PROPERTIES OF CIRCLES

Circumference = diameter × 3.1416.
Area = square of radius × 3.1416.
= square of diameter × 0.7854.
Side of inscribed square = diameter × 0.7071.
Side of inscribed Hexagon = radius of circle.
Length of arc = number of degrees in angle × diameter × 0.008727.
Length of chord = diameter of circle × sine of ½ included angle.
Area of sector = length of arc × ½ of radius.
Area of segment = area of sector minus area of triangle.

FORMULAS FOR AREA

Rectangle—base × altitude.
Parallelogram—base × altitude.
Triangle—½ base × altitude.
Trapezoid—½ sum of parallel sides × altitude.
Parabola—⅔ base × altitude.
Ellipse—product of major and minor diameters × 0.7854.
Regular polygon—½ sum of sides × perpendicular distance from center to sides.
Lateral area of right cylinder = perimeter of base × altitude.
Total area = lateral area + areas of ends.
Lateral area of right pyramid or cone = ½ perimeter of base × slant height.
Total area = lateral area + area of base.
Lateral area of frustum of a regular right pyramid or cone = ½ sum of peri meters of bases × slant height.
Surface area of sphere = square of diameter × 3.1416.

FORMULAS FOR VOLUME

Right or oblique prism—area of base × altitude.
Cylinder—area of base × altitude.
Pyramid or cone—½ area of base × altitude.
Sphere—cube of diameter × 0.5236.
Frustum of pyramid or cone—add the areas of the two bases and add to this the square root of the product of the areas of the bases; multiply by ⅓ of the height: $V = \frac{1}{3} h (B + b + \sqrt{B \times b})$.

IMPORTANT CONSTANTS

$\pi = 3.1416$. $\pi^2 = 9.8696$.
$\sqrt{\pi} = 1.7724$. $1 \div \pi = 0.3183$.
Base of natural logarithms = e = 2.71828.
$M = \log_{10} e = 0.43429$.
$1 \div M = \log_e 10 = 2.3026$.
$\log_e N = 2.3026 \times \log_{10} N$.
Number of degrees in 1 radian = $180 \div \pi = 57.2958$.
Number of radians in 1 degree = $\pi \div 180 = 0.01745$.

WEIGHTS AND MEASURES

Avoirdupois Weight

27 11/32 grs. = 1 dram
16 drams = 1 ounce
16 ounces = 1 pound
25 pounds = 1 quarter
4 quarters = 1 cwt.
2,000 lbs. = 1 short ton
2,240 lbs. = 1 long ton

Mariners' Measure

6 feet = 1 fathom
120 fathoms = 1 cable length
7½ cable lengths = 1 mile
5,280 ft. = 1 stat. mile
6,085 ft. = 1 naut. mile

Troy Weight

24 grains = 1 pwt.
20 pwt. = 1 ounce
12 ounces = 1 pound
Used for weighing gold, silver and jewels.

Apothecaries' Weight*

20 grains = 1 scruple
3 scruples = 1 dram
8 drams = 1 ounce
12 ounces = 1 pound

*The ounces and pound in this are the same as in Troy weight.

Long Measure

12 inches = 1 foot
3 feet = 1 yard
5½ yards = 1 rod
40 rods = 1 furlong
8 furlongs = 1 stat. mile
3 miles = 1 league

Square Measure

144 sq. in. = 1 sq. ft.
9 sq. ft. = 1 sq. yd.
30¼ sq. yds. = 1 sq. rod
40 sq. rods = 1 rood
4 roods = 1 acre
640 acres = 1 sq. mile.

Cubic Measure

1,728 cu. in. = 1 cu. ft.
128 cu. ft. = 1 cord wood
27 cu. ft. = 1 cu. yd.
40 cu. ft. = 1 ton (shpg.)
2,150.42 cu. inches = 1 standard bushel
231 cubic inches = 1 standard gallon
1 cubic foot = about four-fifths of a bushel.

Dry Measure

2 pints = 1 quart
8 quarts = 1 peck
4 pecks = 1 bushel
36 bushels = 1 chaldron

Liquid Measure

4 gills = 1 pint
2 pints = 1 quart
4 quarts = 1 gallon
31½ gallons = 1 barrel
2 barrels = 1 hogshead

Surveyors' Measure

7.92 inches = 1 link
25 links = 1 rod
4 rods = 1 chain
10 sq. chains or 160 sq. rods = 1 acre
640 acres = 1 sq. mile
36 sq. miles (6 miles sq.) = 1 township

Miscellaneous

3 inches = 1 palm
4 inches = 1 hand
6 inches = 1 span
18 inches = 1 cubit
21.8 = 1 Bible cubit
2½ ft. = 1 military pace

ENGRAVED SLIDE RULE

ACUMATH

Price 15 cents No. 44

ACUMATH

Self-Teaching Instruction Manual

MANNHEIM TYPE

SLIDE RULE

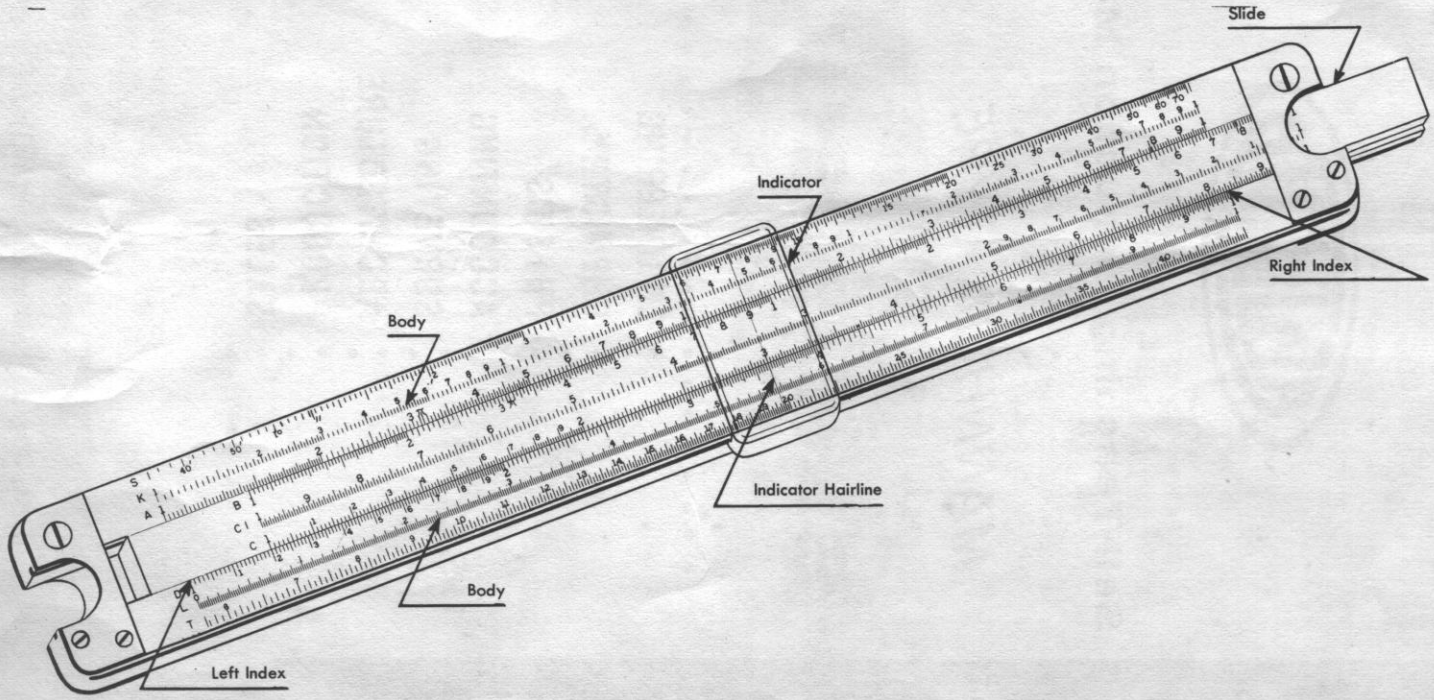
USED IN

- ENGINEERING
- CHEMISTRY
- PHYSICS
- ACCOUNTING
- SURVEYING
- ARCHITECTURE
- PRODUCTION
- SALES

PUBLISHED BY
ACU-RULE MANUFACTURING CO.
ST. LOUIS, MO. • MT. OLIVE, ILL.

DESCRIPTION OF ACU-MATH MANNHEIM TYPE SLIDE RULE

The slide rule consists of three parts: The BODY, or "stock"; the SLIDE, which moves in the grooves of the rule; and the INDICATOR.



INTRODUCTION

If this is your introduction to the use of a slide rule you will probably approach it with some doubt as to your ability to master its scales.

Be assured that you will find it a pleasant task and surprisingly simple.

Your progress will be quite rapid if you make proper use of this manual.

The slide rule is an accurate mechanical device used in solving mathematical problems involving multiplication, division, proportion, percentage, squares and square roots, cubes and cube roots, diameters, and areas, reciprocals, logarithms and exponents, trigonometric formulae, and combinations involving all of these phases of mathematics.

Accuracy will follow if the body, slide and indicator are carefully set. Factors, divisors, dividends, reciprocals, sines and so on must be carefully read on the respective scales. It is possible to obtain accuracy to three figures adequate for most practical application.

Speed in the use of this rule will follow as the result of practice, speed of operation should not be sought because it will be the natural consequence of a thorough understanding of the manipulations.

Study the directions with care and attention to details. It may be necessary to read them over several times. Have your rule handy to carry out the directions step by step as you study the rules of manipulation.

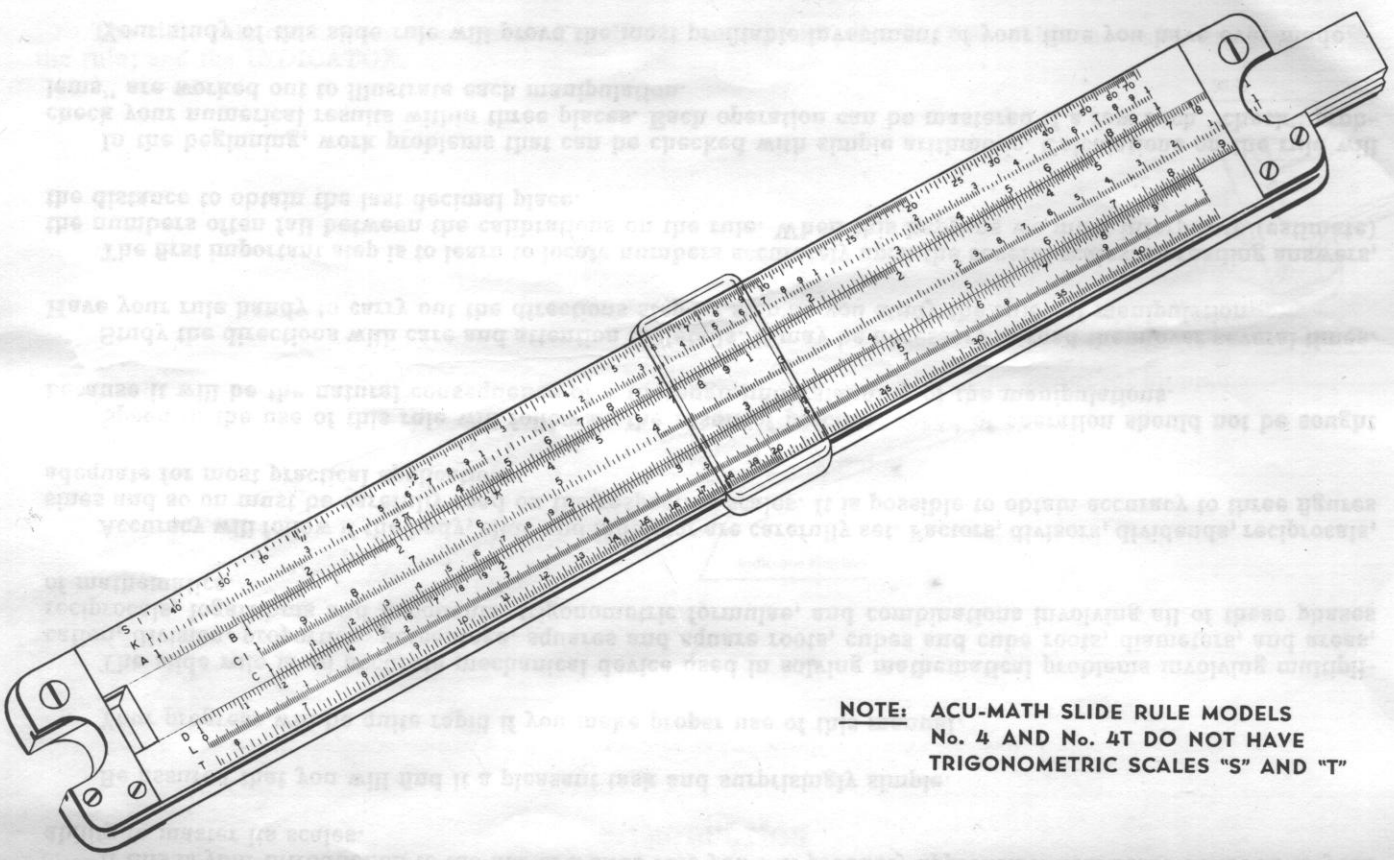
The first important step is to learn to locate numbers accurately upon the several scales. In reading answers, the numbers often fall between the calibrations on the rule. When this happens we must interpolate (estimate) the distance to obtain the last decimal place.

In the beginning, work problems that can be checked with simple arithmetic. Calculations on the rule will check your numerical results within three places. Each operation can be mastered if a few such "check" problems" are worked out to illustrate each manipulation.

Your study of this slide rule will prove the most profitable investment of your time you have ever made.

Remember that practice makes perfect, use your slide rule at every opportunity.

RELATIONSHIP OF SCALES



NOTE: ACU-MATH SLIDE RULE MODELS No. 4 AND No. 4T DO NOT HAVE TRIGONOMETRIC SCALES "S" AND "T"

The specific use of the following scales will be explained in this manual.

"S" Scale — A Trigonometric Scale used with the "C" and "D" Scales for problems involving the Sine of angles.

"K" Scale — Used with "C" and "D" Scales for finding Cubes & Cube Roots.

"A" Scale — Used with the "C" and "D" for finding Squares and Square Roots.

"B" Scale — Identical to the "A" Scale, and also used with the "C" and "D" Scales for finding Squares and Square Roots.

"CI" Scale — A reciprocal Scale used with the "C", "D", and "T" Scales.

"C" Scale — Identical to the "D" Scale, and used with the "D" Scale for Multiplication and Division.

"D" Scale — Used with the "C" Scale for Multiplication and Division.

"L" Scale — Used with the "C" and "D" Scales for finding Logarithms.

"T" Scale — A Trigonometric Scale used with the "C", "D" and "CI" Scales for problems involving the Tangent of angles.

Problems are worked (namely, the various operations of multiplication, division, taking square roots, and so on are carried out) by comparing two of the scales with each other. Since there are nine scales it is easily seen that there are numerous combinations taking two scales at a time. The manipulation of the slide rule consists in moving the slide along the body and in sliding the indicator to right or left over the face of body and slide.

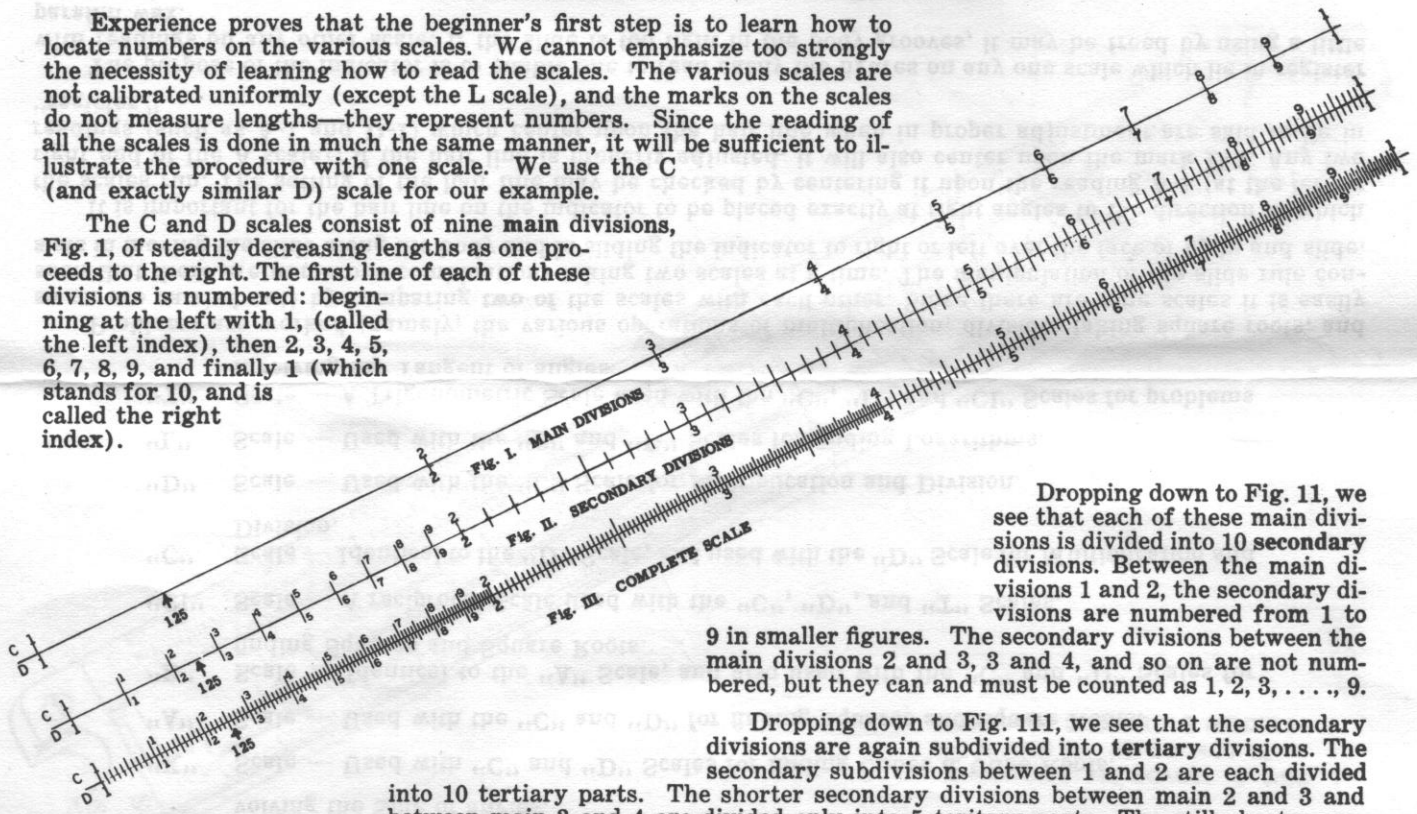
It is important for the hair line on the indicator to be placed exactly at right angles to the direction in which the scales run. The setting of the hair line may be checked by centering it upon the reading A-1 (at the left or right end of the A scale): if the hair line is properly adjusted, it will also center upon the mark D-1. Any two readings (such as A-1 and D-1) which center upon the hair line when in proper adjustment are said to be in "register."

The purpose of the indicator is to enable one to read easily the figures on any one scale which lie in register with readings on any other scale. If the slide is too tight in the body grooves, it may be freed by using a little paraffin wax.

LOCATION OF NUMBERS ON THE SCALES

Experience proves that the beginner's first step is to learn how to locate numbers on the various scales. We cannot emphasize too strongly the necessity of learning how to read the scales. The various scales are not calibrated uniformly (except the L scale), and the marks on the scales do not measure lengths—they represent numbers. Since the reading of all the scales is done in much the same manner, it will be sufficient to illustrate the procedure with one scale. We use the C (and exactly similar D) scale for our example.

The C and D scales consist of nine **main** divisions, Fig. 1, of steadily decreasing lengths as one proceeds to the right. The first line of each of these divisions is numbered: beginning at the left with 1, (called the left index), then 2, 3, 4, 5, 6, 7, 8, 9, and finally 1 (which stands for 10, and is called the right index).



Dropping down to Fig. 11, we see that each of these main divisions is divided into 10 **secondary** divisions. Between the main divisions 1 and 2, the secondary divisions are numbered from 1 to 9 in smaller figures. The secondary divisions between the main divisions 2 and 3, 3 and 4, and so on are not numbered, but they can and must be counted as 1, 2, 3, ..., 9.

Dropping down to Fig. 111, we see that the secondary divisions are again subdivided into **tertiary** divisions. The secondary subdivisions between 1 and 2 are each divided into 10 tertiary parts. The shorter secondary divisions between main 2 and 3 and between main 3 and 4 are divided only into 5 teritary parts. The still shorter secondary divisions between the main divisions beyond 4 are divided into two tertiary parts (of course, to avoid crowding the scale with marks).

To locate a three digit number (say) on the C or D scale, one proceeds as follows: In the first place certain technical terms must be explained. The first significant digit of a number is the first digit appearing on the left which is not zero: thus, 1 is the first significant digit in all the numbers, 125, 12.5, 1.25, 0.125 and 0.0125 etc. One locates on a slide rule only the sequence of numbers, 1-2-5; the decimal point has nothing to do with locating the number. As an example, let us locate this sequence 1-2-5 on the C scale.

Step 1. The first significant digit (1 for the number 125) locates, Fig. 1, the number as lying between the main divisions 1 and 2.

Step 2. The second significant digit (2 for the number 125) locates, Fig. 11, the number between the **secondary** divisions 2 and 3 of the main division 1 to 2.

Step 3. The third significant digit (5 for the number 125) locates the number as on the fifth of the ten tirtiary divisions of the secondary range 2 to 3 of the main division 1 to 2. Had the number been 1257, we should then have located it 7/10 of the tertiary division between 1250 and 1260, this last shift being made by estimating the 7/10 by eye since there are no fourth order divisions.

The above procedure is to be followed for any number on the scale, except that it should be noted that the tertiary divisions toward the right end of the scale represent fifths (between main 2-3 and main 3-4) and halves (between main 4 and the right index). For example, the number 463 lies, first on the main division between 4 and 5 second on the secondary division between 460 and 470, and third 3/5 of the first tertiary division between 460 and 465, this 3/5 being estimated by eye.

The decimal point is ignored in operating the slide rule. At the end of a calculation, the decimal point is located by estimating the answer from rounding off the factors and divisors. One quickly learns how to carry out such estimations. There is a method of keeping account of the decimal point in slide rule calculations; this method depends upon the theory of logarithms, but is universally ignored even by those who have a working knowledge of its use.

DESCRIPTION OF THE SCALES

The C and D scales, which are exactly alike, are calibrated in proportion to the logarithms of the actual numbers which are marked on these scales. It may be a satisfaction to the reader to understand the theory of logarithms, but will not be necessary in using the slide rule. The C-D combination is used for multiplying, dividing, and in ratio and proportion.

The C1 or reciprocal scale is calibrated in the same way as the C and D scales except that it reads from right to left, namely, is the C scale reversed in direction. The C1 scale may be used in reading off the reciprocal of a number as well as in multiplication and division.

Scales A and B, which are alike, are logarithmic scales just half as long as the C and D scales. If the left half of the A (and B) scale represents numbers from 1 to 10, the right half represents numbers 10 times as large, namely, from 10 to 100. Again, if the left half represents numbers from 100 to 1000, the right half represents numbers from 1,000 to 10,000 and so on. These scales may be used in finding squares and square roots.

The K scale is a logarithmic scale 1/3 as long as the C scale. The second third of the scale represents numbers 10 times as large as those of the first third. The right third of the K scale represents numbers 100 times as large as the first third, and 10 times as large as the second third of the scale. Thus the first, second, and third scales may represent numbers 1 to 10, 10 to 100, and 100 to 1,000 respectively.

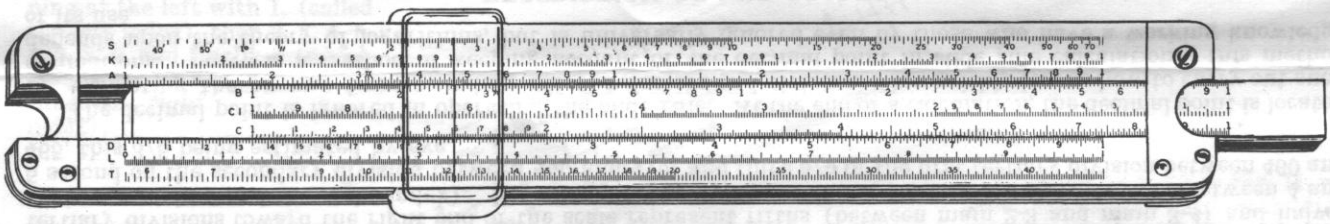
The S scale is used in figuring the sines of angles.

The T scale is used in finding the tangents of angles.

The L scale is uniformly calibrated, and is used in combinations with the C and D scales in finding the logarithms of numbers.

SLIDE RULE OPERATIONS

Multiplication. Use the C-D combination. To multiply two numbers, locate one factor on the D scale, set the index (either the left or right end) of the C scale in register with this factor on the D scale, locate the other factor on C, then in register with this reading on C the product will be found on the D scale.



For example, in Fig. B, the left index of C is set on the number 1.35 of the D scale. If the cursor be moved over to 4 on C, then under this number and in register with it the product of 1.35x4 which is 5.4 will be found on D. In register with C-6 and on D will be found the product 8.1 (1.35x6). How about 135x9 (say)? A glance at Fig. B shows that C-9 is off the D scale. In this and similar examples, the slider is to be pulled to the left in the ruler until the right index of C is in register with the first factor appearing on D (in the present example 1.35), and then the answer is again to be read on D in register with the second factor as read on C.

Division. Use the C-D combination. Division is the inverse of multiplication. Locate the divisor on the C scale and set this reading in register with the dividend on the D scale: the quotient will be found on the D scale in register with the index of the C scale (with whichever index of C, left or right, that appears on the D scale). As an example, note that the divisor C-4 of Fig. B is in register with the dividend 5.4 on D, and that the quotient 1.35 lies on D in register with the left index of C. Note that with this setting of the slide rule, any number on the D scale divided by the number in register on C, gives 1.35 as quotient.

Squares and Square Roots. Use the A-D combination of scales. To find the square of any number, locate this number on the D scale, set the hair-line of the cursor upon this number, and read its square in register on the A scale.

To find the square root of any number, use the scales in reverse order. Thus, locate the given number whose square root is to be found upon the A scale (use the left half of A if this number has an odd number of digits, the right half if the number of digits is even), set the cursor upon this number, and read its square root in register on the D scale.

Cubes and Cube Roots. Use the D-K combination of scales. To find the cube of any number, locate this number on the D scale, set the cursor on this number, and read its cube in register on the K scale.

To find the cube root of any number, use the D-K combination in the reverse order. Thus, locate the given number whose cube root is desired upon the K scale (use the left third of K if the number has 1, 4, 7, etc. digits, namely if its number of digits is 1 plus a multiple of 3; use the middle third of K if the number of digits is 2 plus a multiple of 3, such as 2, 5, 8, etc. digits; and use the right third of K if the number of digits is an exact multiple of 3, such as 3, 6, 9, etc. digits), set the cursor upon this number, and read its cube root in register on D.

Proportion. Use the C-D combination of scales. Problems of proportion arise, for example, in the conversion of yards to feet, dollars to pounds, gallons to cubic feet, and so on. As an example of such use of the slide rule, let us set the rule for the yard-to-foot conversion. Place the index (either right or left) of the C scale upon the number 3 of the D scale. Note the number of yards and fraction thereof on C, and read in register on D the corresponding number of feet. Conversely, locate the number of feet in any given distance upon the D scale, and in register with this number will be found on C this distance expressed in yards.

Reciprocals. Use the C1-D combination of scales. To find the reciprocal of any number, locate this number on the D scale and set the cursor upon this reading: the reciprocal of this number will be found in register on the C1 scale. Alternatively, locate the number on the C1 scale, set the cursor upon this number, and read its reciprocal in register on the D scale.

Further Uses of the C1 Scale. Multiplication by use of the D-C1 combination: To multiply two numbers together, locate one factor on the D scale, the other on the C1 scale, set these two factors in register by use of the cursor, and read their product on D in register with the index of the C1 scale. Since either the left or right index of C1 will always be found upon the scale, this method of multipllication never requires the reversal of the slider which is frequently necesary when multiplying by use of the C-D combination

Observe that this method of multiplication permits finding the product of three factors with one setting of the slider. As an example, let us calculate the volume of a wall 15.5 feet long, 8 feet high, and 0.55 feet thick. Solution: Set the cursor at 155 on D; draw the slider until 8 on C1 coincides with the hair-line; move the cursor to 55 on C; read the product 68.2 cubic feet in register on D.

Division by use of the D-C1 combination: To divide one number by another, locate the dividend on D, set the cursor on this number, draw the slider until its (right or left) index comes into register with the hair-line, locate the divisor on C1 and set the cursor on this number, the quotient lies in register on the D scale.

Sine of an Angle. Use the A-S combination of scales. Set the indices of the S scale in exact register with those of the A scale. When using the No. 1200 and No. 1211 pocket rules, locate angle on S scale on rear of slide. Place in register with indicator line. Then, read sine on the B scale in register with right index of A scale on face of rule.

To find the sine of any angle (greater than 30′), locate this angle on the S scale, its sine will be found in register on the A scale. Note that the left half of the A scale covers the angle ranger 30′ to 5°45′, and that the sines of angles in this range have one zero after the decimal point (for example, sin 4°30′ is 0.0785); whereas the second half of the A scale covers the angle range, 5°45′ to 90°, and that for sines of angles in this range the significant digits begin immediately after the decimal point (for example, sin 35° is 0.574).

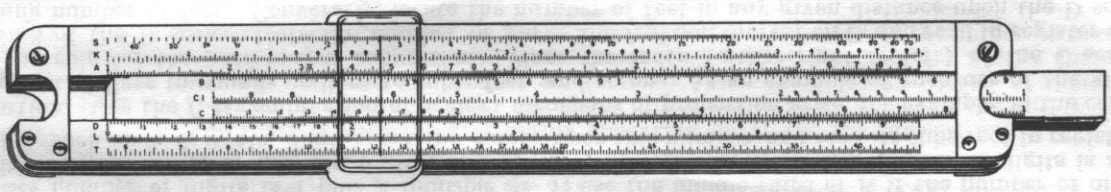
Given the sine of an angle, to find the angle, use the scales A and S in the reverse order. Thus, locate the numerical value of the sin on the A scale, and read off the angle in register on the S scale.

Tangent of an Angle. Use the D-T combination of scales. Set the indices of the T scale in exact register with those of the D scale. When using the No. 1200 and No. 1211 pocket rule, locate angle on T scale on rear of slide. Place in register with indicator line. Then, read tangent on the C scale in register with right index of the D scale on the face of the rule.

To find the tangent of any angle (in the range from about 6° to 45°), locate the angle on the T scale, its tangent will be found in register on the D scale. Throughout the tangent scale, the significant digits begin immediately after the decimal point (for example, tan 19°20′ is 0.351).

To find the tangent of an angle in the range 45° to 90°, find the tangent of 90° minus the given angle, and take the reciprocal of this value as explained in Par. 19.

Given the tangent of an angle, to find the angle: If the given tangent lies in the range 0.1 to 1, locate this number on D, and read the corresponding angle in register on the T scale: If the given tangent exceeds 1, find the reciprocal of the given number (Par. 19), locate this number on the D scale, read off the angle in register with this number on T, subtract this angle from 90° to find the required angle.

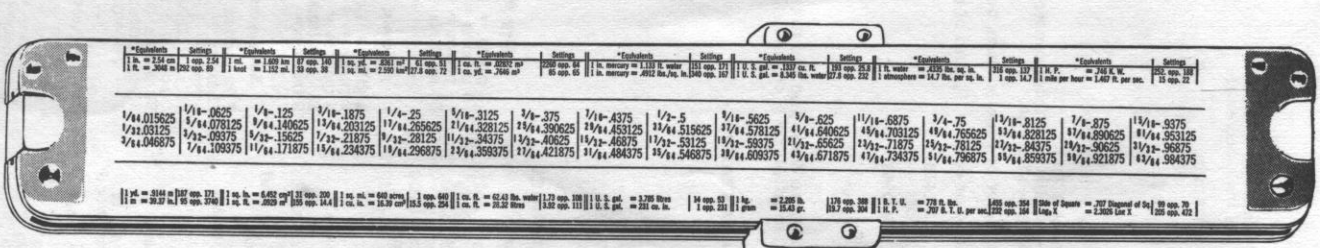


Logarithm of a Number. Use the D-L combination of scales. Set the indices of the L scale in exact register with those of the D scale.

To find the logarithm of a number, locate the significant digits on the D scale, the required logarithm will be found by use of the cursor in register on the L scale. The characteristic of the logarithm is to be found from the position of the decimal point in the same way one determines it when using a logarithmic table.

Given the logarithm of a number, to find the number: locate the mantissa of the logarithm upon the L scale, and read off the significant digits of the number in register on the D scale. The decimal point for the number is fixed by the characteristic of the given logarithm in the usual manner.

BACK OF RULE



SHOWING
TABLE OF EQUIVALENTS AND SETTINGS
TABLE OF DECIMAL EQUIVALENTS

CARE & ADJUSTMENT OF YOUR ACU-MATH SLIDE RULE

Your slide rule should be treated in the same manner as any precision instrument, with a minimum of care it will give you years of trouble-free service.

Keep it in its protective sheath when not in use and avoid severe shock that might upset precision alignment. Avoid exposure to extremes in temperature.

Should your rule become soiled any one of the mild liquid soaps will restore its lustre and improve slide action.

Rules with metal end plates may be adjusted for proper alignment by loosening the two large screws on the end plates. Register (line up) the scales on the left hand index and tighten the screws.

Printed in U.S.A.