repeated product (see Section III-E on page 10).

Ex: $6 \times \sqrt{9} \times 2^2$, performed as $6 \times \sqrt{9} \times 2 \times 2$

Chapter XV

LOGARITHMS

XV-A SCALES USED

The *L* and *D* both on the body. The *L* scale has eleven primary marks labeled, 0, 0.1, 0.2, 0.3, etc. to 1 forming 10 equal primary spaces. The value of secondary and tertiary divisions is similar to the other scales.

XV-B COMPUTING LOGS

To determine the characteristic. C: Write N in powers of ten placing one digit to the left of the d.p. of the multiplier. C = the value of the exponent.

To determine the mantissa, M: Set the hairline over N on *D* scale, read M under the hairline on *L* scale.

Ex: $\log 36$

C: $36 = (3.6 \times 10^1); C = +1$

M: Set hairline on *D*3-6: read $M = 0.556$ on *L*.

ANS: $\log 36 = 1 + .556 = 1.556$

Ex: $\log 0.0622$

C: $.0622 = (6.22 \times 10^{-2}); C = -2$

M: Set hairline on *D*6-2-2; read $M = 0.794$ on *L*.

ANS: $\log 0.0622 = -2 + 0.794$ written as 8. $794 - 10$ or $\bar{2}.794$

XV-C ANTI-LOGS

Given the logarithm of N, find N.

SRO: Set the mantissa on *L*, read N on *D*.

D.P. location: Place the d.p. to the right of the first digit read from the slide rule. Convert the characteristic to a power of ten then move the d.p. the indicated number of places.

Ex: Given $\log N = 9.583 - 10$**, find N.**

SRO: Set .583 on *L*, read under *HLN* *D*3-8-3.

D.P.: Write 3.83. Since $C = 9 - 10 = -1$; $N = (3.83 \times 10^{-1}) = 0.383$

Chapter XVI

TRIGONOMETRIC FUNCTIONS

XVI-A SCALES

The *S* scale for sines and cosines; the *T* scale for tangents (or cotangents) and the *ST* scale for the sine or tangent of small angles.

XVI-B READING THE SCALES

Angles (θ) measured in degrees, are indicated by the numbered marks. On many slide rules, the *S* and *T* scales have two angles associated with the numbered marks: θ (values of θ increase from left to right) and $(90^\circ - \theta)$; values of $(90^\circ - \theta)$ increase from right to left and are sometimes printed in red.

Ex: On the *S* scale, mark: $\underline{70|20}$ represents both $\theta = 20^\circ$ and $(90^\circ - \theta) = 70^\circ$.

Angles not numbered on the scale are positioned by counting the number of primary marks in the space between labeled angles.

Ex: 24° is located on the fourth primary mark between labeled angles 20° and 25°.

Fractions of angles are located between primary marks and may be expressed either in tenths of degrees or minutes (60 min. = 1 deg.) depending upon the make of the slide rule.

	DEGREES			MINUTES		
Number of marks	1	4	9	1	2	5
Number of spaces	2	5	10	2	3	6
Value of space	0.5	0.2	0.1	$30'$	$20'$	$10'$

XVI-C SLIDE RULE OPERATIONS

SIN θ

θ	0.57° to 5.7°	*ST*
$\sin\theta$	0.01 to 0.1	*C*

SRO: Set *HLN* on θ on scale *ST*, read the value of $\sin\theta$ under *HLN* on scale *C*.

D.P.: Place 1 zero between the d.p. and the first digit.

Ex: $\sin 1.62°$

SRO: Set *HLN* on 1.62° on *ST*, read *D*2-8-2.

ANS: 0.0282

Ex: $\sin 3°14'$

SRO: Set *HLN* on 3°14′ on *ST*; read *C*5-6-4.

ANS: 0.0564

θ	5.7° to 90°	*S*
$\sin\theta$	0.1 to 1.0	*C*

NOTE: Use the numbers on the *S* scale which represent θ (usually to the right of the numbered marks). The scale reads from 5.7° on the left, to 90° on the right. The single mark between 80° and 90° represents 85°.

SRO: Set *HLN* on θ on *S*, read value of $sin\theta$ under *HLN* on *C*.

D.P.: Place to the left of the first digit.

Ex: $\sin 20°$

SRO: Set 20 on *S* at $\underline{70|20}$, read *C*3-4-2.

ANS: 0.342

Ex: $\sin 22.3^\circ$ **(**$22^\circ 20'$**)**

SRO: Set *HLN* on 22.3° ($22^\circ 20'$) on *S*, read *C*3-8-0.

ANS: 0.380

NOTE: $\sin 81^\circ$ is 0.988: $\sin 85^\circ$ is 0.996; $\sin 89^\circ$ is 0.999.

COS θ

θ	84.3° to 0°	*S*
$\cos\theta$	0.1 to 1.0	*C*

NOTE: Since $\sin\theta = \cos(90 - \theta)$, the graduations on the *S* scale to the left of the numbered marks, representing $(90^\circ - \theta)$, are used for the cosines of the angles. The cosine scale reads from 0° on the right to 84.3° on the left. The single mark between 0° and 10° represents 5° for the cosine (and also $(90^\circ - 5^\circ) = 85^\circ$ for the sine).

SRO: Set *HLN* on θ on *S*, read value of the cos under *HLN* on *C*.

D.P.: Place to the left of first digit.

Ex: $\cos 65^\circ$

SRO: Set *HLN* on 65° on *S* at $\underline{65|25}$; read *C*4-2-2.

ANS: 0.422

Ex: $\cos 66.4^\circ$

SRO: Set *HLN* on 66.4° on *S*, read *C*4-0-1.

ANS: 0.401

Ex: $\cos 4^\circ$

SRO: Set *HLN* on 4° on *S* by dividing the space between 0° and 5° by eye, read *C*9-9-7.

ANS: 0.997

θ	89.4° to 84.3°	*ST*
$\cos\theta$	.01 to 0.1	*C*

SRO: Using the relationship $\sin\theta = \cos(90^\circ - \theta)$, set $(90^\circ - \theta)$ on scale ST; read cos value on C.

D.P.: Place one zero between the d.p. and the first digit.

Ex: $\cos 86^\circ$

SRO: Set $(90^\circ - 86^\circ)$ or 4° on ST, read C6-9-7.

ANS: 0.0697

TAN θ

θ	0.57° to 5.7°	ST
$\tan\theta$	.01 to 0.1	C

SRO: Set θ on ST, read value of $\tan\theta$ from the C scale.

D.P.: Place one zero between the d.p. and the first digit.

Ex: $\tan 3.5^\circ$

SRO: Set 3.5° on ST, read C6-1-1.

ANS: 0.0611

θ	5.7° to 45°	T
$\tan\theta$	0.1 to 1.0	C

NOTE: Use the graduation on the T scale to the right of the numbered marks, which represent θ. The scale reads from 5.7° on the left, to 45° on the right.

SRO: Set θ on T, read the value of $\tan\theta$ on scale C.

D.P.: Place to the left of the first digit.

Ex: $\tan 11^\circ$

SRO: Set 11° on T at $\underline{79|11}$, read C1-9-4.

ANS: 0.194

Ex: $\tan 11.7^\circ$ **($11^\circ 40'$)**
SRO: Set 11.7° ($11^\circ 40'$) on T, read C2-0-7.
ANS: 0.207

θ	45° to 84.3°	T
$\tan\theta$	1.0 to 10	CI

NOTE: Use the graduations on the T scale to the left of the numbered marks, which represent $(90^\circ - \theta)$. This scale reads from 45° on the right, to 84.3° on the left.

SRO: Using the relationship $\tan\theta = 1 \div \tan(90^\circ - \theta)$, set θ on T and read the value of $\tan\theta$ from the CI scale. If there is no CI scale, use $\tan\theta = 1 \div \tan(90^\circ - \theta)$.

D.P.: Place after the first digit.

Ex: $\tan 55^\circ$
SRO: Set 55° on T at $\underline{55\vert 35}$, read CI1-4-3.
ANS: 1.43

Ex: $\tan 52.5^\circ$
SRO: Set 52.5° on T, read CI1-3-0-3.
ANS: 1.303

θ	84.3° to 89.4°	ST
$\tan\theta$	10 to 100	CI

SRO: Using relationship $\tan\theta = 1 \div \tan(90^\circ - \theta)$, set $(90^\circ - \theta)$ on ST scale and read the value of $\tan\theta$ from the CI scale.

D.P.: Place after the second digit.

Ex: $\tan 86^\circ$
SRO: Set $(90^\circ - 86^\circ)$ or 4° on ST; read CI1-4-3.
ANS: 14.3

XVI-D COMBINED TRIGONOMETRIC OPERATIONS

Multiplication and division involving trigonometric functions may be performed without recording the value of these functions by using the *S*. *T*, and *ST* scales exactly as the *C* scale. This is possible since the angles on the *S*, *T*, and *ST* scales are in line with the corresponding trigonometric functions of these angles on the *C* scale and the right and left indices on the trigonometric scales are in line with the indices on the *C* scale.

Ex: $2.3 \times \sin 8°$

AA: $\sin 8° \cong 0.1$, $2 \times \sin 8° \cong 0.2$

SRO: Set *LC1* on *D*2-3. Set *HLN* on *S*8°. Read *D*3-2 under *HLN*.

ANS: 0.32

Ex: $0.315 \div \tan 39°$

AA: $\tan 39° \cong 1; 0.3 \div \tan 39° \cong 0.3$

SRO: Set *HLN* on *D*3-1-5. Bring *T*39° under *HLN*. Read *D*3-8-9 under RT1.

ANS: 0.389

Ex: $6.38 \times (\cos 58°)^2 \div 0.132$

AA: $\cos 58° \cong 0.5; 6 \times (0.5)^2 \div .1 \cong 15$

SRO: Use *A* and *B* scales. (See Section XIV-B on page 30) Set *RB1* at *A*6-3-8. Set *HLN* on *S*58° (cosine marking). Bring *B*1-3-2 under *HLN*. Read *A*1-3-6 on *B* index.

ANS: 13.6

Chapter XVII

LOG LOG SCALES

XVII-A DESCRIPTIONS

The scales labeled *LL1*, *LL2*, *LL3* cover numbers > 1. Numbers < 1 are on the reciprocal scales which may be labeled *LL01*, *LL02*, etc; or *LL1-*, *LL2-*, etc.; *LL/1*, *LL/2*, etc.; or *LL0* and *LL00*. All scales are read with the d.p. in the printed position.

XVII-B APPLICATIONS

To find natural logarithms ($\log_e N$ or $\ln N$):

SRO: Set hairline on N on appropriate *LL* scale. Read $\log_e$ under hairline on *D* (or *DF/M* scale).

D.P.: Located by the exponent range (or first digit position) of the *LL* scale used: N on *LL1*, $\log_e N$ on *D* has two decimal places (.01→0.1 or 0.0D); on *LL2*, one decimal place; on *LL3*, one digit left of the d.p. in $\log_e N$.

Ex: $\log_e 12.2$

SRO: Set *HLN* on 12.2 on *LL3*. Read under *HLN D* (or *DF/M*) 2-5-0.

ANS: 2.50

Ex: $\log_e 0.98$

SRO: Set *HLN* on 0.98 on *LL01* (or *LL1-*). Read under *HLN D* (or *DF/M*) 2-0-2.

ANS: Since exponent range on *LL01* is -0.01 to -0.1 (or on *LL1-*, first digit position is -0.0D) answer is -0.0202

NOTE: On slide rules having only the *LL0* and *LL00*, read $\log_e N$ on the *A* instead of the *D* scale.

D.P.: N on *LL0*, use AA = N-1; N on *LL00*, left half of *A* scale is -0.D: right half is -D.0

Ex: $\log_e 0.97$

SRO: Set *HLN* on 0.97 on *LL0*. Read under *HLN A*3-0-5.

AA: $0.97 - 1 = -0.03$

ANS: -0.0305

Ex: $\log_e 0.50$

SRO: Set *HLN* on 0.50 on *LL00*. Read under *HLN* 6-9-5 on left half of *A*.

ANS: -0.695

To find non-integer powers and roots:

SRO: $N^x = P$ or $\sqrt[x]{N} = Q$. Calculate AA. Set hairline on N on appropriate *LL* scale, then set a *C* index under the hairline. Move hairline to x on *C* scale for powers, to x on *CI* scale for roots. Read under hairline on appropriate *LL* scale as indicated by the AA.

Ex: 4^2

SRO: Set *HLN* on 4 on *LL3*. Set *LC1* under *HLN*. Set *HLN* on *C*2. Read 16 on *LL3*.

Ex: $6.2^{-2.1}$

AA: $6^{-2} = 1 \div 36 = 0.03$

SRO: Set *HLN* on 6.2 on *LL3*. Set *LC1* under *HLN*. Move *HLN* to *C*2-1; read 0.0217 under *HLN* on *LL03*, (or *LL/3*, or *LL3-*).

Ex: $\sqrt[4.1]{30}$

AA: $\sqrt[4]{30} = 2.3$.

SRO: Set *HLN* on 3 on *LL3*. Set *LC1* under *HLN*. Move *HLN* to *CI*4-1.

ANS: Read 2.29 under *HLN* on *LL2*.

NOTE: On rules having only two reciprocal scales (*LL0*, *LL00*), use instead of scale *C*, scale *B* (or *A*) with the correct half to employ determined by the AA. Furthermore, negative powers of N can only be solved by first evaluating the positive reciprocal.

Ex: $6.2^{-2.1} = 1/(6.2)^{2.1} = (0.162)^{2.1}$

AA: $(0.16)^2 = 0.026$

SRO: Set *HLN* on 0.162 on *LL0*. Set central *B*1 under *HLN*. Set *HLN* on 2-1 on *right* half of *B* scale.

ANS: Read 0.0217 under *HLN* on *LL00*.

Appendix A

GLOSSARY

Notations in this document include:

Ex: An example.

Form: How to re-arrange the question in order to facilitate slide rule operations.

AA: An approximate answer. This is the rough estimate used to determine the final order of magnitude of a calculation.

SRO: Slide rule operations. What steps are done to arrive at the answer.

D.P.: Where to set the decimal point.

M:, C: The mantissa and characteristic of a power-of-ten notation number. $(M \times 10^C)$

ANS: The final answer.

Scales Slide rule scales are italicized, such as scale "*C*".

Markings Slide rule readings are indicated such as "*C*4-3" for primary mark 4 and secondary mark 3 on scale *C*.

HLN The slide rule's hairline, also italicized as *HLN*.

Appendix B

ORIGINAL DOCUMENT

The following pages are a grayscale version of the original document. The original colors were as shown on the title page.

Data-Guide's®
SOLID PLASTIC REFERENCE CHARTS

Slide Rule Guide

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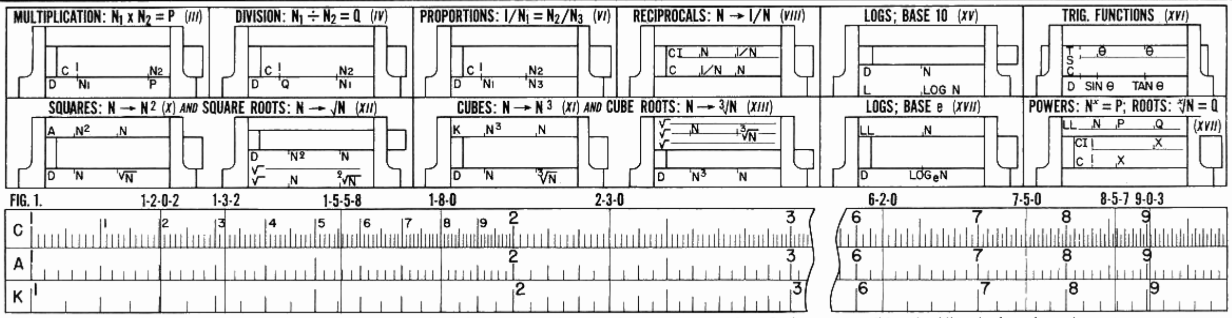

NOTE: The C, A, and K scales shown above are not in their proper length proportion as you can see by referring to your slide rule. All scales have been drawn to equal length to more clearly illustrate the respective differences in scale division and to simplify the mastery of the number location method explained in Sec. I.

I. READING THE SLIDE RULE SCALES

A. THE DECIMAL POINT (d.p.). There is no way of indicating the position of the d.p. in a number read on a slide rule scale. Only the sequence of *significant digits* is indicated.

B. SIGNIFICANT DIGITS (s.d.'s.) in a number are the first non-zero digit and those following it, up to and including the last non-zero digit. **Ex:** s.d.'s in italics: *6*00, *45*0, *405*00, 0.0*6*00, 0.*602*0, 0.00*16006*0. Thus the numbers 10,500, 1,050, and .00105 are treated as the same number consisting only of the three s.d.'s 1-0-5. Likewise .002, .02, 2, 200, 2,000, etc. are treated as a number with the single s.d. 2. **NOTE:** Numbers may be expressed to three places using zeros when necessary since slide rule scales can usually be read accurately to just three places. **Ex:** 2 may be written 2-0-0; 69 as 6-9-0; etc. For the location of the d.p. in the answer see Section II.

C-1. PRIMARY MARKS AND THE FIRST SIGNIFICANT DIGIT
The ten primary marks on each of the scales in Fig. 1 are labeled with the largest numbers (1, 2, 3, 4, 5, 6, 7, 8, 9, 1) and divide the *length of a scale into nine primary spaces.* The scale may run the length of the rule (C scale) or may be repeated several times (A and K scales) as seen on your slide rule.

C-2. A NUMBER WITH ONE SIGNIFICANT DIGIT IS LOCATED AT THE CORRESPONDING PRIMARY MARK. **Ex:** No.'s 1-0-0, 2-0-0, 3-0-0, etc. are located at primary marks 1, 2, 3, etc.

D-1. SECONDARY MARKS AND THE SECOND SIGNIFICANT DIGIT. Secondary marks (the heavy lines in Fig. 1) form the major divisions of the space between two consecutive primary marks and may vary in number. Note in Fig. 1 and on your slide rule that nine secondary marks form ten secondary spaces. Each space is then equal to one unit in the second place of a number and s.d.'s 1 to 9 can be located on secondary marks. Four marks form only five secondary spaces, each space representing two units in the second place. This means that even digits (2, 4, 6, 8) are located on marks and odd digits (1, 3, 5, 7, 9) are located midway between marks.

D-2. A NUMBER WITH TWO SIGNIFICANT DIGITS IS LOCATED AT THE SECONDARY MARK OR IN THE SECONDARY SPACE REPRESENTING THE SECOND DIGIT FOLLOWING THE PRIMARY MARK THAT REPRESENTS THE FIRST DIGIT.

Ex: 1. No. 1-8-0 is located on each scale at the eighth secondary mark following primary mark 1.

Ex: 2. No. 2-3-0 is located on each scale at the third secondary mark after primary mark 2.

Ex: 3. No. 6-2-0 on scale K is located at the first secondary mark after primary mark 6.

Ex: 4. 7-5-0 on scale K is located halfway between second secondary mark (7-4-0) and third secondary mark (7-6-0).

E-1. TERTIARY MARKS AND THE THIRD DIGIT. Tertiary marks (the thin lines in Fig. 1) divide the space between two consecutive secondary marks.

E-2. A NUMBER WITH THREE SIGNIFICANT DIGITS IS LOCATED AT THE CORRESPONDING TERTIARY MARK OR IN THE TERTIARY SPACE FOLLOWING THE SECOND DIGIT POSITION.

Ex: 5. No. 1-3-2. On scale C it is located at the second tertiary mark following position 1-3-0. On scale A it is located at the first tertiary mark following position 1-3-0, since each space is valued two units. On scale K, 1-3-2 is estimated two-fifths of the way between 1-3-0 and the next tertiary mark 1-3-5.

Ex: 6. No. 8-5-7. On scale C it is located two-fifths of the way between the center tertiary mark 8-5-5 and mark 8-6-0. On scale A, 8-5-7 is estimated at a point seven-tenths of the way between 8-5-0 and 8-6-0 since the entire space is equivalent to 10 units in the third place. On scale K first locate 8-5-0 midway between marks 8-4-0 and 8-6-0. Then estimate a point seven-tenths of the way between 8-5-0 and 8-6-0 to locate 8-5-7.

Ex: 7. No. 9-0-3. **NOTE:** When the second digit is zero the number is always located in the space between the appropriate primary mark and first secondary mark following it. No. 9-0-3. On scale C, located three-fifths of the way between primary mark 9 (9-0-0) and the first tertiary mark (9-0-5). On scale A, since there are no tertiary marks, it is located three-tenths of the way between primary mark 9 (9-0-0) and the first secondary mark (9-1-0). On scale K, first estimate 9-1-0; then estimate 9-0-3 at a point three-tenths of the distance between 9-0-0 and 9-1-0.

F. THE FOURTH DIGIT OF A NUMBER can be located only on that portion of a scale containing ten tertiary spaces.

Ex: 8. No. 1-5-5-8 is located on scale C eight-tenths of the way between 1-5-5-0 and 1-5-6-0.

Ex: 9. No. 1-2-0-2. **NOTE:** When the third digit is zero, the number is always located in the space between the appropriate secondary mark and the first tertiary mark following it. No. 1-2-0-2 on scale C is two-tenths of the way between 1-2-0-0 and 1-2-1-0.

G. IF A NUMBER HAS MORE SIGNIFICANT DIGITS THAN CAN BE LOCATED ACCURATELY ON A GIVEN SCALE, it is first rounded off. See II.

SUMMARY OF VARIATIONS IN SLIDE RULE SCALE DIVISIONS

MARKS	SPACES	SPACE/VALUE	DIGIT LOCATION
9	10	1 unit	all digits located on marks
4	5	2 units	2, 4, 6, 8 on marks; 1, 3, 5, 7, 9 half-way between marks.
1	2	5 units	5 on the mark; 1 to 4 and 6 to 9 estimated in space left or right of the mark.
0	1	10 units	all digits estimated by approximate division of the space into ten parts.

II. LOCATION OF THE DECIMAL POINT IN THE ANSWER

Found by obtaining an approximate answer (**AA**) as follows:

STEP 1. ROUND OFF. Set all s.d.'s but the first equal to "0". **Ex:** 1340 becomes 1000; .0609→.06; 53.65→50; .003006→.003. **NOTE:** Increase the first s.d. by one unit if the second is five or more. **Ex:** 4.62→5; .987→1.0

STEP 2. CONVERT TO POWERS OF TEN

A. POWERS OF TEN $10^0 = 1;\ 10^1 = 10;\ 10^2 = 100;\ 10^3 = 1000$; etc. $10^{-1} = 0.1;\ 10^{-2} = 0.01;\ 10^{-3} = 0.001$; etc.

NOTE: Negative powers of ten are the reciprocals of the corresponding powers of ten. **Ex:** $10^{-2} = 1/10^2 = 1/100 = .01$

B. CONVERSION FORM. Numbers are written with one (or two) s.d.'s to the left of the d.p. **Ex:** $300 = 3 \times 10 \times 10 = 3 \times 10^2$ The integer is called the multiplier. The exponent of ten is the power. Numbers > 10· Shift the d.p. "m" places left, multiply by 10^m. **Ex:** $500 = 5 \times 10^2$; $6000 = 6 \times 10^3$ Numbers < 1· Shift the d.p. "m" places right and multiply by 10^{-m}. **Ex:** $0.06 = 6 \times 10^{-2}$, $0.0030 = 3 \times 10^{-3}$

STEP 3. PERFORM INDICATED OPERATIONS

A. MULTIPLICATION. $(N_1 \times 10^x)(N_2 \times 10^y) = (N_1 \times N_2)(10^{x+y})$. Exponents are added algebraically. **Ex:** $(6 \times 10^2)(3 \times 10^3) = 18 \times 10^5$ **Ex:** $(4 \times 10^3)(3 \times 10^{-2}) = 12 \times 10^1$ **Ex:** $(7 \times 10^1)(2 \times 10^{-4}) = 14 \times 10^{-3}$

B. DIVISION. $(N_1 \times 10^x) \div (N_2 \times 10^y) = (N_1 \div N_2)(10^{x-y})$. Exponents are subtracted algebraically. **Ex:** $(6 \times 10^3) \div (3 \times 10^2) = 2 \times 10^1$ **Ex:** $(8 \times 10^4) \div (4 \times 10^4) = 2 \times 10^0 = 2$ **Ex:** $(9 \times 10^1) \div (3 \times 10^{-5}) = 3 \times 10^{(1)-(-5)} = 3 \times 10^6$

C. POWERS. $(N \times 10^x)^y = (N^y)(10^{xy})$. Exponents are multiplied algebraically. **Ex:** $(2 \times 10^3)^2 = 2^2 \times 10^{3 \times 2} = 4 \times 10^6$ **Ex:** $(2 \times 10^{-3})^3 = 8 \times 10^{-9}$

D. ROOTS. $\sqrt[y]{N \times 10^x} = \sqrt[y]{N} \times 10^{x/y}$. Exponents are divided algebraically. **Ex:** $\sqrt{400} = \sqrt{4 \times 10^2} = \sqrt{4} \times 10^{2/2} = 2 \times 10^1$ **Ex:** $\sqrt{.0004} = \sqrt{4 \times 10^{-4}} = 2 \times 10^{-2}$ **Ex:** $\sqrt[3]{27{,}000} = \sqrt[3]{27 \times 10^3} = 3 \times 10^1$

STEP 4. CONVERT ANSWERS BACK TO DECIMAL NOTATION

A. $N \times 10^m$: Shift the d.p. "m" places right. **Ex:** $6 \times 10^3 = 6000$ **Ex:** $5.4 \times 10^1 = 54$

B. $N \times 10^{-m}$: Shift decimal point "m" places left. **Ex:** $7.14 \times 10^{-2} = 0.0714$ **Ex:** $.0600 \times 10^{-1} = .006$

C. COMBINED OPERATIONS

$$\frac{3.02 \times 120 \times \sqrt{392}}{1.15 \times (30.6)^2} \quad AA: \frac{(3 \times 10^0)(1 \times 10^2)(\sqrt{4 \times 10^2})}{(1 \times 10^0)(3 \times 10^1)^2} = \frac{3 \times 1 \times 2}{1 \times 9} \times 10^{\left(0+2+\frac{2}{2}-0-(1\times 2)\right)} = 2/3 \times 10^1 = 6.67$$

III. MULTIPLICATION

A. SCALES USED. The C on the slide and the D on the body extend the length of the rule. The left and right "1" marks are called the left and right C and D indices. ($LC1$, $RC1$; $LD1$, $RD1$)

B. SLIDE RULE OPERATION (SRO) $N_1 \times N_2 = P$. Set the left C index over the first number N_1 on the D scale. Move the hairline (**hln**) to the second number N_2 on the C scale. Read the product P under the hairline on the D scale. **Ex:** 2×3 SRO: Set $LC1$ over $D2$. Move hln to $C3$. Read product under the hln at $D6$. ANS: 6. NOTE: If in the second step, N_2 cannot be positioned on the C scale, set the right C index over N_1 instead. **Ex:** 2×9. SRO: If $LC1$ is set over $D2$, $C9$ is off scale; therefore, set $RC1$ over $D2$. Move hln to $C9$. Read product under hln at $D1$-8. ANS: 18

C. COMPLETE OPERATION **Ex:** 21×320 AA: Round off and express as powers of ten; $21 \to 20 = 2 \times 10^1$; $320 \to 300 = 3 \times 10^2$. Perform the indicated operation; *multiply:* $(2 \times 10^1)(3 \times 10^2) = 6 \times 10^3 = 6000$. SRO: Set $LC1$ on $D2$-1. Move hln to $C3$-2. Read the product under the hln at $D6$-7-2. ANS: Since AA = 6000, the true answer is 6,720. **Ex:** 0.0855×4120 AA: $(9 \times 10^{-2})(4 \times 10^3) = 36 \times 10^1 = 360$ SRO: $RC1$ on $D8$-5-5, hln to $C4$-1-2. Product under hln at $D3$-5-2. ANS: 352 **Ex:** 0.442×11.6 AA: $(4 \times 10^{-1})(1 \times 10^1) = 4 \times 10^0 = 4$ SRO: $LC1$ on $D4$-4-2, hln to $C1$-1-6. Product under hln at $D5$-1-2. ANS: 5.12

D. PERCENTAGES. $x\%$ **of** $N = (x) \times (N) \times (10^{-2})$. **Ex:** 50% of $12 = 50 \times 12 \times 10^{-2} = 600 \times 10^{-2} = 6$ **Ex:** 6.4% of .036 AA: $6 \times (4 \times 10^{-2}) \times 10^{-2} = 24 \times 10^{-4} = .0024$ SRO: Set $RC1$ over $D6$-4. Move hln to $C3$-6. Read under hln, $D2$-3. ANS: 0.0023

E. CONTINUED PRODUCTS. $N_1 \times N_2 \times N_3 = P$. SRO Multiply the first two factors ($N_1 \times N_2 = P_a$). Multiply this partial product by the next factor ($P_a \times N_3 = P_b$). Continue multiplying each partial product by the next factor until the final product is obtained. **Ex:** $6.4 \times .088 \times 12.3$; AA: $6 \times (9 \times 10^{-2}) \times (1 \times 10^1) = 5.4$ SRO: It is not necessary to read any of the partial products. Set $RC1$ over $D6$-4. Move hln to $C8$-8. Bring $LC1$ under the hln. Move hln to $C1$-2-3. The final product is under hln at $D6$-9. ANS: 6.9

IV. DIVISION.

A. SCALES USED are C and D.

B. SRO· $N_1 \div N_2 = Q$. Set hairline over the numerator N_1 on D scale. Bring the denominator N_2 on the C scale under the hairline. Read quotient Q under whichever C index falls on the D scale. **Ex:** $6 \div 3$ SRO: Set hln on $D6$. Bring $C3$ under hln. Read quotient under $LC1$ at $D2$. ANS: 2 **Ex:** $62 \div 305$ AA: $(6 \times 10^1) \div (3 \times 10^2) = 2 \times 10^{-1} = 0.2$. SRO: Set hln on $D6$-2. Bring $C3$-0-5 under hln. Read quotient under $LC1$ at $D2$-0-3. ANS: 0.203 **Ex:** $17.55 \div 0.00203$ AA: $(2 \times 10^1) \div (2 \times 10^{-3}) = 1 \times 10^4 = 10{,}000$ SRO: hln on $D1$-7-5-5. Bring $C2$-0-3 under hln. Under $RC1$ read $D8$-6-4. ANS: 8,640

V. COMBINED MULTIPLICATION AND DIVISION

A. ONE FACTOR IN NUM. OR DENOM. Perform sequence mult. then division. **Form:** $N_1 \times N_2 \times N_3 \ldots\ldots \div N_d$ or $(N_n \div N_1) \times N_2 \times N_3 \ldots\ldots$

B. SEVERAL FACTORS IN NUM. AND DENOM. Perform mult. and div. operations alternately whenever possible since the least number of slide rule motions will then be required. **Form:** $\frac{N_1 \times N_2}{N_3 \times N_4}$ perform as $N_1 \div N_3 \times N_2 \div N_4$; $\frac{N_1 \times N_2 \times N_3 \times N_4}{N_5 \times N_6}$ perform as $N_1 \times N_2 \div N_5 \times N_3 \div N_6 \times N_4$; $\frac{N_1 \times N_2}{N_3 \times N_4 \times N_5}$ perform as $N_1 \div N_3 \times N_2 \div N_4 \div N_5$; etc.

Ex: $\frac{2.02 \times 120 \times 0.0925}{1.15 \times 0.81}$ AA: $\frac{2 \times (1 \times 10^2) \times (9 \times 10^{-2})}{1 \times (8 \times 10^{-1})} = 18 \div 8 \times 10^1 \cong 20$ SRO: It is not necessary to read any intermediate results. Perform as 2-0-2 ÷ 1-1-5 × 1-2-0 ÷ 8-1 × 9-2-5. *Divide:* Set hln on $D2$-0-2. Bring $C1$-1-5 under hln. *Multiply:* Move hln to $C1$-2-0. *Divide:* Bring $C8$-1-0 under hln. *Multiply:* Move hln to $C9$-2-5. Read under hln, $D2$-4-1. ANS: 24.1 (See also Sec. VII.)

VI. PROPORTIONS ON THE SLIDE RULE

A. PRINCIPLE. Any pair of numbers set opposite each other on the C and D (or CF and DF) scales are in the same proportion as any other pair of numbers found opposite each other along the entire length of the scales. **Ex:** Set $C1$ over $D2$; the proportion is 1 to 2 (written also 1/2 or 1:2); read on the scales $C2$ opposite $D4$, $C3$ opposite $D6$, etc.

B. FORMATION OF PROPORTIONS. A whole number may be divided by 1. **Ex:** $6 = 2.6/x$ solve as $6/1 = 2.6/x$ Any factor in the num. (*denom.*) of one ratio may be transferred to the denom. (*num.*) of the other. **Ex:** $6 = \frac{2.4 \times 9.4}{x}$ solve as $\frac{6}{9.4} = \frac{2.4}{x}$ or $\frac{x}{2.4} = \frac{9.4}{6}$; etc.

C. MULTIPLE PROPORTIONS. **Ex:** $\frac{.0202}{.182} = \frac{x}{.3} = \frac{4.5}{y}$ $\frac{\text{(Set nums on } C)}{\text{(Set denoms on } D)}$ AA: $x = (2 \times 10^{-2}) \times (3 \times 10^{-1}) \div (2 \times 10^{-1}) = 3 \times 10^{-2} = .03$; $y = (5) \times (2 \times 10^{-1}) \div (2 \times 10^{-2}) = 5 \times 10^1 = 50$. SRO: Set $C2$-0-2 over $D1$-8-2. Move hln to $D3$; read $C3$-3-3. Move hln to $C4$-5; read $D4$-0-5. ANS: $x = .0333$; $y = 40.5$

VII. FOLDED SCALES

A. SCALES. The CF, a folded C scale is on the slide; the DF, a folded D scale, is on the body. Both scales have a single index in the center. Their extreme right and left ends are labeled π.

B. PRINCIPLE. Operations performed on the C and D scales are simultaneously being performed on the CF and DF scales.

C. APPLICATIONS

When numbers can not be conveniently matched because of their position on the C and D scales, the operation can be transferred to the folded scales. The calculation can either be completed on the folded scales or returned to the C and D scales at will. **NOTE:** When the answer is to be found under an index, it can be read under either the CF or C indices; but when the answer is to be found under the hairline, it must be read on the scale concerned. **Ex:** $(18 \div 4) \times 11$. AA: $(20 \div 4) \times 10 = 50$. SRO: *Divide:* Over $D1$-8 set $C4$; quotient is then under $RC1$ at $D4$-5. *Multiply:* Move hairline to $C1$-1; since 1-1 is off scale, it would be necessary to switch $LC1$ over 4-5 to bring 1-1 back on scale. Instead, note that $DF4$-5 is over $CF1$. Then, merely move hln to $CF1$-1 and read under hln, $DF4$-9-5. ANS: 49.5

Multiplication by π. SRO· Set N on *D* under hln, read $\pi \times$ N on *DF*. **Ex:** Opposite 3 on *D* read $3\pi = 9.42$ on *DF*.

Division by π. SRO: Set N on *DF* under hln, read N $\div \pi$ on *D*. Opposite 4 on *DF* read $4/\pi = 1.273$ on *D*. **NOTE:** Circumference (on *DF*) $= \pi \times$ diameter (on *D*); diameter (on *D*) = circumference (on *DF*)$/\pi$.

VIII. RECIPROCAL (or INVERSE) SCALES

A. SCALES. The *CI*, on the slide, is an inverted *C* scale, and reads from right to left. The *CIF* (above the *CI*) is a folded *CI* scale having a single index in the center of the scale.

B. RECIPROCALS. Definition. The reciprocal of the number N equals 1/N; also written as N^{-1}. **Ex:** $5^{-1} = 1/5 = .200$

Properties. Division by N can be replaced by multiplication by 1/N. $a \div N = a \times 1/N$. **Ex:** $6 \div 3 = 6 \times 1/3 = 2$ Multiplication by N can be replaced by division by 1/N. $a \times N = a \div 1/N$. **Ex:** $4 \times 2 = 4 \div 1/2 = 8$

C. USING THE RECIPROCAL SCALES

To obtain a reciprocal. SRO: Set N on scale *C* under the hairline, read 1/N on the scale *CI*. If N is on the *CF*, 1/N is read from the *CIF* scale. **Ex:** Find 1/246 AA: $1/246 \rightarrow 1/200 = 1/2 \times 10^{-2} = .5 \times 10^{-2} = .005$ SRO Set *C*2-4-6 under hln and read *CI*4-0-6 ANS: 0.00406

To reduce slide motions in mult. and div. when factors are widely separated. *Remember:* When using the *CI* answers are read on *D*; with the *CIF*, answers are read on the *DF*. **Ex:** $12 \div 7.5$ Perform as 12×7.5^{-1} SRO: Set *LC*1 over *D*1-2. Move hln to *CI*7-5. Read under hln, *D*1-6. ANS: 1.6 **Ex:** 12×9.1 Perform as $12 \div 9.1^{-1}$ SRO: Set hln over *D*1-2. Bring *CI*9-1 under hln. Read under *RC*1, *D*1-0-9-2. ANS: 109.2 **NOTE:** 12×9.1 could also have been calculated with the *CF* and *DF*.

To simplify combined operations by permitting complete alternation of mult. and div. operations. **NOTE:** The proficient use of the *CI* and *CIF* scales is of fundamental importance in fast computation. **Ex:** $2.1 \times 14 \times 6.6 \div 0.073$ AA: $(2 \times 10 \times 7) \div (7 \times 10^{-2}) = 140 \div 7 \times 10^{-2} = 20 \times 10^2 = 2000$ SRO: Perform as $2\text{-}1 \times 1\text{-}4 \div 6\text{-}6^{-1} \times 7\text{-}3^{-1}$ *Multiply:* Set *LC*1 over *D*2-1, move hln to *C*1-4. *Divide:* Bring *CI*6-6 under hln. *Multiply:* Set hln on *CI*7-3. Read under hln, *D*2-6-6. ANS: 2660

IX. COMBINED OPERATIONS· FOLDED AND INVERSE SCALES

NOTE: With the combined use of folded and inverse scales, a minimum number of slide and hln shifts is required. **Ex:** $2 \times 1.4 \times 6.2 \times 7 \times 0.51$ AA: $2 \times 1 \times 6 \times 7 \times (5 \times 10^{-1}) = 42$ SRO: Perform as $2 \times 1.4 \div 6.2^{-1} \times 7 \div 0.51^{-1}$ *Multiply:* Set *LC*1 on *D*2, hln on *C*1-4. *Divide:* Bring *CI*6-2 under hln. *Multiply:* Since *C*7 is off scale, set hln on *CF*7. *Divide:* Bring *CIF*5-1 under hln. Read under *CF* index, *DF*6-2. ANS: 62 **Ex:** $6.04 \times .051 \times 86 \div 2.64$ AA: $6 \times (5 \times 10^{-2}) \times 8 \times 10 \div 2 = 12$ SRO: Perform as $6.04 \times .051 \div 86^{-1} \times 2.64^{-1}$ *Multiply:* Set *LC*1 at *D*6-0-4, hln on *C*5-1. *Divide:* Bring *CI*8-6 under hln. *Multiply:* Set hln on *CIF*2-6-4. Read under hln, *DF*1-0-0-2. ANS: 10.02

X. SQUARES.

A. SCALES USED. *D* and *C* with the *A* and *B* [or $\sqrt{\ }$] scales. The *A* on the body and *B* on the slide each contain two scales, similar to, but ½ the length of the *D*. [Two full-length $\sqrt{\ }$ scales may replace the *A* and *B*.]

B. SRO: $N \rightarrow N^2$. Set hairline over N on *D* scale and read N^2 under hairline on *A* scale (or set hairline over N on *C* scale and read N^2 under hairline on *B* scale). **Ex:** 3^2 SRO: Set hln over *D*3, read under hln, *A*9. ANS: 9 **Ex:** $(41)^2$ AA: $(4 \times 10^1)^2 = 16 \times 10^2 = 1600$ SRO: hln on *D*4-1, read under hln, *A*1-6-8. ANS: 1680. **Ex:** $(.115)^2$ AA: $(1 \times 10^{-1})^2 = 1 \times 10^{-2} = .01$ SRO: hln on *D*1-1-5; read under hln, *A*1-3-2. ANS: 0.0132 **Ex:** $(613)^2$ AA: $(6 \times 10^2)^2 = 36 \times 10^4 = 360{,}000$ SRO: hln on *D*6-1-3; read under hln, *A*3-7-6. ANS: 376,000. **C. SRO:** Set hairline on N on $\sqrt{\ }$ scale. Read N^2 on *D*. **Ex:** 6.1^2 SRO: Set hln on 6-1 on $\sqrt{\ }$ scale; read *D*3-7-2. ANS: 37.2

XI. CUBES.

A. SCALES USED. The *D* with *K* [or $\sqrt[3]{\ }$] scales. The *K* on the body is composed of three scales, similar to, but each ⅓ the length of the *D*. [Three full-length $\sqrt[3]{\ }$ scales may replace the *K*.]

B. SRO: $N \rightarrow N^3$. Set hairline over N on *D* scale; read N^3 under hairline on *K* scale. **Ex:** 2^3 SRO: Set hln over *D*2; read under hln, *K*8. ANS: 8 **Ex:** $(0.117)^3$ AA: $(0.117)^3 = (1 \times 10^{-1})^3 = .001$ SRO: hln on *D*1-1-7, read under hln, *K*1-6-1 ANS: .00161

XII. SQUARE ROOTS.

A. SCALES USED. Same as for squares.

B. FORM OF N. Must have either one or two digits left of the d.p. Otherwise, re-write N with an even power of ten ($10^{\cdots -4, -2, 0, 2, 4 \cdots}$) such that one or two digits are placed left of the d.p. in the multiplier. Then, take the square root of this power of ten. **Ex:** $\sqrt{400} = \sqrt{4 \times 10^2} = \sqrt{4} \times 10$. **Ex:** $\sqrt{0.00225} = \sqrt{22.5 \times 10^{-4}} = \sqrt{22.5} \times 10^{-2}$. The square root of the multiplier is found on the slide rule as follows.

C. SRO: $N \rightarrow \sqrt{N}$. Set the hairline over N located on the proper section of the *A* or *B* scales as shown:

No. of digits left of the d.p. in the multiplier	1	2
Root location on section of *A* or *B* scale	left (1st)	right (2nd)

Read $\sqrt{N}$ under the hairline on the *D* scale if N is set on *A* (or on the *C* scale is N is set on *B*). **D. SRO:** Set hairline on N on *D*.

Read $\sqrt{N}$ on upper or lower $\sqrt{\ }$ scale if N has one or two digits left of the d.p.

E. DECIMAL POINT LOCATION. Always place the d.p. after the first digit of the number read from the slide rule. When the square root is multiplied by a power of ten, move the d.p. the indicated number of places. **Ex:** $\sqrt{900}$ *Form:* $\sqrt{900} = \sqrt{9 \times 10^2} = \sqrt{9} \times 10^1$ SRO: hln on *A*9 (left section). Read under hln *D*3-0-0. D.P.: 3.0×10^1 ANS: 30 **Ex:** $\sqrt{25}$ *Form:* $\sqrt{25}$ is already in the proper form. SRO: Set hln on *A*2-5 (right section). Read under hln, *D*5-0-0. D.P.: 5.0 ANS: 5.0 **Ex:** $\sqrt{415} = \sqrt{4.15 \times 10^2} = \sqrt{4.15} \times 10^1$ SRO: Set hln on *A*4-1-5 (left section). Read under hln, *D*2-0-4. D.P.: 2.04×10^1 ANS: 20.4 **Ex:** $\sqrt{0.00365} = \sqrt{36.5 \times 10^{-4}} = \sqrt{36.5} \times 10^{-2}$ SRO: hln on *A*3-6-5 (right section). Read under hln, *D*6-0-4. D.P.: 6.04×10^{-2} ANS: 0.0604 [**Ex:** $\sqrt{52.4}$ SRO: Set hln on *D*5-2-4; read 7-2-4 on lower $\sqrt{\ }$ scale. ANS: 7.24].

XIII. CUBE ROOTS.

A. SCALES USED. Same as for cubes.

B. FORM OF N. Must have either one, two, or three digits to the left of the d.p. Otherwise, rewrite N with a power of ten that is a multiple of three ($10^{\cdots -6, -3, 0, 3, 6 \cdots}$) such that one, two or three digits are placed to the left of the d.p. in the multiplier. Then, take the cube root of this power of ten. **Ex:** $\sqrt[3]{27000} = \sqrt[3]{27 \times 10^3} = \sqrt{27} \times 10^1$; $\sqrt[3]{.0000157} = \sqrt[3]{15.7 \times 10^{-6}} = \sqrt[3]{15.7} \times 10^{-2}$. The cube root of the multiplier is found on the slide rule as follows.

C. SRO: $N \rightarrow \sqrt[3]{N}$ Set the hairline over N on the proper section of the *K* scale as shown:

Digits left of the d.p. in the multiplier	1	2	3
Root location on section of *K* scale	left (1st)	middle (2nd)	right (3rd)

Read $\sqrt[3]{N}$ under the hairline on the *D* scale. **D. SRO:** Set N on *D*.

Read $\sqrt[3]{N}$ on upper, middle or lower $\sqrt[3]{\ }$ scale if N has one, two, or three digits left of the d.p.

E. THE LOCATION OF THE DECIMAL POINT. Always place the d.p. after the first digit of the number read from the slide rule.

When the cube root is multiplied by a power of ten, move the d.p. the indicated number of places. **Ex:** $\sqrt[3]{4150}$ *Form:* $\sqrt[3]{4150} = \sqrt[3]{4.15 \times 10^3} = \sqrt[3]{4.15} \times 10^1$. SRO: Set hairline on *K*4-1-5 (left section). Read under hln, *D*1-6-0-5. D.P.: 1.605×10^1 ANS: 16.05 **Ex:** $\sqrt[3]{0.000068}$ *Form:* $\sqrt[3]{0.000068} = \sqrt[3]{68.0 \times 10^{-6}} = \sqrt[3]{68.0} \times 10^{-2}$. SRO: Set hln on *K*6-8-0 (middle section). Read under hln, *D*4-0-8. D.P.: $4.08 \times 10^{-2} = 0.0408$. [**Ex:** $\sqrt[3]{47.3}$ SRO: Set hln on *D*4-7-3; read 3-6-1-5 on middle $\sqrt[3]{\ }$ scale. ANS: 3.615]

XIV. COMBINED OPERATIONS: SQUARES OR SQUARE ROOTS

These problems can be solved without first finding the required roots or powers using the following methods.

A. SQUARE ROOTS. Write all roots in the proper form (see XII:B).

Perform the mult. and div. operations in the usual manner on the scales previously described but *when the square root of a number N is needed:* on the *C* (moving) scale, set the hairline over N on the proper section of the *B* (moving) scale; on the *D* (fixed) scale, set the hairline over N on the proper section of the *A* (fixed) scale. **Ex:** $2 \times \sqrt{9}$ SRO: Set *LC*1 at *D*2. Since the root is required on the *C* scale set hln on *B*9 (left section). Read under hln, *D*6. ANS: 6 **Ex:** $\sqrt{16} \div 2 = 2$ SRO: Since root is required on the *D* scale set hln on *A*1-6 (right section). Bring *C*2 under hln. Read under *LC*1, *D*2. ANS: 2 **Ex:** $2.06 \times \sqrt{.062} \div \sqrt{916}$. *Form:* $2.06 \times \sqrt{6.2} \times 10^{-1} \div \sqrt{9.16} \times 10^1$. AA: $2 \times (2 \times 10^{-1}) \div (3 \times 10^1) \cong .01$ SRO: Set *LC*1 at *D*2-0-6. Set hln over *B*6-2 (left section). Bring *B*9-1-6 (left section) under hln. Read under *LC*1, *D*1-6-9-5. ANS: 0.01695

B. SQUARES. Mult. and div. may be performed on the *A* and *B* scales exactly as on the *C* and *D* scales. *When the square of a number N is needed:* on the *B* (moving) scale, set the hairline over N on the *C* (moving) scale; on the *A* (fixed) scale, set the hairline over N on the *D* (fixed) scale. **Ex:** 2×3^2 SRO: Set *LB*1 at *A*2. Set hln on *C*3. Read under hln, *A*1-8. ANS: 18 **Ex:** $6^2 \div 4$ SRO: Set hln on *D*6. Bring *B*4 under hln. Read under *B*1, *A*9. ANS: 9 **Ex:** $(4.1)^2 \div (6.8)^2 \times 2$ AA: $20 \div 50 \times 2 = 0.800$ SRO: Set hln on *D*4-1. Bring *C*6-8 under hln. Set hln on *B*2 and read under hln *A*7-2-7. ANS: 0.727

C. MIXED SQUARE ROOTS AND SQUARES. For the roots, use the rules in Sec. A, but compute the squares as a repeated product (see Sec. III:E). **Ex:** $6 \times \sqrt{9} \times 2^2$ performed as $6 \times \sqrt{9} \times 2 \times 2$.

XV. LOGARITHMS.

A. SCALES USED. The *L* and *D* both on the body. The *L* scale has eleven primary marks labeled, 0, 0.1, 0.2, 0.3, etc. to 1 forming 10 equal primary spaces. The value of secondary and tertiary divisions is similar to the other scales.

B. COMPUTING LOGS. To determine the characteristic, C: Write N in powers of ten placing one digit to the left of the d.p. of the multiplier. C = the value of the exponent.

To determine the mantissa, M: SRO: Set the hairline over N on *D* scale, read M under the hairline on *L* scale. **Ex:** log 36; C: $36 = 3.6 \times 10^1$; C = +1. M: Set hairline on *D*3-6; read M = 0.556 on *L*. ANS: log 36 = 1 + .556 = 1.556 **Ex:** log 0.0622; C: $.0622 = 6.22 \times 10^{-2}$; C = −2. M: Set hairline on *D*6-2-2; read M = 0.794 on *L*. ANS: log 0.0622 = −2 + 0.794 written as 8. 794 − 10 or $\bar{2}.794$.

C. ANTILOGS. Given the logarithm of N, find N. SRO: Set the mantissa on *L*, read N on *D*. D.P. location: Place the d.p. to the right of the first digit read from the slide rule. Convert the characteristic to a power of ten then move the d.p. the indicated number of places. **Ex:** Given log N = 9.583 − 10 find N. SRO: Set .583 on *L*, read under hln *D*3-8-3. D.P.: Write 3.83. Since C = 9 − 10 = −1; N = $3.83 \times 10^{-1} = 0.383$

XVI. TRIGONOMETRIC FUNCTIONS.

A. SCALES. The *S* scale for sines and cosines; the *T* scale for tangents (or cotangents) and the *ST* scale for the sine or tangent of small angles.

B. READING THE SCALES

Angles (θ), measured in degrees, are indicated by the numbered marks. On many slide rules, the *S* and *T* scales have two angles associated with the numbered marks: θ (values of θ increase from left to right) and $(90° - \theta)$; values of $(90° - \theta)$ increase from right to left and are sometimes printed in red. **Ex:** On the *S* scale, mark 70 | 20 represents both $\theta = 20°$ and $(90° - \theta) = 70°$.

Angles not numbered on the scale are positioned by counting the number of primary marks in the space between labeled angles. **Ex:** 24° is located on the fourth primary mark between labeled angles 20° and 25°.

Fractions of angles are located between primary marks and may be expressed either in tenths of degrees or minutes (60 min. = 1 deg.) depending upon the make of the slide rule.

	DEGREES			MINUTES		
Number of marks	1	4	9	1	2	5
Number of spaces	2	5	10	2	3	6
Value of space	0.5	0.2	0.1	30′	20′	10′

C. SLIDE RULE OPERATIONS

SIN θ

θ	0.57° to 5.7°	ST
sin θ	0.01 to 0.1	C

SRO Set hln on θ on scale *ST*, read the value of sin θ under hln on scale *C*. D.P.: Place 1 zero between the d.p. and the first digit. **Ex:** sin 1.62°. SRO: Set hln on 1.62° on *ST*, read *D*2-8-2. ANS: 0.0282 (**Ex:** Sin 3° 14′. SRO: Set hln on 3° 14′ on *ST*; read *C*5-6-4. ANS: 0.0564)

θ	5.7° to 90°	S
sin θ	0.1 to 1.0	C

NOTE: Use the numbers on the *S* scale which represent θ (usually to the right of the numbered marks). The scale reads from 5.7° on the left, to 90° on the right. The single mark between 80° and 90° represents 85°. SRO: Set hln on θ on *S*, read value of sin θ under hln on *C*. D.P.: Place to the left of the first digit. **Ex:** sin 20°. SRO: Set 20° on *S* at 70 | 20, read *C*3-4-2. ANS: 0.342 **Ex:** sin 22.3° (22°20′) SRO: Set hln on 22.3° (22°20′) on *S*, read *C*3-8-0. ANS: 0.380 **NOTE:** sin 81° is 0.988; sin 85° is 0.996; sin 89° is 0.999.

COS θ

θ	84.3° to 0°	S
cos θ	0.1 to 1.0	C

NOTE: Since $\sin\theta = \cos(90° - \theta)$, the graduations on the *S* scale to the left of the numbered marks, representing $(90° - \theta)$, are used for the cosines of the angles. The cosine scale reads from 0° on the right to 84.3° on the left. The single mark between 0° and 10° represents 5° for the cosine (and also $(90° - 5°) = 85°$ for the sine). SRO: Set hln on θ on *S*, read value of the cos under hln on *C*. D.P.: Place to the left of first digit. **Ex:** cos 65°. SRO: Set hln on 65° on *S* at 65 | 25; read *C*4-2-2. ANS: 0.422 **Ex:** cos 66.4°. SRO: Set hln on 66.4° on *S*, read *C*4-0-1. ANS: 0.401 **Ex:** cos 4°. SRO: Set hln on 4° on *S* by dividing the space between 0° and 5° by eye, read *C*9-9-7. ANS: 0.997

θ	89.4° to 84.3°	ST
cos θ	.01 to 0.1	C

SRO: Using the relationship $\sin\theta = \cos(90° - \theta)$, set $(90° - \theta)$ on scale *ST*; read cos value on *C*. D.P.: Place one zero between the d.p. and the first digit. **Ex:** cos 86° SRO: Set (90° − 86°) or 4° on *ST*, read *C*6-9-7. ANS: 0.0697

TAN θ

θ	0.57° to 5.7°	ST
tan θ	0.01 to 0.1	C

SRO: Set θ on *ST*, read value of tan θ from the *C* scale. D.P.: Place one zero between the d.p. and the first digit. **Ex:** tan 3.5° SRO: Set 3.5° on *ST*, read *C*6-1-1 ANS: 0.0611

θ	5.7° to 45°	T
tan θ	0.1 to 1.0	C

NOTE: Use the graduation on the *T* scale to the right of the numbered marks, which represent θ. The scale reads from 5.7° on the left, to 45° on the right. SRO: Set θ on *T*, read the value of tan θ on scale *C*. D.P.: Place to the left of the first digit. **Ex:** tan 11° SRO: Set 11° on *T* at 79 | 11, read *C*1-9-4. ANS: 0.194 **Ex:** tan 11.7° (11°40′) SRO: Set 11.7° (11°40′) on *T*, read C2-0-7. ANS: 0.207

θ	45° to 84.3°	T
tan θ	1.0 to 10	CI

NOTE: Use the graduations on the *T* scale to the left of the numbered marks, which represent $(90° - \theta)$. This scale reads from 45° on the right, to 84.3° on the left. SRO· Using the relationship $\tan\theta = 1 \div \tan(90° - \theta)$, set θ on *T* and read the value of tan θ from the *CI* scale. If there is no *CI* scale, use $\tan\theta = 1 \div \tan(90° - \theta)$. D.P.: Place after the first digit. **Ex:** tan 55°. SRO: Set 55° on *T* at 55 | 35, read *CI*1-4-3. ANS: 1.43 **Ex:** tan 52.5° SRO: Set 52.5° on *T*, read *CI*1-3-0-3. ANS: 1.303

θ	84.3° to 89.4°	ST
tan θ	10 to 100	CI

SRO: Using relationship $\tan\theta = 1 \div \tan(90° - \theta)$, set $(90° - \theta)$ on *ST* scale and read the value of tan θ from the *CI* scale. D.P.: Place after the second digit. **Ex:** tan 86° SRO: Set (90°—86°) or 4° on *ST*; read *CI*1-4-3. ANS: 14.3

D. COMBINED TRIGONOMETRIC OPERATIONS. Multiplication and division involving trigonometric functions may be performed without recording the value of these functions by using the *S*, *T*, and *ST* scales exactly as the *C* scale. This is possible since the angles on the *S*, *T*, and *ST* scales are in line with the corresponding trigonometric functions of these angles on the *C* scale and the right and left indices on the trigonometric scales are in line with the indices on the *C* scale. **Ex:** $2.3 \times \sin 8°$ AA: $\sin 8° \cong 0.1$ $2 \times \sin 8° \cong 0.2$ SRO: Set *LC*1 on *D*2-3. Set hln on *S*8°. Read *D*3-2 under hln. ANS: 0.32 **Ex:** $0.315 \div \tan 39°$ AA: tan 39° = 1; $0.3 \div \tan 39° = 0.3$ SRO: Set hln on *D*3-1-5. Bring *T*39° under hln. Read *D*3-8-9 under *RT*1. ANS: 0.389 **Ex:** $6.38 \times (\cos 58°)^2 \div 0.132$ AA: cos 58° = 0.5; $6 \times (0.5)^2 \div .1 = 15$ SRO: Use *A* and *B* scales. (See Section XIV: B.) Set *RB*1 at *A*6-3-8. Set hln on *S*58° (cosine marking). Bring *B*1-3-2 under hln. Read *A*1-3-6 on *B* index. ANS: 13.6

XVII. LOG LOG SCALES.

A. DESCRIPTION. The scales labeled *LL*1, *LL*2, *LL*3 cover numbers > 1. Numbers < 1 are on the reciprocal scales which may be labeled *LL*01, *LL*02, etc; or *LL*1–, *LL*2–, etc.; *LL*/1, *LL*/2, etc.; or *LL*0 and *LL*00. All scales are read with the d.p. in the printed position.

B. APPLICATIONS. To find natural logarithms ($\log_e$ N or ln N) SRO: Set hairline on N on appropriate *LL* scale. Read $\log_e$ under hairline on *D* [or *DF*/*M* scale]. D.P.: Located by the exponent range [or first digit position] of the *LL* scale used: N on *LL*1, $\log_e$ N on *D* has two decimal places (.01→0.1 or 0.0D); on *LL*2, one decimal place; on *LL*3, one digit left of the d.p. in $\log_e$ N. **Ex:** $\log_e 12.2$ Set hln on 12.2 on *LL*3. Read under hln *D* [or *DF*/*M*] 2-5-0. ANS: 2.50 **Ex:** $\log_e 0.98$ Set hln on 0.98 on *LL*01 [or *LL*1–]. Read under hln *D* [or *DF*/*M*] 2-0-2. ANS: Since exponent range on *LL*01 is −0.01 to −0.1 [or on *LL*1–, first digit position is −0.0D] answer is −0.0202 **NOTE:** On slide rules having only the *LL*0, and *LL*00, read $\log_e$ N on the *A* instead of the *D* scale. D.P.: N on *LL*0, use AA = N−1; N on *LL*00, left half of *A* scale is −0.D: right half is −D.0 **Ex:** $\log_e 0.97$ Set hln on 0.97 on *LL*0. Read under hln *A*3-0-5. AA: 0.97 − 1 = − 0.03 ANS: −0.0305 **Ex:** $\log_e 0.50$ Set hln on 0.50 on LL00 Read under hln 6-9-5 on left half of *A*. ANS· −0.695

To find non-integer powers and roots. SRO $N^x = P$ or $\sqrt[x]{N} = Q$. Calculate AA. Set hairline on N on appropriate *LL* scale, then set a *C* index under the hairline. Move hairline to x on *C* scale for powers, to x on *CI* scale for roots. Read under hairline on appropriate *LL* scale as indicated by the AA. **Ex:** 4^2 Set hln on 4 on *LL*3. Set *LC*1 under hln. Set hln on *C*2. Read 16 on *LL*3. **Ex:** $6.2^{-2.1}$ AA: $6^{-2} = 1 \div 36 = 0.03$ SRO: Set hln on 6.2 or *LL*3. Set *LC*1 under hln. Move hln to *C*2-1; read 0.0127 under hln on *LL*03, [or *LL*/3, or *LL*3–]. **Ex:** $\sqrt[4.1]{30}$. $\sqrt[4]{30} = 2.3$. SRO: Set hln on 3 on *LL*3. Set *LC*1 under hln. Move hln to *CI*4-1. ANS: Read 2.39 under hln on *LL*2. **NOTE:** On rules having only two reciprocal scales [*LL*0, *LL*00], use instead of scale *C*, scale *B* (or *A*) with the correct half to employ determined by the AA. Furthermore, negative powers of N can only be solved by first evaluating the positive reciprocal.
Ex: $6.2^{-2.1} = 1/(6.2)^{2.1} = (0.162)^{2.1}$ AA: $(0.16)^2 = 0.026$. SRO: Set hln on 0.162 on *LL*0. Set central *B*1 under hln. Set hln on 2-1 on *right* half of *B* scale. ANS: Read 0.0217 under hln on *LL*00.