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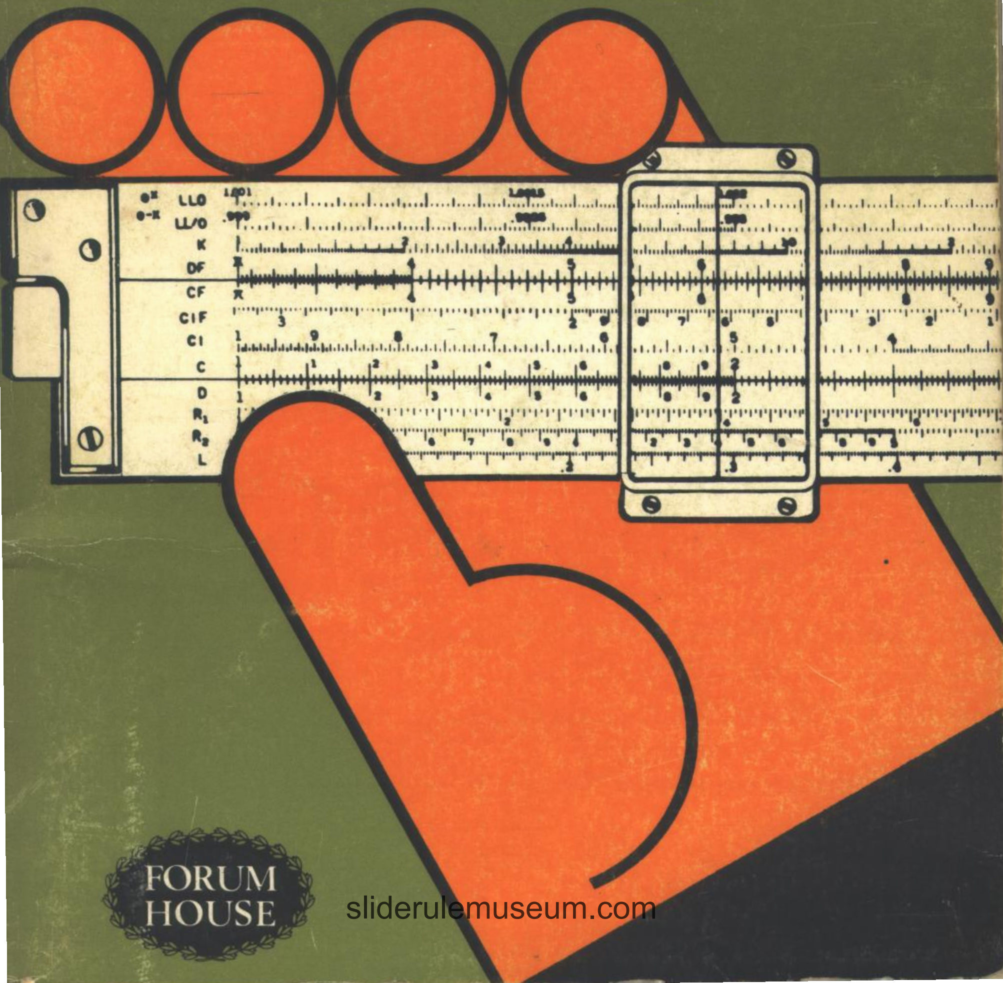
HOW TO USE THE SLIDE RULE



FORUM HOUSE

HOW TO USE THE SLIDE RULE

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CONTENTS

PREFACE

Efficiency when associated with accomplishment of work infers economy of time and effort. Skill developed in the use of the slide rule enables the student or professional engineer to make numerical calculations rapidly and easily. The material contained in the following pages is presented in a simple manner to assist either the self-directed or classroom student in acquiring skill in the use of this portable calculating instrument.

In the interest of conciseness and simplicity, the authors feel that where students in one class may represent several fields of engineering, science, etc., it is advantageous to restrict practice operations to arithmetical computations only and, therefore, have omitted special problem applications. The type of transition required to move from a practical problem taken from a specific field to arithmetical form seems to be a concern related to courses other than a general course in slide rule operation.

Again in the interest of conciseness, an attempt has been made to present basic scale patterns of the slide rule with only the minimum essential reference to significant variations on particular models of slide rules.

Unit problems and answers are located immediately following the explanation of the unit and, thus, it is not necessary to look somewhere in the back of the book for answers. The answers can be conveniently covered by an answer slip located at the end of each unit while problems are being worked and answers recorded in spaces provided. Spacing on the answer slip allows for the minimum of pencil work that is sometimes required.

As with all skills, meaningful repetition improves and establishes the particular operation. Since speed is a primary objective in using the slide rule, the student should be conscious of, and note, the suggested time to work each set of problems.

Several trials may be needed before the set of problems can be completed in the suggested time.

A modern Log Log duplex deci-trig slide rule is required if all units are to be completed. Scales required for complete coverage of the following material are the C, D, CI, DF, CF, CIF, A, B, K, L, S, T, ST and at least six Log Log scales. Many rules now have eight Log Log scales with increased range in this respect but only six are required to do the problems given in this book. The S, T and ST scales should be located on the slide. An acceptable alternative to the A and B scales is the rule which makes use of R1, R2 or SQ.1, SQ.2 or $\sqrt{}$ scales. The Log Log scales are designated by different makers in different ways as: LL1, LL01 and Ln1.

PREFACE

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UNIT 1—KNOW YOUR SLIDE RULE

The slide rule is made up of three parts: the body, the movable glass, and the slide. See Figure 1. A vertical hairline is located in the center of the glass. Scales have been placed on both sides of the body and slide. Frequent reference in explanations to the hairline and index will make it necessary to recognize these parts.

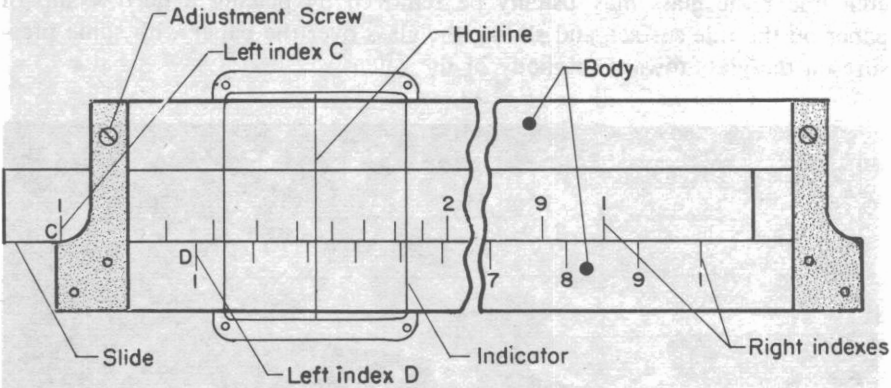


Fig. 1 The Slide Rule.

In order to obtain smooth operation and relatively accurate results, the slide rule must be in proper adjustment. A new rule is usually correctly adjusted, but it is advisable that it be checked as follows. Set the slide to bring the left indexes of the C and D scales into alignment with one another. The like readings on the DF and CF scales should now be in perfect alignment with one another. If the DF and CF scales do not align in this position, loosen the screws in the body frame and move the DF part of the body to the left or right until the DF and CF scales are aligned, then tighten the screws. (Note: on the K. & E. Deci-lon the D scale is adjustable).

If the slide is binding or slides too freely, it may be necessary to loosen the screws in one end of the body and move this end of the body up or down as required to allow for proper movement of the slide.

With the body and slide in alignment, the relationship of the hairline to the scales should also be checked. Move the hairline to align with the left index of the D scale. The hairline should now align with the Pi symbol on the DF scale. The hairline on the opposite side of the rule when set to the left index of the D scale should align itself with L/e on the Log Log scale on many rules or with the left index of the A scale. If the hairline is not in alignment, the four screws in the metal frame which holds the glass may be loosened, the glass tilted to properly align the hairline, and the screws once more tightened.

Clarity of slide rule readings is insured by keeping the rule clean. When the slide rule is being used, cleanliness of hands is important. The rule should be kept in its case, when not in use, to protect it from dust. If the body and slide need cleaning, a *slightly* dampened cloth may be used. Dirt which has gathered under the glass may usually be removed by placing a narrow slip of paper on the rule surface and sliding the glass over the paper with some pressure on the glass toward the body of the rule.

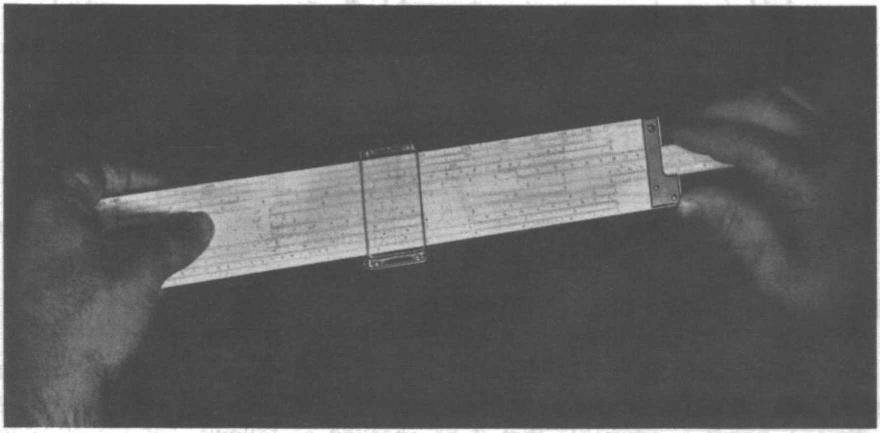


Fig. 2 Setting the Slide.

One of the factors affecting speed of calculation with the slide rule is smooth hand performance in setting the hairline and slide to desired readings. Some suggestions follow. Two hands are required to make most settings. One hand, either the left or right as suits the situation, is used to hold the body with the thumb placed against the lower edge of the body and fingers on the top of the body. Care should be used to avoid squeezing the body, since excessive pressure may cause the slide to bind. The other hand is used to move the hairline or slide to the general area of the desired setting. Fine setting of the hairline may now be obtained by placing the hands so that the back of the hands face the operator, thumbs against the lower corners of the glass frame, and forefingers against the upper corners of the frame. By a slight rolling motion of the thumbs and forefingers, controlled force is now exerted for movement to an exact setting. In a somewhat similar manner, control of fine slide settings is possible. One index finger is placed against the end of the slide which is within the body while at the end of the body where the slide is projecting, a thumb and forefinger are placed against the body frame.

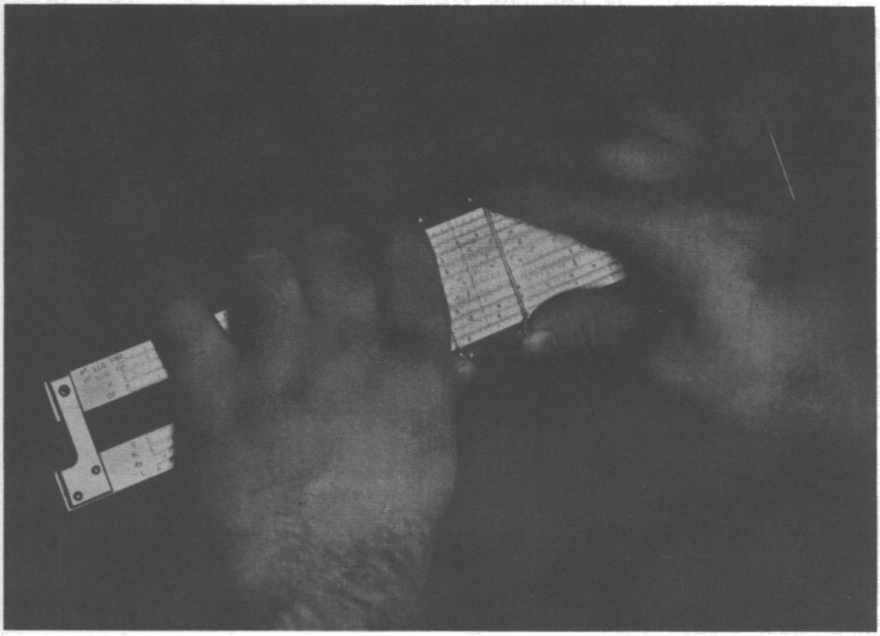


Fig. 3 Setting the Hairline.

UNIT 2—GETTING ACQUAINTED WITH THE C & D SCALES

Of the many scales on the slide rule, the C and D scales are used the most frequently. A thorough acquaintance with the divisions of these scales is necessary.

A study of these two scales indicates that they are identical. Unlike the standard foot scale, the major or primary divisions of the C and D scales are not equally spaced. Reference to figure 4 below reveals that the distances on the D scale (or C scale), when compared with the L or logarithm scale, are in proportion to the logarithms of the numbers represented. (It is not a necessity for the student to understand logarithms in order to solve problems in multiplication and division on the slide rule).

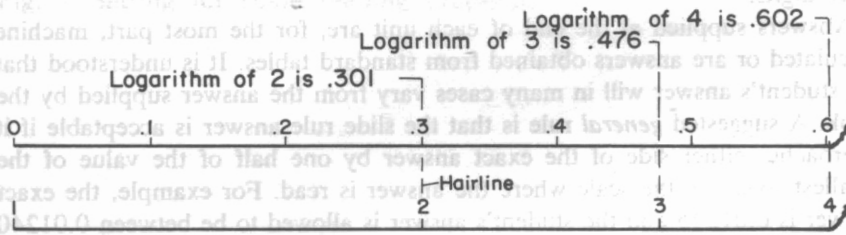


Fig. 4 C scale and L scale relationship.

The C & D scales are known as logarithmic scales. These logarithmic scales have been divided into ten primary parts or distances whose limits are indicated by the large nos. 1, 2, etc. If a number whose first significant figure is 1 (as 0.01245) is to be read on the scale, the number regardless of where the decimal point is located, must be read within the limits indicated by the large 1 and 2 on the scale as shown in Fig. 5.

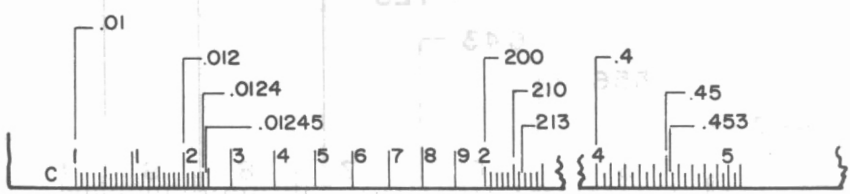


Fig. 5 Readings on the C scale.

The primary distances are subdivided into secondary distances to which the numbers 1, 2, etc. (other than for the first primary distance) must be mentally assigned. The location of the number to be read is further limited on the scale by associating the figure which follows the first significant figure with the respective secondary division. Since the primary distances become progressively more cramped, the number of tertiary divisions decreases. It follows from the foregoing that a number of four digits beginning with 1 must be read within the primary distance limited by the calibrations 1 and 2, with the first three digits being read according to the graduations and the fourth digit being approximated. For the remaining primary distances, three digit accuracy of numbers may be read.

In cases of numbers which begin with one, the one and the three digits following the one would be read. Any digits beyond this point would be dropped. Numbers which begin with other than 1 would be read to no more than three digits.

Answers supplied at the end of each unit are, for the most part, machine calculated or are answers obtained from standard tables. It is understood that the student's answer will in many cases vary from the answer supplied by the book. A suggested *general* rule is that the slide rule answer is acceptable if it approaches either side of the exact answer by one half of the value of the smallest space on the scale where the answer is read. For example, the exact answer is 0.01245 and the student's answer is allowed to be between 0.01240 and 0.01250, since the small space here is worth 10. It is recognized that this is a rather liberal allowance where only two operations were required to arrive at the answer. However, if five factors must be used in arriving at the answer, it is apparent that the possibility of accumulation of error is greater.

A study of the readings indicated in the following figure may be made to become more acquainted with the divisions.

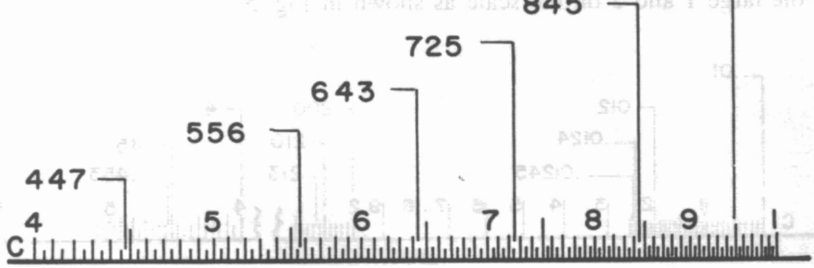


Fig. 6 Readings on C scale.

Tearing along the perforated line on the sheet following the problems at the end of this unit, remove an answer slip and with it cover the column on the next page headed "D Scale Reading." With the C and D scales arranged as shown below in fig. 7, move the hairline to the readings as given for the C scale. Record the readings, on the slip of paper, found under the hairline on the D scale.

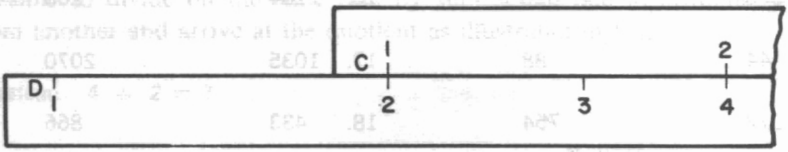


Fig. 7 Setting for scale reading problems.

READING THE C & D SCALES

C Scale Setting	D Scale Reading	C Scale Setting	D Scale Reading
1. 21	42	14. 457	914
2. 214	428	15. 1140	2280
3. 313	626	16. 104	208
4. 44	88	17. 1035	2070
5. 372	754	18. 433	866
6. 444	888	19. 372	744
7. 353	706	20. 385	770
8. 377	754	21. 111	222
9. 42	84	22. 1015	2030
10. 324	648	23. 462	924
11. 245	490	24. 301	602
12. 45	90	25. 243	486
13. 241	482		

UNIT 3—DIVISION PROBLEMS and PLACEMENT OF DECIMAL POINTS

It was shown in Fig. 4 that the distances along the C and D scales are logarithmic or proportional to the logarithms of numbers represented there. The logarithm is a mathematical tool which enables us to find the quotient or answer to a division problem by subtracting the logarithm of the divisor from the logarithm of the dividend. Because of the above relationships, it is possible to divide on the slide rule by subtracting one logarithmic distance from another and arrive at the quotient as illustrated in Fig. 8.

Problem: 4 ÷ 2 = ?

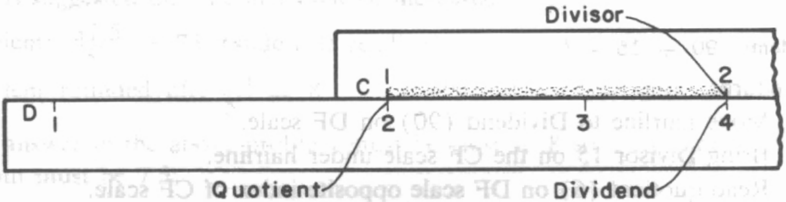


Fig. 8 C-D scale setting for division.

Procedure:

1. Move hairline to dividend (4) on D scale.
2. Bring divisor (2) on C scale under hairline.
3. Read quotient (2) on D scale opposite left index of C scale.

Note here that, if in using this procedure on a division problem, the left index of the C scale does not contact the D scale, the quotient will be found opposite the right index of the C scale on the D scale as illustrated in Fig. 9.

Problem: 40 ÷ 8 = ?

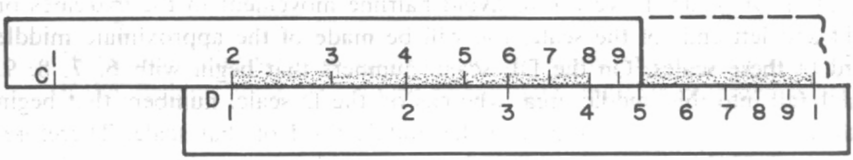


Fig. 9 Dividing with C and D scales, left index out of body.

Procedure:

1. Move hairline to dividend (40) on D scale.
2. Bring divisor (8) on C scale under hairline.
3. Read quotient (5) on D scale opposite right index of C scale.

The CF scale, located on the upper part of the slide and the DF scale located on the upper part of the body, may also be used to do division problems. These upper scales are basically the same as the C and D scales. The F indicates that these scales are *folded* scales. They can be thought of as originally being D scales which were split at Pi and reassembled so that the Pi falls at the beginning and the index falls approximately in the middle of the rule. Procedure for dividing with these scales is the same as with the C and D scales.

Problem: $90 \div 15 = ?$

Procedure:

1. Move hairline to Dividend (90) on DF scale.
2. Bring Divisor 15 on the CF scale under hairline.
3. Read quotient (6) on DF scale opposite index of CF scale.

It should be noted here that an answer, when being read opposite the index of the CF on the DF, will also appear opposite the index of the C scale (which is in contact with the D scale) on the D scale. If the index of the CF scale should not be in contact with the DF scale after a DF-CF combination has been used, the answer is available on the D scale opposite the index of the C scale.

At this point, two combinations of scales have been used to divide, C-D and CF-DF. The scale combination, which involves an appreciable less amount of movement of hairline and slide in doing a particular problem, than another scale combination, is more efficient and should be selected. For some problems there may be no significant difference as to which combination is used, but some attention should be given to the choice of scales. A division or multiplication problem is started by setting to the first factor on the D or DF scale. If we are to avoid hairline movement to the extremes or right and left ends of the scale, use will be made of the approximate middle third of these scales. On the DF scale, numbers that begin with 6, 7, 8, 9, and 1 fall into this middle area, whereas on the D scale, numbers that begin with 2, 3, 4, and 5 are located in the middle third of that scale. Therefore, in general, if the dividend or first factor is used is a number which begins with a 6, 7, 8, 9, or 1, the hairline is set to the reading on the DF scale and a DF-CF combination is used. If the dividend or first factor used is a number which begins with 2, 3, 4, or 5, the hairline is set to the dividend or first factor used on the D scale and a C-D combination is used.

The numbers 140, 1-4, and .014 are all read in the same place on the D scale. The slide rule operator does not have to concern himself with the decimal points until the manipulative steps are completed and the final reading is being made on the D scale or DF scale. It is absolutely imperative that some system of determining decimal point placement be adopted.

Following are two of many methods:

Rounding Off

By this method all digits, except the first significant digit in the numbers, are made zeros. If the digit following the first significant digit is greater than 5, it is suggested that the first digit be increased by one.

Problem: $\frac{37.5}{5} = 75$ (slide rule reading)

Problem rounded off: $\frac{40}{5} = 8$

The answer to the above problem must be close to 8 so it can not be .75 or 75 but must be 7.5.

Single Digit (Digit here refers to any number from 1 to 9 inclusive)

Problem: $\frac{.00015}{250} = 6$ (slide rule reading)

Procedure:

1. Change each factor to a number having 1 digit to the left of the decimal point by shifting the given decimal point either to the left or right and determine by observation decimal point placement in the answer at this stage.

   $$\frac{0001.5}{2.50} = .6$$

2. Record near each factor the number of places the given decimal point was removed.

   $$\frac{\overset{4}{0001.5}}{\underset{2}{2.50}} = .6$$

3. If decimal point was moved to the left, indicate recorded value as plus; if the decimal point was moved to the right, indicate recorded value as minus.

   $$\frac{\overset{-4}{0001.5}}{\underset{+\ 2}{2.50}} = .6$$

4. Algebraically subtract the number recorded for the denominator from the number recorded for the numerator and record result near quotient.

$$\frac{\overset{-4}{00001.5}}{\underset{+2}{2.50}} = .6^{(-4\ -2\ =\ -6)}$$

5. If value recorded above quotient is negative, move decimal point in quotient to left no. of places indicated by this value. If value recorded above quotient is plus, decimal movement must be to the right.

   —6
   .6 or final answer .0000006

DECIMAL POINT PLACEMENT

Place an answer slip over the "Answer" column. Record the slide rule for each problem and locate the decimal point by "rounding off," use of the single digit method or other suitable means.

Problem			Slide Rule Reading	Answer
1.	$\frac{2.1}{3}$	=	7	0.7
2.	$\frac{0.054}{4}$	=	135	0.0135
3.	$\frac{48}{0.012}$	=	4	4000.
4.	$\frac{4650}{30,000}$	=	155	0.155
5.	$\frac{525}{0.015}$	=	35	35,000
6.	$\frac{0.01}{52}$	=	1923	0.0001923
7.	$\frac{2240}{0.056}$	=	4	40,000
8.	$\frac{501}{27.4}$	=	1828	18.28
9.	$\frac{0.789}{0.0912}$	=	865	8.65
10.	$\frac{583}{0.74}$	=	788	788
11.	$\frac{0.907}{0.976}$	=	929	0.929
12.	$\frac{0.0445}{8230}$	=	540	0.0000054
13.	$\frac{34000}{0.855}$	=	398	39,800
14.	$\frac{0.0000306}{70.2}$	=	436	0.000000436
15.	$\frac{2240}{3.91}$	=	573	573
16.	$\frac{3189}{36.5}$	=	874	87.4
17.	$\frac{8.53}{644}$	=	1324	0.01324
18.	$\frac{23.8}{929}$	=	256	0.0256

19.	$\frac{.556}{0.00494}$	=	1125	112.5
20.	$\frac{46100}{17.3}$	=	266	2660
21.	$\frac{8160}{0.479}$	=	1704	17,040
22.	$\frac{53.2}{.1484}$	=	358	358
23.	$\frac{48,500}{1.91}$	=	254	25,400
24.	$\frac{310}{83,600}$	=	371	0.00371
25.	$\frac{5.58}{48.4}$	=	1153	0.1153
26.	$\frac{1650}{0.519}$	=	318	3180
27.	$\frac{0.00856}{29.92}$	=	286	0.000286
28.	$\frac{68200}{42.2}$	=	1616	1616
29.	$\frac{60.1}{0.488}$	=	1232	123.2
30.	$\frac{6990}{3.89}$	=	1797	1797

PROBLEMS—DIVISION (1-50)

Suggested Time: 36 Min.

1.	87.5 ÷ 37.7	=	2.32
2.	1063 ÷ 7.29	=	145.8
3.	539 ÷ 23.6	=	22.8
4.	60000 ÷ 815	=	73.6
5.	70.7 ÷ 388	=	0.1822
6.	3.14 ÷ 2.72	=	1.154
7.	10.05 ÷ 30.3	=	0.332
8.	15.86 ÷ 4.52	=	3.51
9.	0.00486 ÷ 0.00015	=	32.4
10.	3450 ÷ 43.5	=	79.3
11.	14.46 ÷ 4.52	=	3.2
12.	1.03 ÷ 63	=	0.01635
13.	5.42 ÷ 26.3	=	0.206
14.	2875 ÷ 37.1	=	77.5
15.	0.00377 ÷ 5.29	=	0.000713
16.	0.0592 ÷ 1.983	=	0.0298
17.	299 ÷ 1.73	=	172.8
18.	97 ÷ 0.13	=	746
19.	78.3 ÷ 403	=	0.1943
20.	83.8 ÷ 612	=	0.1369

PROBLEMS—DIVISION

21.	50.4 ÷ 916	=	0.0550
22.	147.4 ÷ 321	=	0.459
23.	0.00058 ÷ 83.6	=	0.00000694
24.	3780 ÷ 42.4	=	89.2
25.	3.75 ÷ 0.0227	=	165.2
26.	14.67 ÷ Pi	=	4.67
27.	104.7 ÷ 40.7	=	2.57
28.	100.8 ÷ 33.5	=	3.01
29.	3,160,000 ÷ 201	=	15,720
30.	0.0722 ÷ 8.42	=	.00857
31.	283 ÷ 2.08	=	136.1
32.	0.0362 ÷ 57.5	=	0.000630
33.	1036 ÷ 7.95	=	130.3
34.	0.00437 ÷ 0.0001745	=	25
35.	79.1 ÷ Pi	=	25.2
36.	1029 ÷ 96	=	10.72
37.	3780 ÷ 136.4	=	27.7
38.	10.48 ÷ 84.8	=	0.1236
39.	0.685 ÷ 8.93	=	0.0767
40.	871 ÷ 0.468	=	1861

41.	3.42 ÷ 81.7	=	0.0419
42.	2385 ÷ 795	=	3
43.	390 ÷ 0.7	=	557
44.	27.5 ÷ 0.0631	=	436
45.	0.0109 ÷ 99	=	0.0001101
46.	0.560 ÷ 0.667	=	0.840
47.	1.008 ÷ 256	=	0.00394
48.	0.472 ÷ 32.3	=	0.01461
49.	3.08 ÷ 566	=	0.00544
50.	0.0385 ÷ 0.001462	=	26.3

UNIT 4—MULTIPLICATION, TWO or MORE FACTORS

The slide rule with its provision for sliding scales allows us to add two logarithmic distances, as illustrated in Fig. 10, to obtain the product of two numbers.

Problem: 3 x 2 = ?

Fig. 10 Multiplying with C and D scales.

Procedure:

1. Bring left index of C scale to 3 on the D scale.
2. Move hairline to 2 on C scale.
3. Read product (6) under hairline on D scale.

If the second factor in the problem was 8 instead of 2 the problem could be solved by setting the right index of the C scale opposite 3 on the D scale. It is not difficult to see how distance is added onto the 3 if the D scale is thought of as being cyclical. In adding onto the right, the D scale is thought of as reading from 1 to 10 but in coming back onto the left end of it, now the D scale reads from 10 to 100 with the 8 of the C scale falling opposite the 24 of the D scale.

Problem: 3 x 8 = ?

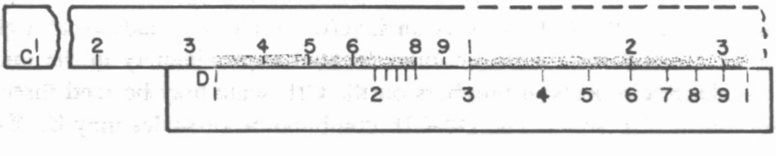


Fig. 11 Multiplying, setting to right of index of C scale.

Procedure:

1. Bring right index of C scale to 3 on D scale.

2. Bring 8 on CIF scale under hairline.
3. Read answer (88) opposite index of CF scale on DF scale, or opposite right index of C scale on D scale.

Having seen how either the D and C scales or the D and CI scales may be used to multiply, a basis has been set up for multiplying any number of factors efficiently.

Problem: 30 x 2.5 x 300 = ?

Procedure:

1. Move hairline to 30 on D scale.
2. Bring 2.5 on CI scale under hairline.
3. Move hairline to 3 on C scale.
4. Make reading (225) under hairline on D scale.
5. Determine decimal point placement:

   +1 0 +2 +3
   3.0 x 2.5 x 3.00 = 22.5 or 22,500

In multiplication problems, the single digit method for decimal point placement is the same as for division, except that values assigned above factors are algebraically *added*.

30 x 3 x 300 = 27000 (rounded approximate answer; final answer is 22,500).

It is suggested that the student visualize where an answer will appear (under the hairline or at the index) after each step. It is then logical as to what the next step should be to add distance and, thereby, multiply by another factor. It is not necessary to memorize a series of mechanical steps.

Problem: 4.5 x 2 x 35 x 410 = ?

Procedure:

1. Move hairline to 4.5 on D scale.
2. Bring 2 on CI scale under hairline.
3. Move hairline to 35 on C scale.
4. Bring 410 on CI scale under hairline.
5. Make reading (1291) on D scale opposite index of C scale.
6. Determine decimal point placement.

   0 0 +1 +2 +3
   4.5 x 2 x 3.5 x 4.1 = 129.1 or 129,100

It may occasionally be obviously efficient to select factors in other than the sequences in which they occur in the problem, but this has a tendency to be confusing.

Use of the upper scales (DF, CIF and CF) is indicated in the following problem. It should be understood that it is possible to move from the upper scales to the lower scales or visa versa, in going to another factor, *IF* at that particular stage the answer for that part of the problem thus far completed is opposite the INDEX of the C (or CF) on the D (or DF).

Problem: 8.5 x 250 x .12 x 50 = ?

Procedure:

1. Move hairline to 8.5 on DF scale.
2. Bring 250 on CIF scale under hairline (Note: answer for this much of problem is opposite index of CF or C on DF or D scale).
3. Move hairline to 1.2 on C scale.
4. Bring 5 on CI scale under hairline.
5. Make reading (1275) opposite index of C scale on D scale.
6. Determine decimal point placement.

   0 +2 −1 +1 +2

   8.5 x 2.5 x 1.2 x 5.0 = 127.5 = 12750

PROBLEMS—MULTIPLICATION (1-50)

Suggested Time: 42 Min.

1.	4.87 × 811	=	3950
2.	5.78 × 6.35	=	36.7
3.	813 × 1.951	=	1586
4.	51. 4 × 27.6	=	1419
5.	847 × Pi	=	2660
6.	8320 × 0.608	=	5060
7.	314 × 5.09	=	1598
8.	55.6 × 407	=	22,630
9.	0.273 × 3.14	=	0.857
10.	0.0587 × 1.765	=	0.1036
11.	8.33 × 25.6	=	213
12.	1.23 × 1.234	=	1.518
13.	0.0456 × 4.40	=	0.201
14.	1.047 × 3080	=	3220
15.	1.876 × 5.32	=	9.98
16.	48.7 × 1.173	=	57.1
17.	0.00021 × 939	=	0.1972
18.	64.3 × 229	=	14720
19.	0.0469 × 375	=	17.59
20.	859 × 0.0005	=	0.430

21. 368 × 72 = 26,500

22. 3.1867 × 0.678 = 2.16

23. 15.57 × 0.067 = 1.043

24. 0.0632 × 753 = 47.6

25. 456 × 326 = 148,600

26. 52.6 × 1.37 × 0.054 = 3.89

27. 3.65 × 2.48 × 764 = 6920

28. 2.32 × 7.68 × 46.8 = 834

29. 86.3 × 285 × 0.00402 = 98.9

30. 66.2 × 1.72 × 0.045 = 5.12

31. 37.7 × 48.2 × 30.9 = 56,100

32. 0.553 × 7.48 × 0.633 = 2.62

33. 3.18 × 38 × 0.0616 = 7.44

34. 3440 × 0.0836 × 69.2 = 19,900

35. 16.3 × 27.1 × 1.2 = 530

36. 54.7 × 4.39 × 921 = 221,000

37. 0.222 × 1.11 × 0.0833 = 0.0205

38. 460 × 0.351 × 0.137 = 22.1

39. 50.1 × 4.91 × 2.01 = 494.

40. 291 × 0.336 × 2.06 = 201

PROBLEMS—MULTIPLICATION

41.	30.4 × 9.06 × 2.48 × 8.01	=	5470
42.	8.9 × 7.6 × 9.03 × 1.12	=	684
43.	2.28 × 0.0371 × 98.1 × 1.50	=	12.45
44.	8.18 × 0.919 × 3.03 × 3.11	=	70.8
45.	0.376 × 16.57 × 0.851 × 4.07	=	21.6
46.	3380 × 0.0103 × 0.0490 × 8.01	=	13.66
47.	2.84 × 6.52 × 5.19 × 6.5	=	624.
48.	187 × 0.00236 × 0.768 × 1047 × 3.14	=	1114
49.	6.5 × 7.6 × 8.7 × 9.8 × 1.53	=	6440
50.	3.06 × 3.14 × 3.21 × 2.4 × 8.11	=	599

It is not necessary to select numerators in the sequence in which they occur, but it may be less confusing. Occasionally, it may be advantageous in decreasing movement to select the factor next which obviously requires much less movement.

In a combination problem in which there are several numerators and denominators, the hairline is first set to a numerator on either the D or DF scale. From this point, the problem may be worked by multiplying all the numerators and all the denominators and then these two results are divided. Some students feel this is less confusing than alternately dividing and multiplying numerators and denominators. The latter method of alternating involves fewer steps and is preferred by the authors.

Problem: $\frac{420 \times 61.5}{8.1 \times .312} = ?$

Procedure:

1. Move the hairline to 420 on the D scale.
2. Bring 8.1 on the C scale under the hairline.
3. Move the hairline to 61.5 on the C scale.
4. Bring .312 on the C scale under the hairline.
5. Make reading (1022) opposite index of C or CF on D or DF scale.
6. Determine decimal point placement.

$$\frac{\overset{+2}{4.20} \times \overset{+1}{6.15}}{\underset{0}{8.10} \times \underset{-1}{3.12}} = \underset{-1}{\overset{+3}{1.022}} = \overset{+4}{1.022} = 10{,}220$$

UNIT 5—COMBINATION MULTIPLICATION AND DIVISION PROBLEMS

Problems in this unit combine operations dealt with in units 2 and 3 and, in addition, introduce the use of the CI and CIF scales for the purpose of dividing.

The following problem consists of one numerator and several denominators. The answer could be arrived at by multiplying all of the denominators first to obtain a product and then the numerator divided by this product. However, in this type of problem, it is more efficient to start with the numerator and use the CI scale with the C scale for repeated dividing. The numerator is divided first by 42; the result of this is divided by 370 and then this result is divided by 5.

Problem: $\frac{2800}{42 \times 370 \times 5} = ?$

Procedure:

1. Move hairline to 2800 on D scale.
2. Bring 42 on C scale under hairline.
3. Move hairline to 370 on CI scale.
4. Bring 5 on C scale under hairline.
5. Make reading opposite index of C scale on D scale (36).
6. Determine decimal point placement.

$$\frac{\overset{+3}{2.800}}{\underset{+1}{4.2} \text{ x } \underset{+2}{3.70} \text{ x } 5} = .0360 \quad \frac{+3}{+3} \quad = 0.0360$$

A problem may be worked similarly on the upper scales.

Problem: $\frac{87000}{1200 \times 110 \times 1.01 \times .812} = ?$

Procedure:

1. Move hairline to 87000 on DF scale.
2. Bring 1200 on CF scale under hairline.
3. Move hairline to 110 on CIF scale.
4. Bring 1.01 on CF scale under hairline.
5. Move hairline to 812 on CIF scale.
6. Read answer (125) under hairline on DF scale.
7. Determine decimal point placement.

$$\frac{\overset{+4}{8.7}}{\underset{+3}{1.2} \text{ x } \underset{+2}{1.10} \text{ x } \underset{0}{1.01} \text{ x } \underset{-1}{8.12}} = .804 \quad \frac{+4}{+4} \quad = .804$$

PROBLEMS—COMBINATION (1-25)

Suggested Time: 26 Min.

1. $\frac{11 \times 12 \times 1}{7 \times 8}$ = 2.36

2. $\frac{45.2 \times 11.24}{336}$ = 1.512

3. $\frac{235}{3.86 \times 3.54}$ = 17.2

4. $\frac{67.5 \times 0.835}{3.58}$ = 15.74

5. $\frac{75.5 \times 63.4 \times 95}{3.14}$ = 144,800

6. $\frac{3.82 \times 6.95 \times 7.85 \times 436}{79.8 \times 0.0317 \times 870}$ = 41.3

7. $\frac{47.3 \times 3.14}{32.5 \times 16.4}$ = 0.279

8. $\frac{24.1}{261 \times 32.1}$ = 0.00288

9. $\frac{48.6}{7.45 \times 0.0168}$ = 388

10. $\frac{60.3}{3.15 \times 7.65}$ = 2.50

11. $\frac{546.9}{80.3 \times 0.00578 \times 6.31}$ = 186.7

12. $\frac{78.3 \times 6.98}{104}$ = 5.26

13. $\frac{72.1 \times 0.0893}{9.42 \times 74.9}$ = .00913

14. $\frac{8.99 \times 37.1}{63.7}$ = 5.24

15. $\frac{487}{47.3 \times 0.0785 \times 5.68}$ = 23.1

16. $\frac{13.5 \times 3.49}{2.78}$ = 16.95

17. $\frac{70.4 \times 14.8}{3.97}$ = 262.

18. $\frac{2689}{84.8 \times 38 \times 63.8}$ = .01308

19. $\frac{1}{4.57 \times 19.4 \times 60.7}$ = .0001858

20. $\frac{87,400}{1200 \times 2.43 \times 1.005 \times 0.812}$ = 36.7

PROBLEMS—COMBINATION

21. $\dfrac{14.55 \times 9.04}{31.6 \times 2.33} = 1.786$

22. $\dfrac{7.28 \times 53.6 \times 1.377}{22.2 \times 0.882} = 27.4$

23. $\dfrac{8.37 \times 6.04}{2.73} = 18.52$

24. $\dfrac{28{,}300}{42.1 \times 3.72 \times 5.05} = 35.8$

25. $\dfrac{2.17 \times 0.0983}{72.1 \times 0.870} = .00340$

UNIT 6—RATIO AND PROPORTION PROBLEMS

The relationship between two numbers may be expressed as a fraction. This expressed relationship is also called a ratio. A proportion exists when one ratio equals another as ¼ = 4/16 or 1 : 4 :: 4 : 16.

The identical paired scales, one sliding and one stationary, of the slide rule lend themselves very well to the solution for a missing term in a proportion problem. When the slide is set to any position, the ratios between numbers opposite one another at any point on the C and D scales or CF and DF scales are equal. Thus, if the left index of the C scale is set opposite 2 on the D scale, 1 on the C scale is opposite 2 on the D scale and the ratio of ½ exists at this point. If the hairline is now moved to 2 on the C scale, the reading opposite on the D scale is 4 and the ratio exists here.

A proportion problem may be mentally set up on the slide rule with the cross bars between the numerators and denominators thought of as being on the line which separates the slide from the body.

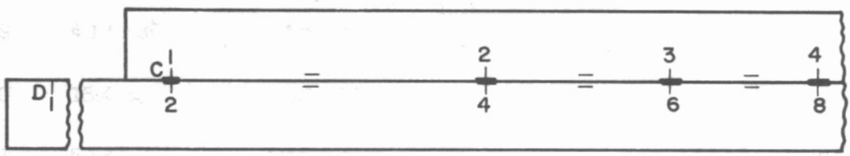


Fig. 13 Ratio and proportion.

Problem: $\frac{2}{25} = \frac{x}{62.5} \quad x = ?$

Procedure:

1. Bring 2 on C scale opposite 25 of D scale.
2. Move hairline to 62.5 of D scale.
3. Make reading (5) under hairline on C scale.
4. Locate decimal point by simplifying known ratio.

$\frac{2}{25} = \frac{1}{12}$ approx., x must be about 1/12 of 62.5 or *5*

Problem: $\frac{.004}{.05} = \frac{6}{x}$

Procedure:

1. Bring 4 on C scale opposite 5 on D scale.
2. Move hairline to 6 on C scale.

3. Make reading (75) under hairline on D scale.
4. Locate decimal point by simplifying known ratio.

$\frac{.004}{.05} = \frac{4}{50}$ or approx. 1/12, x must be about 12 times as great as 6 and therefore about 75.

Any proportion problem may be set up to be worked as a combination problem: $x = \frac{6 \times .05}{.004}$

PROBLEMS—RATIO & PROPORTION (1-25)

Suggested Time: 20 Min.

1.	2.43 : ×	=	47.1 : 68.4	× = 3.53
2.	15.9 : 30.4	=	× : 47.6	× = 24.9
3.	421 : 7940	=	× : 303	× = 16.07
4.	17.33 : 111.5	=	× : 31.6	× = 4.91
5.	24.7 : 8.11	=	2.02 : ×	× = .663
6.	4.95 : 8.73	=	× : 6.84	× = 3.88
7.	6.87 : 1.92	=	5.53 : ×	× = 1.546
8.	× : 8.6	=	5.2 : 64	× = .699
9.	4.17 : 30	=	54.5 : ×	× = 392
10.	15.4 ×	=	298 : 51.3	× = 2.65
11.	5.13 : 28	=	60.5 : ×	× = 330
12.	× : 9.6	=	4.7 : 64	× = .705
13.	12.6 : ×	=	306 : 28.2	× = 1.161
14.	5.23 : 30	=	62.5 : ×	× = 359
15.	13.4 : ×	=	302 : 27.4	× = 1.216
16.	842 : 630	=	281 : ×	× = 210
17.	× : 562	=	43 : 317	× = 76.2
18.	$\frac{35.6}{\times}$	=	$\frac{817}{5.87}$	× = .256
19.	15.2 : ×	=	2.58 : 10.5	× = 61.9
20.	841 : 1.8	=	246 : ×	× = .527

21. $\times : 806 = 83 : 312$ $\times = 214$

22. $\frac{0.569}{\times} = 0.0739$ $\times = 7.7$

23. What % of 973 is 42.5 = 4.37%

24. What % of 83 is 34 = 41.0%

25. What % of 69 is 18 = 26.1%

UNIT 7—SQUARES, SQUARE ROOTS, CIRCLE PROBLEMS, AND CUBE ROOTS

Problems to be solved in previous units required movement of both the slide and hairline. The square or square root of a number may be arrived at with only one slide rule manipulation, a hairline setting.

On many rules, the A scale located on the upper part of the body and the B scale located on the upper part of the slide give the squares of numbers read directly opposite on the C and D scales. To find the square of a number, the hairline is moved to the number on the D scale and the square of the number appears under the hairline on the A scale. Likewise, the hairline may be set to the number on the C scale and the square of that number appears under the hairline on the B scale.

Problem: $(15)^2 = ?$

Procedure:

1. Move hairline to 15 on D scale.
2. Read answer (225) under hairline on A scale.

Placement of the decimal point may be accomplished by rounding or a variation of the single digit method as previously discussed and as shown in the following problem.

Problem: $(0.000122)^2 = ?$

Procedure: −4

1. Move decimal point to set up single digit number. $(0001.22)^2$.
2. Move hairline to 1.22 on D scale. −4 −8
3. Read answer under hairline on A scale; $(1.22)^2 = 1.49$
4. Move decimal point according to value recorded; .0000000149

Some students prefer, in the original number, to move the decimal point an even number of places, two at a time, either to the right or left (as the situation demands), until the number reads as a number between 1 and 100. Thus, $(21300)^2$ is temporarily changed to $(2.13)^2$. After reading the square of the number (4.54), the decimal point is moved in reverse of the direction originally moved, *twice* as many places for final placement. 4.54 is changed to read as 454,000,000. The decimal point was first moved four places to the left and, in the final stage, moved eight places to the right.

On rules having the R1 and R2 (Post) or Sq. 1 and Sq. 2 (K. & E. Decilon) or $\sqrt{\quad}$ (Picket & Ekel) scales, a number is squared by moving the hairline to the number on one of these scales as applicable and the square is read under the hairline on the D scale.

Problem: $(2.5)^2 = ?$

Procedure:

1. Move hairline to 2.5 on Sq. 1 or R1 or upper side of back to back $\sqrt{\quad}$ scale.
2. Read answer (6.25) under hairline on D scale.

Problem: $(5.2)^2 = ?$

Procedure:

1. Move hairline to 5.2 on Sq.2 or R2 or lower side of back to back $\sqrt{\quad}$ scale.
2. Read answer (27.04) under hairline on D scale.

The procedure for finding square roots on the rule is the reverse of the procedure for finding squares. On rules having A and B scales, the hairline is set to the number on the A scale (or B) and the square root is read under the hairline on the D (or C) scale. However, since the right and left halves of the A scale are alike, there will be a question as to which place on the A scale the setting is to be made. It is suggested that this scale be thought of as reading from 1 to 10 on the left half and 10 to 100 on the right half. The number whose square root is sought is changed by moving the decimal point two places at a time, to the right or left as the case demands, until it reads as a number between 1 and 100. If the number now reads as a number between 1 and 10, the number must be set on the left side of the scale or, if it reads as a number between 10 and 100, it must be set on the right side of the scale. For placement of decimal point, movement of decimal point is in opposite direction originally moved and half as many places.

Problem: $\sqrt{.000637} = ?$

Procedure:

1. Move decimal point by twos to make a number between 1 and 100.
2. Move hairline to find $\sqrt{6.37}$ (*Left* half of A scale).
3. Read answer (252) under hairline on D scale.
4. Determine decimal point for $\sqrt{6.37} = 2.52$.
5. Move decimal point back half as many places (2) as originally moved (4). Answer is .0252.

Problem: $\sqrt{.3844} = ?$

Procedure:

1. Move decimal point by twos to make a number between 1 and 100.
2. Move hairline to find $\sqrt{38.44}$ (*Right* half of A scale).
3. Read answer under hairline on D scale (6.2).

4. Move decimal point back half as many places (1) as originally moved (2). Answer is .62.

For rules with R1 and R2, Sq. 1 and Sq. 2 or $\sqrt{}$ scales, the number for which the square root is to be determined is set on the D scale after the number is changed, as indicated previously, to read as number between 1 and 100. If the number is between 1 and 10, the square root will be read under the hairline on the R1, Sq.1 or upper side of the $\sqrt{}$ scale. If the changed number reads as a number between 10 and 100, the square root will be read under the hairline on the R2, Sq.2 or lower side of the $\sqrt{}$ scale as applicable.

Problems involving circles are conveniently worked with the scales dealt with thus far. The circumference of a circle is determind by multiplying its dia. by Pi. Here again only a hairline setting is required to arrive at the product. If the hairline is set to the dia. on either the D or C scale, the circumference may be read under the hairline on the DF or CF scale respectively. If the circumference is known and the dia. is to be found, set the hairline to the circumference on the DF or CF scale and read the dia. under the hairline on the C or D scale respectively.

The formula, Pi x r^2, is used to find the area of a circle where radius is given. If, for rules having an A & B scale, Pi on the left side of the B scale is set to the extreme left or right index of the A scale, then any number on the A scale may be multiplied by Pi by setting the hairline on the A scale and reading the product on the B scale under the hairline. It has also been seen that any number on the A scale is the square of a number directly opposite it on the D scale. To find the area of a circle with radius given, set Pi on the left part of the B scale to the extreme left or right index of the A scale. Move the hairline to the radius on the D scale. Read the area under the hairline on the *B* scale. If the hairline does not fall across a reading on the B scale, set Pi of B scale to opposite extreme index of A scale. Locate decimal point by rounding or by other means.

Referring to rules having R1 type of scales, area is found by setting the hairline to the radius on the R1 or R2 scale. The square of the radius is read under the hairline on the D scale and the area is read under the hairline on the DF scale. For a problem which requires the finding of area with dia. given, divide the dia. by 2 and proceed as when radius is given.

The formula Pi/4 (.7854) x D^2 = area is suited to rules with A & B scales for the problem where dia. is given. A special graduation mark indicates the value of .7854 on the right side of the A & B scales. Set the hairline to the dia. on the D scale. Bring the mark for .7854 on the B scale opposite the extreme right or left index of the A scale. The hairline, which was set to the dia. on the D scale, must line up across some part of the B scale, thus determining whether the right or left index shall be used. The area is read under the hairline on the B scale. The decimal point may be located by rounding.

Problem: Dia. = 60 Area = ?

Procedure:

1. Move hairline to dia. (60) on D scale.
2. Bring Pi/4 or .7854 on right of B scale to right index of A scale.
3. Make reading (2830) for area under hairline on B scale.
4. Round to locate decimal point; .8 x 60 x 60 = 2800
   Answer is 2830.

Problem: Dia. = 10.5 Area = ?

Procedure:

1. Move hairline to dia. (10.5) on D scale.
2. Bring .7854 on right portion of B scale to left index of A scale.
3. Read area (87) on B scale.
4. Round to locate decimal point; .8 x 10 x 10 = 80. Answer is 87.

The procedure is reversed for finding dia. or radius where area is given.

Problem: Area = 28.27 Dia. = ?

Procedure:

1. Bring .7854 on right portion of B scale to right index of A scale.
2. Move hairline to 28.27 on right portion (number is between 10 and 100) of B scale.
3. Read dia. (6) under hairline on D scale.

Problem: Area = 5026 r = ?

Procedure:

1. Bring Pi (3.1416) on left portion of B scale to left index of A scale.
2. Change 5026, as in square root procedure, to read as a number between 1 and 100.
3. Move hairline to 50.26 on right portion of B scale.
4. Read radius (40) under hairline on D scale.

On rules having R1, R2 or Sq.1, Sq.2 or $\sqrt{}$ scales, the hairline is set to the area on the DF scale and radius is read under the hairline on the R1, Sq.1 or upper side of the $\sqrt{}$ scale if the area ÷3 reads as a number between 1 and 10, or on the R2, Sq.2, or lower side of the $\sqrt{}$ scale if the area reads as a number between 10 and 100.

Cubes and Cube Roots

The K scale provided on many slide rules, when used in combination with the D scale, allows the cube or cube root of a number to be found. Procedure is similar to the use of the A scale for finding squares and square roots, except that decimal point movement must be by groups of three. The cube of a number is found by setting the hairline to the number on the D scale and the cube of the number is read under the hairline on the K scale. Decimal point placement may be accomplished if the procedure is started by changing the number, if necessary, to read as a number between 1 and 1000; approximate the answer after reading the number under the hairline on the K scale and move the decimal point three times as many places as originally moved.

Problem: $(.002)^3 = ?$

Procedure:

1. Change number to number between 1 & 1000 by moving decimal point three places at a time. $(002.)^3$.
2. Move hairline to 2 on D scale.
3. Read 8 under hairline on K scale.
4. Locate decimal point; $(2)^3 = 8$.
5. Move decimal point in opposite direction three times the number of places originally moved; .000,000,008.

On some rules, the K scale is marked at the right end of the three equal portions from left to right, respectively 10, 100, and 1000. The user of a K scale, not marked thus should mentally assign these values when attempting to find the cube root of a number. The number, whose cube root is sought, is changed to read as a number between 1 and 1000 by moving the decimal three places at a time either to the left, if the number is greater than 1000, or to the right if the number is less than 1. If the number thus changed is between 1 and 10, the hairline is set to the number on the left third of the scale, if between 10 and 100 the hairline is set to the reading in the middle third of the scale, and, if between 100 and 1000, the hairline is set to the reading on the right third of the scale. After approximation of the decimal point in the answer, final location of the decimal point is achieved by moving the decimal point back one third as many places.

Problem: $\sqrt[3]{2450} = ?$

Procedure:

1. Change to number between 1 and 1000. ($\sqrt[3]{2.450}$).

SQUARES, SQUARE ROOTS, AREAS of CIRCLES & CUBE ROOTS

21.	$\sqrt{23{,}600}$	=	153.6
22.	$\sqrt{0.417}$	=	.646
23.	$\sqrt{0.0205}$	=	.1432
24.	$\sqrt{0.0000929}$	=	.00964
25.	D = 2.49	Area =	4.87
26.	D = 0.374	Area =	.1100
27.	D = 7.92	Area =	49.3
28.	D = 0.0186	Area =	.000272
29.	Area = 12.7	D =	4.02
30.	Area = 149	D =	13.77
31.	Area = 37.3	D =	6.89
32.	Area = 8.46	D =	3.28
33.	R = 7.35	Area =	170.
34.	R = 28.4	Area =	2530.
35.	R = 40.5	Area =	5150.
36.	R = 0.1163	Area =	.0425
37.	Area = 69.3	R =	4.70
38.	Area = 678	R =	14.70
39.	8^3	=	512
40.	3.2^3	=	32.70

41. 21.7^3 = 10200.

42. $\sqrt[3]{27,000,000}$ = 300

43. $\sqrt[3]{0.000585}$ = 0.0836

44. $\sqrt[3]{8.72}$ = 2.06

45. $\sqrt[3]{0.625}$ = 0.855

46. $\sqrt[3]{0.763}$ = 0.914

47. $\sqrt[3]{7630}$ = 19.69

48. $\sqrt[3]{30}$ = 3.11

49. $\sqrt[3]{850}$ = 9.47

50. $\sqrt[3]{0.00763}$ = .1969

UNIT 8—SINE, COSINE AND TANGENT TRIGONOMETRIC FUNCTIONS

Trigonometric functions are the ratios between the lengths of specified sides of a right triangle in relationship to a given angle. Three trigonometric functions are restated as follows for review purposes.

Sine $A = \frac{a}{c}$

Tan $A = \frac{a}{b}$

Cos $A = \frac{b}{c}$

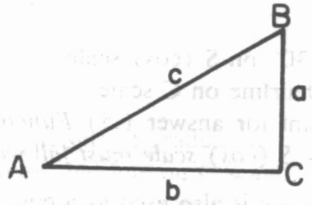


Fig. 14.

The value of these functions may be taken from tables in a mathematics or other hand book with trigonometry tables, but may also be found quickly, and with reasonable accuracy, through the use of the trigonometric scales on the slide rule. The ST (SRT), S and T scales are used in combinations with the C, D, and CI (DI) scales for those operations.

On the deci-trig rule, the graduations on the scales, ST (SRT) and S (cos), represent angles expressed in degrees and *decimal* fractions of degrees. The same scales on a Trig. rule are graduated in terms of degrees and *minutes*. A change from one kind of measurement to the other may be made using the observation that 0.1 of a degree equals 6 minutes. In order to make settings to other than the graduations with labelled values, it is necessary to give careful attention to the subdivisions and their values, since they are not uniform over the scales.

With the hairline moved to the left index of the C scale, the reading under the hairline on the ST (SRT) scale is .574°, while with the hairline moved to the right index of the C scale, the reading on the ST scale is 5.74°. Angles less than .574° will be dealt with in a later unit.

To find the sine of .574°, the hairline is moved to this reading on the ST (SRT) scale and the sine is read under the hairline on the C scale as 1. A decimal point must be placed to make the value read as .01. If the operator used the same procedure to find the sine of 5.74° at the right end of the ST scale, the reading again is 1, but this time the function value must be read as .1. A legend at the right end of the ST scale on many rules indicates that *the sine or tangent of an angle between .574° and 5.74° must have functional values falling within the limits of .01 to .1*.

Problem: Sin 3° = ?

Procedure:

1. Move hairline to 3° on ST scale.
2. Read (523) under hairline on C scale.
3. Move decimal for answer (.0523) (must be between .01 and .1)

Problem: Sin 30° = ?

Procedure:

1. Move hairline to 30° on S (cos) scale.
2. Read (5) under hairline on C scale.
3. Move decimal point for answer (.5) *Functional values for the sine of angles read off the S (cos) scale must fall within the limits of .1 to 1.*

The Sin (S or Cos) scale is also used as a cosine scale. This scale contains two sets of figures. Toward the right end of this scale where the sin of 70° would be read, the graduation mark is also labeled to the left with the number 20. The setting to find the functional value for the cosine of 20° is the same as for the sine of 70° and with the same answer. Many slide rules have made use of two colors to prevent confusion. Also it should be observed that the labeled angles for cosine angles are read to the *left* side of the graduation mark while the figure on the right side of the same graduation mark is for the sine.

Setting the hairline to 84.29° (cosine reading), the value is read under the hairline on the C scale as .1. The same range of values applies to this scale for cosine values as it does for sine values.

The ST scale on some rules does not contain two sets of figures, but is used for finding the cosine of angles from 84.29° to 89.43°. Since *the cosine of an angle is equal to the sine of the complementary angle*, the cosine of 85° would be found by using the setting for the sine of 5°; the answer is read in the same place and the same range of values applies.

Problem: Cos 40° = ?

Procedure:

1. Move hairline to 40° (left side of graduation mark) on S (cos) scale.
2. Make reading (766) under hairline on C scale.
3. Locate decimal point (.766). Value range limit is .1 to 1.

Problem: Cos 86° = ?

Procedure:

1. Move hairline to 86° (if marked) or 4° of ST scale.

2. Make reading (698) under hairline on C scale.
3. Locate decimal point (.0698). Value range limit is .01 to .1.

It has been indicated that the ST (SRT) scale is used for finding the tangent of angles from .574° to 5.74°. The procedure is the same for finding the sine of the identical angles. For angles above 5.74°, the T scale is provided and reads from left to right from 5.74° to 45°. Range of values for tangents of angles must be between .1 and 1, and answers are read on the C scale opposite the angle on the T scale.

Problem: Tan 40° = ?

Procedure:

1. Move hairline to 40 (right side of graduation mark) on T scale.
2. Make reading (84) under hairline on C scale.
3. Locate decimal point (.84). *Value range limit is .1 to 1 for angles from 5.71°* to *45°*.

For angles from 45° to 84.29°, the T scale is read from right to left, and on many slide rules, the labeled graduations are of red color. On some rules, as Pickett & Ekel, the tangent for angles from 45° to 84.29° are read on the T scale from left to right, and functional values are read off the C scale. On most rules, the function value is read under the hairline on the C I scale or D I scale with the C and D indexes together. *The value range limit for angles from 45° to 84.29° is 1-10.*

Problem: Tan 60° = ?

Procedure:

1. Move hairline to 60° on T scale.
2. Make reading (1732) under hairline on CI scale or if Pickett & Ekel on C scale.
3. Locate decimal point (1.732) within value range limit which is 1 to 10.

For finding the tangent of angles between 84.29° and 89.43°, the ST scale is used reading from right to left as it is for the cosine. On some rules, 85° is labeled to the left of the 5° graduation mark. On rules not labeled with the tangent angles in this range, the operator may use the complement of the angle. *Value range limit of angles between 84.29° and 89.43° is 10 to 100, and the values are read on the C I scale opposite the angle on the ST scale.*

Problem: Tangent of 86° = ?

Procedure:

1. Move hairline to 86° (or marked 4°) on ST scale.

2. Make reading (143) under hairline on CI (or DI scale if C and D indexes are opposite one another).
3. Locate decimal point (14.3) with respect to value range limit (10 to 100).

PROBLEMS—TRIGONOMETRIC FUNCTIONS (78 values)

Suggested Time: 25 Min.

Place an answer slip over each of the three columns on the right and record functional values for each of the angles given in the left-hand column.

Angle	Sine	Cosine	Tangent
1°	0.01746	0.999	0.01746
2°	0.0349	0.999	0.0349
3°	0.0523	0.998	0.0524
4°	0.0698	0.997	0.0699
5°	0.0872	0.996	0.0875
10°	0.1736	0.984	0.1763
15°	0.259	0.966	0.268
20°	0.342	0.940	0.364
25°	0.423	0.906	0.466
30°	0.5000	0.866	0.577
35°	0.574	0.819	0.700
40°	0.643	0.766	0.839
45°	0.707	0.707	1.000
50°	0.766	0.643	1.192
55°	0.819	0.574	1.428
60°	0.866	0.5000	1.732
65°	0.906	0.423	2.144
70°	0.940	0.342	2.747
75°	0.966	0.259	3.732

80°	0.985	0.1736	5.671
85°	0.996	0.0871	11.43
86°	0.998	0.0698	14.30
87°	0.999	0.0523	19.08
88°	0.999	0.0349	28.6
89°	0.9998	0.01746	57.3
90°	1.000	.0000	–

PROBLEMS—TRIGONOMETRIC FUNCTIONS (1-25)

Suggested Time: 15 Min.

1.	Sin 2.39°	=	0.0417
2.	Sin = 0.449	Angle =	26.7°
3.	Sin 3° 15′	=	0.0567
4.	Sin 22°	=	0.375
5.	Sin 1.5°	=	0.0262
6.	Sin 7.8°	=	0.1358
7.	Sin 34°	=	0.559
8.	Cos 23°	=	0.921
9.	Cos. 87.3°	=	0.0471
10.	Cos 47.2°	=	0.679
11.	Cos 25.3°	=	0.904
12.	Cos 72.5°	=	0.301
13.	Cos 42.1°	=	0.742
14.	Cos 36.2°	=	0.807
15.	Tan 80.6°	=	6.04
16.	Tan = 2.85	Angle =	70.6°
17.	Tan 55.8°	=	1.47
18.	Tan = 3.61	Angle =	74.52°
19.	Tan 81.4°	=	6.61
20.	Tan 58.6°	=	1.64

21.	Tan 2.8°	=	0.0489
22.	Tan 43°	=	0.933
23.	Cos 89°	=	0.01745
24.	Sin 3° 24'	=	0.0593
25.	Tan 87.1°	=	19.74

UNIT 9—COTANGENT, COSECANT, AND SECANT TRIGONOMETRIC FUNCTIONS

After the student has acquired the ability to find the tangent, sine, and cosine functional values of an angle on the slide rule, the finding of the cotangent, cosecant, and secant values becomes only a matter of observing reciprocals or complements of the angles.

The cotangent of an angle is equal to the tangent of the complementary angle. On some rules the labeled graduation marks on the trigonometry scales have numbers placed on both the left side and right side of the graduation mark. One number is the complement of the other.

Problem: Cotan of 5° = ?

Procedure:

1. Note complement of angle (90 − 5 = 85, Cotan of 5° = tan of 85°).
2. Move hairline to 85° or 5° on ST scale.
3. Read 1143 under hairline on CI or DI (C & D indexes aligned).
4. Locate decimal point. Answer is 11.43.
   For cotangents of angles from .574° to 5.74°, the value range limit is 10-100.

Problem: Cotan 30° = ?

Procedure:

1. Determine complement of angle (Beside 30° on T scale is complement: 60°).
2. Move hairline to 60° on T scale.
3. Read 1732 under hairline on CI scale or on DI with indexes of C & D scales aligned.
4. Locate decimal point. Answer is 1.732.
   For cotangents of angles from 5.74° to 45°, the value range limit is 10-1.

Problem: Cotan 50° = ?

Procedure:

1. Determine complement of angle (40°).
2. Move hairline to 40° on T scale.
3. Read (84) under hairline on C scale.
4. Locate decimal point. Answer is .84.
   For cotangents of angles from 45° to 84.29°, the value range limit is 1-.1.

Problem: Cotan 86° = ?

Procedure:

1. Determine complement of angle (4°).
2. Move hairline to 4° on ST scale.
3. Read 699 under hairline on C scale.
4. Locate decimal point. Answer is .0699.

   For cotangents of angles from 84.29° to 89.43° the value range limit is .01-.1.

The cosecant of an angle is equal to the reciprocal of the sine of the same angle.

Problem: Csc 5° = ?

Procedure:

1. Move hairline to 5° on ST scale.
2. Read sine (.0870) under hairline on C scale.
3. Round for locating decimal point in reciprocal; 1/.09 = approx. 11.
4. Read reciprocal under hairline on CI scale or on DI scale with C & D indexes together. Answer is *11.47*.

Note that the range of values of secants and cosecants when reading from ST to CI are between 10 and 100 and when reading from S to CI are between 1 and 10.

The secant of an angle is equal to the reciprocal of the cosine of the same angle.

Problem: Sec 10° = ?

Procedure:

1. Move hairline to 10° (cosine reading) on S scale.
2. Read cosine (.985) under hairline on C scale.
3. Read reciprocal (1.015) under hairline on CI scale.

   Note that step number 2 above may be eliminated from the procedure when the range of values is well established in mind.

PROBLEMS—TRIGONOMETRIC FUNCTIONS (81 values)

Suggested Time: 45 Min.

Place an answer slip over each of the columns on the right and record functional values for each of the angles given in the left-hand column.

Angle	Cotangent	Cosecant	Secant
0°	-----	-----	1.000
1°	57.3	57.3	1.000
2°	28.6	28.6	1.000
3°	19.08	19.1	1.001
4°	14.30	14.3	1.002
5°	11.43	11.47	1.004
10°	5.67	5.76	1.015
15°	3.73	3.86	1.035
20°	2.75	2.92	1.064
25°	2.145	2.366	1.103
30°	1.732	2.000	1.155
35°	1.428	1.743	1.221
40°	1.192	1.556	1.305
45°	1.000	1.414	1.414
50°	0.839	1.305	1.556
55°	0.700	1.221	1.743
60°	0.577	1.155	2.000
65°	0.466	1.103	2.366
70°	0.364	1.064	2.924

75°	0.268	1.035	3.86
80°	0.1763	1.015	5.76
85°	0.0875	1.004	11.47
86°	0.0699	1.002	14.3
87°	0.0524	1.001	19.11
88°	0.0349	1.000	28.6
89°	0.01746	1.000	57.3
90°	-----	1.000	-----

PROBLEMS—TRIGONOMETRIC FUNCTIONS (1-25)

Suggested Time: 18 Min.

1.	Cot 17°	=	3.27
2.	Cot 88°	=	0.0349
3.	Cot 56.6°	=	0.659
4.	Cot = 3.42	Angle =	16.3°
5.	Cot 83.2°	=	0.1192
6.	Cot = 45.8	Angle =	1.25°
7.	Cot 14.3°	=	3.92
8.	Cot 19.68°	=	2.79
9.	Csc 3°	=	19.11
10.	Csc 18°	=	3.24
11.	Csc 52.4°	=	1.262
12.	Csc 14.5°	=	3.99
13.	Csc 15.75°	=	3.68
14.	Csc 68°	=	1.079
15.	Csc 7.65°	=	7.52
16.	Csc 2° 15′	=	25.5
17.	Sec 17°	=	1.046
18.	Sec 79°	=	5.24
19.	Sec 88.5°	=	38.2
20.	Sec = 1.34	Angle =	41.7°

21.	Sec 26.3°	=	1.116
22.	Sec 13°	=	1.026
23.	Sec 29° 36′	=	1.15
24.	Sec 3.4°	=	1.002
25.	Sec 34°	=	1.206

UNIT 10—RADIANS AND SMALL ANGLES

It was observed in a previous unit that the ST scale is not graduated below .574° or 34′. Although angles less than this are not frequently dealt with, the question will arise as to how functional values for the tangent and sine of angles from 0° to .574° are obtained on the slide rule.

It was also noted previously that the sine and tangent functions from .574° to 5.74° were for slide rule purposes identical. Slide rule operational procedure for functions of angles below .574° is based on the fact that the tangent or sine of small angles is closely equal to the angle in radians. A radian is defined as being the angle subtended at the center of a circle by an arc whose length is equal to the radius or one radian = 180° ÷ Pi = 57.3°.

The relationship between radius and arc (chordal distance very nearly the same) when the angle is changed to 1° becomes 1/57.3 = .01745 for the sine or tangent of 1°. It follows that the sine of 1′ = 1 ÷ (57.3 x 60) = .000291 and that the sine or tangent of 1″ = 1 ÷ (57.3 x 60 x 60) = .00000485. For rounding purposes, the sine of 1′ may be thought of as three zeros three and the sine of 1″ may be thought of as five zeros five.

The tangent or sine of 2′ is found by multiplying the number of minutes by .000291 using the C and D scales, D and CI scales, or by making use of the minute gauge mark found on some slide rules.

Post has provided second and minute gauge marks on the ST scale near the 1.2° and the 2° graduation marks respectively. The hairline is moved to the number of minutes or seconds on the D scale as applicable and with the minute or second gauge mark on the ST scale brought under the hairline, the answer is read opposite the index of the C scale on the D scale.

Problem: Tan 23′ = ?

Procedure:

1. Move hairline to number of minutes (23) on D scale.
2. Bring minute gauge mark on ST scale under hairline.
3. Read 669 opposite index of C scale on D scale.
4. Round for locating decimal point; .0003 x 23 = .0069. Answer is 0.00669.

The minute and second gauge marks are located on the C and D scales of the K. & E. Decilon slide rule. The hairline may be moved to the number of minutes or seconds on the DI scale and with the minute or second gauge mark on the C scale brought under the hairline, the functional value is read opposite the index of the D scale on the C scale.

Problem: Sine 23′ = ?

Procedure:

1. Move hairline to number of minutes (23) on DI scale.
2. Bring minute gauge mark on the C scale under the hairline.
3. Make reading (669) opposite index of D scale on C scale.
4. Round for locating decimal point; .0003 x 23 = .0069. Answer is .00669.

Problem: Cotan 89° 58′ = ?

Procedure: Using D and CI scales

1. Note that Cotan 89° 58′ equals tangent of complementary angle or tangent of 2′.
2. Move hairline to 2 on D scale.
3. Bring 291 on CI scale under hairline.
4. Make reading (582) opposite index of C scale on D scale.
5. Round to locate decimal point; .0003 x 2 = .0006. Answer is .000582.

Problem: Csc 14′ = ?

Procedure:

1. Note that cosecant equals reciprocal of sine of same angle.
2. Move hairline to 14 on D scale.
3. Bring 0.000291 on CI scale under hairline.
4. Read sine of 14′ (.00407) opposite index of C scale on D scale.
5. Read reciprocal (246) of .00407 opposite index of D scale on C scale.
6. Round for locating decimal point; 1/.005 = 200. Answer is 246.

Problem: Sec. 89° 58′ = ?

Procedure:

1. Note that secant equals reciprocal of cosine of same angle and that cosine of angle is equal to sine of complementary angle.
2. Bring hairline to 2 on D scale.
3. Bring 291 on CI scale under hairline.
4. Read sine of 2′ (.000582) opposite index of C scale on D scale.
5. Read reciprocal (1718) of .000582 opposite index of D scale on C scale.
6. Round for decimal point; 1/.0006 = 1600. Answer is 1718.

Radians may be changed to degrees by handling as a multiplication problem of two factors.

Problem: 2.5 radians = ? °

Procedure:

1. Bring right index of C scale opposite 57.3 on D scale (some slide rule makers have provided a graduation mark at this point on the C and D scales.
2. Move hairline to 2.5 on C scale.
3. Read (1432) under hairline on D scale.
4. Round for decimal point location; 60 x 2.5 = 150. Answer is 143.2°.

Conversion of radians to degrees or visa versa may also be thought of as a problem in proportion. With the right index of the C scale set to 57.3 of the D scale, any successive number of conversion problems may be solved with only movement of the hairline to the radians on the C scale or to degrees on the D scale. Radians that can not be set to on the C scale may be set to on the CF scale and the answer in degrees read under the hairline on the DF scale.

Problems: .9 radians = °

1.7 radians = °

Procedure:

1. Bring right index of C scale to 57.3 on D scale.
2. Move hairline to 9 on C scale.
3. Under hairline on D scale read 516. Answer is 51.6°.
4. Move hairline to 1.7 on CF scale.
5. Under hairline on DF scale read 974. Answer is 97.4°.

PROBLEMS—SMALL ANGLES & RADIANS (1-50)

Suggested Time: 30 Min.

1.	4.5 Rad.	=	258°
2.	0.0531 Rad.	=	3.04°
3.	5.31 Rad.	=	304°
4.	0.01823 Rad.	=	1.044°
5.	2.35 Rad.	=	134.7°
6.	5.24 Rad.	=	300°
7.	0.296 Rad.	=	16.96°
8.	0.0462 Rad.	=	2.65°
9.	6.58 Rad.	=	377°
10.	2.56 Rad.	=	146.7°
11.	1.416°	=	0.0247 Rad.
12.	0.833°	=	0.01454 Rad.
13.	2.5°	=	0.0436 Rad.
14.	2.67°	=	0.0466 Rad.
15.	3.59°	=	0.0627 Rad.
16.	9.12°	=	.159 Rad
17.	435°	=	7.59 Rad.
18.	29°	=	0.506 Rad.
19.	48.2°	=	0.841 Rad.
20.	201°	=	3.51 Rad.

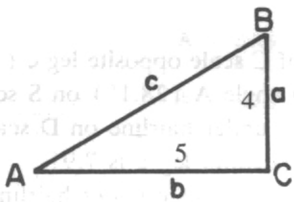
21.	Sin 36′	=	0.01047
22.	Sin 17′	=	0.00495
23.	Tan 37″	=	0.0001794
24.	Tan 24′	=	0.00698
25.	Cos 89° 54′	=	0.001746
26.	Sin 24″	=	0.0001164
27.	Tan 31′	=	0.00903
28.	Csc 13″	=	15860
29.	Sin 22′	=	0.00640
30.	Csc 39′	=	88.1
31.	376°	=	6.56 Rad.
32.	Cot. 89° 58′	=	0.000582
33.	Csc 4′	=	859.
34.	Csc = 421	Angle =	8.16′
35.	Cos 89.75°	=	0.00437
36.	Sec 89.75°	=	229
37.	Tan 89.75°	=	229
38.	Cot 89.75°	=	0.00436
39.	Tan 0.056°	=	0.000978
40.	Tan 13′	=	0.00378

41.	Csc 14″	=	14730
42.	Sin 8″	=	0.0000388
43.	Sec 89° 59′ 20″	=	5150.
44.	Csc = 12560	Angle =	16.42″
45.	Sin = 0.00216	Angle =	7.42′
46.	Sin 3′	=	0.000873
47.	Tan 8′	=	0.00233
48.	Tan 89° 47′	=	264
49.	Tan = 0.00465	Angle =	15.98′
50.	Sin 38″	=	0.0001843

UNIT 11—RIGHT TRIANGLES

Problems requiring the solution of triangles as in the application of vectors occur frequently in the fields of engineering and science. A means of fast solution of problems involving the sides and angles of triangles is afforded by use of the slide rule.

In review of trigonometric functions it was stated that Tan A equals a/b. This suggests that in the solution for Angle A in the figure below that side "a" would be divided by side "b" using the C and D scales. The resulting functional value would be .8.



The angle corresponding to this functional value obtained would then be found by setting the hairline to 8 on the C scale and reading the angle (38.6°) under the hairline on the T scale.

However, a general rule may be followed where two sides of a right triangle are given. To the larger leg when read on the D scale bring that index of the C scale which will allow the smaller leg read on the D scale also to be opposite some part of the slide scales. Move the hairline to the smaller leg on the D scale and under the hairline on the T scale read the smaller acute angle. Bring this angle on the S scale under the hairline and read the hypotenuse "c" opposite the index of the C scale on the D scale.

The above method does not apply to angles smaller than 5.74°. For angles smaller than 5.74° use $c = \sqrt{a^2 + b^2}$.

Problem: a = 4 b = 8 A = ? c = ?

Procedure:

1. Bring right index of C scale opposite large leg (8) on D scale.
2. Move hairline to smaller leg (4) on D scale.
3. Read smaller acute angle A (26.52°) under hairline on T scale.
4. Bring 26.52° on S scale under hairline.
5. Read hypotenuse c (895) on D scale opposite index of C scale.

6. Approximate decimal point by noting proportion of a and b to c. Answer is 8.95.

Problem: a = 97 c = 328 A = ? b = ?

Procedure:

1. Bring left index of C scale opposite hypotenuse (328) on D scale.
2. Move hairline to leg "a" (97) on D scale.
3. Read under hairline on S scale angle A (17.2°).
4. Bring angle A (17.2°) on T scale under hairline.
5. Read leg "b" (313) opposite index of C on D scale.

Problem: A = 28.1° c = 16.79 a = ? b = ?

Procedure:

1. Bring left index of C scale opposite leg c (16.79) on the D scale.
2. Move hairline to angle A (28.1°) on S scale.
3. Read leg a (791) under hairline on D scale.
4. Note general proportion; leg a is 7.91.
5. Bring A (28.1°) on T scale under hairline.
6. Read leg b (1481) opposite left index of C scale on D scale.
7. Note general proportion; leg b is 14.81.

Problem: b = 645 c = 829 A = ? a = ?

Procedure:

1. Bring right index of C scale opposite c (829) on D scale.
2. Move hairline to leg b (645) on D scale.
3. Note b/c equals cosine; read angle A (38.9°) under hairline on *cosine* scale.
4. Move hairline to angle A on *sine* scale.
5. Read leg a (521) under hairline on D scale.

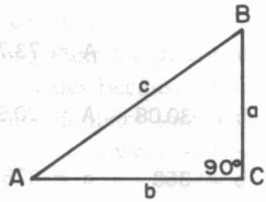
Problem: a = 305 A = 65.9° b = ? c = ?

Procedure:

1. Bring right index of C scale opposite leg a (305) on D scale.
2. Move hairline to angle A (65.9°) on T scale. Note that *smaller* acute angle (24.1°) or complement is read in same place on T scale.
3. Read leg b (136.4) under hairline on D scale.
4. Bring 24.1° on sine scale under hairline.
5. Read hypotenuse c opposite right index of C scale on D scale. Hypotenuse c is 334.

SOLVING RIGHT TRIANGLES (1-25)

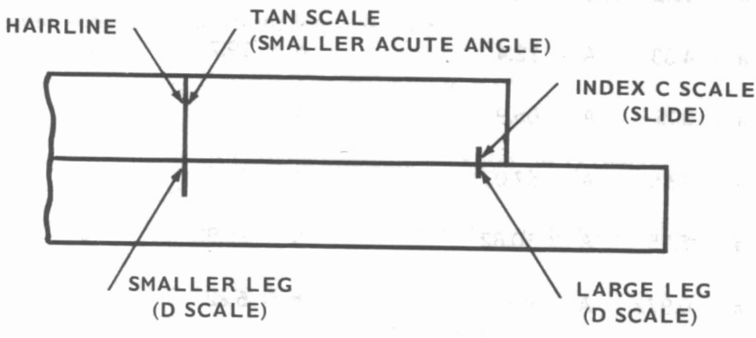
Suggested Time: 50 Min.

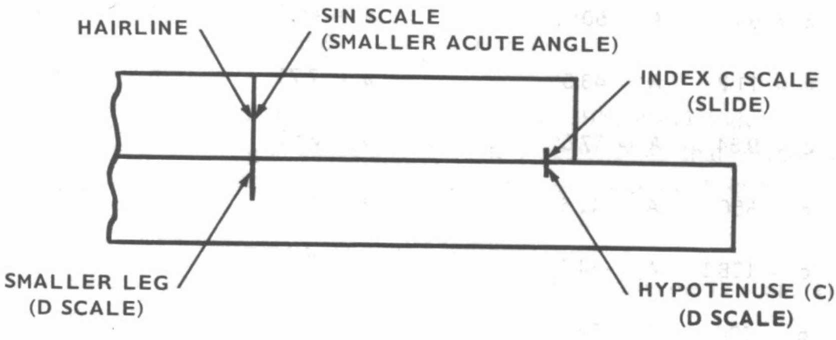


	Given		Missing	
1.	a = 12.3	b = 20.2	A = 31.3°	c = 23.7
2.	a = 42	b = 71	A = 30.6°	c = 82.5
3.	a = 28	b = 34	A = 39.5°	c = 44
4.	a = 50	b = 23.3	A = 65°	c = 55.2
5.	a = 13.2	b = 13.2	A = 45°	c = 18.67
6.	a = 4.33	A = 12.4°	b = 19.70	c = 20.16
7.	a = 305	A = 65.9°	b = 136.4	c = 334
8.	a = 73.5	A = 57.03°	b = 47.7	c = 87.6
9.	a = 5.15	A = 10.82°	b = 26.95	c = 27.4
10.	a = 0.972	A = 8.88°	b = 6.22	c = 6.30
11.	c = 60	A = 50°	a = 46.0	b = 38.6
12.	c = 11.2	A = 43.5°	a = 7.71	b = 8.12
13.	c = 9.54	A = 17.6°	a = 2.88	b = 9.09
14.	c = 856	A = 41.5°	a = 567	b = 641
15.	c = 138.1	A = 34.3°	a = 77.8	b = 114.1
16.	b = 200	A = 64°	c = 456	a = 410

17.	b = 4250	A = 52.68°	c = 7010	a = 5580
18.	b = 1.908	A = 8.908°	c = 1.931	a = 0.299
19.	b = 225	A = 73.79°	c = 806	a = 774.
20.	b = 30.08	A = 20.9°	c = 32.3	a = 11.49
21.	b = 368	c = 378	A = 13.2°	a = 86.3
22.	a = 7.19	c = 27.5	A = 15.15°	b = 26.55
23.	b = 8.75	B = 9.52	a = 52.2	c = 52.9
24.	b = 74.57	B = 64.5°	a = 35.6	c = 82.6
25.	b = 1.912	B = 76.6°	a = 0.456	c = 1.970

SOLUTION OF TRIANGLES (UNIT II)





UNIT 12—LOGARITHMS

Logarithms are a valuable mathematical tool which makes it possible to multiply or divide numbers by adding or subtracting their logarithms. This in effect is accomplished with the use of the C and D scales because these scales are divided in proportion to the logarithms of the numbers they represent. In this unit, logarithms will be used to find fractional powers and roots of numbers and to determine anti-logarithms.

A logarithm is defined as being the exponent or power of a number called the base. The most commonly used base is 10, which was made use of in the tables of logarithms established by Briggs. The logarithm of a particular number is that number which when used as an exponent of the base will raise or lower the base to the particular number. The logarithm of 100 to the base 10 is 2.

Usually the logarithm consists of two parts, the characteristic and the mantissa. The characteristic of the logarithm is the portion of the logarithm to the left of the decimal point and its value for a mixed or whole number is one less than the number of digits to the left of the decimal point in the mixed or whole number. In determining the logarithm of the number 56.5, the characteristic is 1. In a decimal fraction, the characteristic is one more than the number of zeros between the decimal point and the first significant figure and is indicated as being minus with minus being placed *above* the characteristic OR the minus is omitted and the logarithm is followed by a minus 10. Thus, the logarithm of .0000516 is $\bar{5}.713$ or $5.713 - 10$.

This mantissa portion of the logarithm of a number may be found in logarithm tables or read on the L scale of the slide rule after the hairline has been set to the number on the D scale if the L scale is located on the body of the slide rule. The hairline is set to the number on the C scale if the L scale is located on the slide.

Problem: Find the logarithm of 58.70

Procedure:

1. Determine mentally the characteristic; the number of digits to the left of decimal point minus 1 equals characteristic; characteristic is 1.
2. Move hairline to 587 on D scale if L scale is on body and on C scale if L scale is on slide.
3. Under hairline on L scale read mantissa (.769).
4. Combine the characteristic and mantissa to form the logarithm. (1.769).

It follows from the above that the anti-logarithm (the number which is obtained when the given logarithm is used as an exponent of the base) may be found by setting the hairline to the mantissa on the L scale and reading the number under the hairline on the D or C scale as noted previously with the decimal point determined in relation to the characteristic. If the characteristic is positive, the anti-log must show one more digit to the left of the decimal point than the value indicated by the characteristic. If the characteristic in the anti-log is minus, the number is a decimal fraction and must show one less zero between the decimal point and the first significant figure than indicated by the value of the characteristic.

Problem: Find the anti-logarithm of the logarithm 6.584.

Procedure:

1. Move hairline to .584 on the L scale.
2. Read number (384) under hairline on D or C scale.
3. Determine decimal point placement; there must be one more digit to the left of the decimal point then the value (6) of the characteristic. Answer is 3,840,000.

Problem: Find the anti-logarithm of the logarithm $\bar{1}.146$

Procedure:

1. Move hairline to .146 on L scale.
2. Read number (14) under hairline on D or C scale.
3. Determine decimal point placement; there must be one less zero between decimal point and the first significant figure following the decimal point than indicated by the minus characteristic. Anti-log is .14.

A number may be raised to a fractional power by first multiplying the logarithm of the number by the exponent. The anti-logarithm of the product of this operation supplies the power to which the number was to be raised.

Problem: $(2)^{5.2} = ?$

Procedure:

1. Move hairline to 2 on the D or C scale as applicable to find mantissa.
2. Read mantissa (.301) under hairline on the L scale.
3. Determine characteristic of 2; characteristic is 0.
4. Multiply logarithm of number by exponent ($0.301 \times 5.2 = 1.565$).
5. Find anti-log of 1.565, move hairline to .565 on L scale.
6. Read number (367) under hairline on D or C scale.
7. Determine decimal point placement in anti-log; characteristic as indicated in the figure 1.565 is 1, therefore, anti-log must have two digits to left of decimal point. Answer is 36.7.

Problem: $(29.2)^{6.3}$ = ?

Procedure:

1. Determine characteristic of log of 29.2; characteristic is 1.
2. Move hairline to 292 on C or D scale.
3. Read mantissa (.466) under hairline on L scale.
4. Multiply log (1.466) by exponent (6.3) to get product (9.23).
5. Move hairline to .23 on L scale.
6. Read anti-log (17) on C or D scale under hairline.
7. Determine decimal point placement in anti-log as indicated by characteristic (9). Answer is 1,700,000,000.

Problem: $(.06)^5$

Procedure:

1. Determine characteristic of log of .06; characteristic is $\overline{2}$.
2. Move hairline to 6 on C or D scale.
3. Read mantissa (.778) under hairline on L scale.
4. Since the characteristic is minus and the mantissa positive, separate and multiply each by the exponent; $\overline{2} \times 5 = \overline{10}$ and $.778 \times 5 = 3.890$.
5. Combine results of above: $\overline{10} + 3.890 = \overline{7}.890$.
6. Move hairline to .890 on L scale.
7. Read anti-log (776) under hairline on C or D scale.
8. Determine decimal point placement as indicated by characteristic ($\overline{7}$). Answer is .000000776.

Obtaining the root of a number by logarithms involves dividing the logarithm of the number by the root and finding the anti-logarithm of the new logarithm.

Problem: $\sqrt[4]{25.7}$ = ?

Procedure:

1. Determine characteristic of logarithm of number (25.7); characteristic is 1.
2. Move hairline to 257 on D or C scale.
3. Read mantissa (.41) under hairline on L scale.
4. Divide logarithm (1.41) by root (4); $1.41 \div 4 = 0.352$.
5. Move hairline to .352 on L scale.
6. Read anti-log (225) under hairline on C or D scale.
7. Determine decimal point placement as indicated by characteristic in new log (0.352). Answer is 2.25.

Problem: $\sqrt[4]{0.0284} = ?$

Procedure:

1. Determine characteristic of logarithm of number (0.0284); characteristic is $\bar{2}$.
2. Move hairline to 284 on C or D scale.
3. Read mantissa (.452) under hairline on L scale; log is $\bar{2}.452$.
4. Divide logarithm by root; since characteristic is minus, add and subtract a number that may be divided by the root an even number of times; $4 + \bar{2}.452 - 4 = +2.452 - 4$.
5. Divide above result by root;

$$\begin{array}{c} .613 \;\; -1 \\ \dfrac{2.452 \quad -4}{4} \end{array} = \bar{1}.613$$

6. Move hairline to .613 on L scale and read anti-log (41) under hairline on C or D scale.
7. Determine decimal point placement as indicated by characteristic ($\bar{1}$). Answer is .41.

PROBLEMS—LOGARITHMS, ANTI-LOGARITHMS (1-50)

Suggested Time: 22 Min.

Find Logarithm to Base 10

1.	50	=	1.699
2.	1.6	=	0.204
3.	0.35	=	9.544–10
4.	32.7	=	1.515
5.	6.51	=	0.814
6.	980,000	=	5.991
7.	0.676	=	9.830–10
8.	432	=	2.635
9.	72.6	=	1.861
10.	0.208	=	9.318–10
11.	0.00317	=	$\bar{3}.501$
12.	0.00248	=	$\bar{3}.394$
13.	7.56	=	0.879
14.	58.71	=	1.769
15.	3000	=	3.477
16.	156530	=	5.194
17.	38.4	=	1.584
18.	1087	=	3.036
19.	1.993	=	0.300

20.	0.726	=	$\bar{1}.861$
21.	3.56	=	0.551
22.	4250	=	3.628
23.	25200	=	4.401
24.	61.5	=	1.789
25.	48000	=	4.681

Find Anti-Logarithm

26.	3.9	=	7950
27.	0.882	=	7.62
28.	1.74	=	55
29.	2.65	=	447
30.	1.61	=	40.74
31.	3.36	=	2290
32.	4.42	=	26300.
33.	0.51	=	3.24
34.	$\bar{2}.45$	=	0.0282
35.	$\bar{1}.41$	=	0.257
36.	$\bar{4}.38$	=	0.00024
37.	$\bar{2}.354$	=	0.0226
38.	3.338	=	2180.

39.	1.31	=	20.4
40.	4.274	=	18800.
41.	$\bar{1}.412$	=	0.258
42.	$\bar{3}.56$	=	0.00363
43.	7.608	=	40,600,000
44.	2.72	=	525.
45.	5.816	=	655,000
46.	2.068	=	117.
47.	3.316	=	2070
48.	1.09	=	12.3
49.	4.22	=	16600.
50.	5.086	=	122,000

PROBLEMS—SOLVE USING LOGARITHMS (1-30)

Suggested Time: 35 Min.

1.	$(3)^{2.5}$	=	15.56
2.	$(30)^{2.4}$	=	3500.
3.	$(26.7)^{5.3}$	=	36,300,000
4.	$(4.5)^{1.4}$	=	8.2
5.	$(6.2)^{4.5}$	=	3670
6.	$(2.57)^{2.9}$	=	15.46
7.	$(.02)^{1.5}$	=	0.00283
8.	$(16.5)^{2.3}$	=	630.
9.	$(0.0426)^{4.0}$	=	0.00000331
10.	$(0.318)^{3.0}$	=	0.0321
11.	$(1.5)^{3.5}$	=	4.13
12.	$(6.12)^{4.2}$	=	2,000
13.	$(8.1)^{4.6}$	=	15,000
14.	$(30)^{5}$	=	24,200,000
15.	$(3.5)^{7.5}$	=	12,030.
16.	$\sqrt[6]{250}$	=	2.51
17.	$\sqrt[3]{0.65}$	=	0.866
18.	$\sqrt[5]{26.3}$	=	1.92
19.	$\sqrt[4]{0.025}$	=	0.398
20.	$\sqrt[7.5]{1500}$	=	2.65

21. $\sqrt[3.1]{238}$ = 5.84

22. $\sqrt[4]{24}$ = 2.21

23. $\sqrt[6]{0.003}$ = 0.380

24. $\sqrt[4]{0.0384}$ = 0.443

25. $\sqrt[2.7]{1.5}$ = 1.162

26. $\sqrt[5]{0.05}$ = .549

27. $\sqrt[4]{528}$ = 4.79

28. $\sqrt[2]{0.96}$ = 0.98

29. $\sqrt[3.6]{8000}$ = 12.13

30. $\sqrt[3]{0.00728}$ = 0.194

UNIT 13—POWERS AND ROOTS OF NUMBERS GREATER THAN ONE

In unit 7, consideration was given to finding the square roots of numbers through the use of scales designated on some rules as the A & B scales and on other rules as the R1, R2 or Sq.1, Sq.2 or $\sqrt{\quad}$ scales. Other roots and powers of numbers in addition to squares and square roots may be obtained by use of the log log scales.

The log log scales on modern rules are arranged in two groups. This unit will relate to that group which represents numbers ranging from 1.01 (3 scales provided on some rules) or 1.001 (4 scales provided on other models) to approximately 22,000 and reading from left to right. The decimal points on these scales are fixed; 2.5 can be read only on the LL2 (Ln2) (LL02) and 25 can be read only on the LL3 (Ln3) (LL03). This group of log log scales which encompasses a range from 1.01 or 1.001 to approximately 22,000 should be thought of as one continuous scale which has been split into three or four parts and stacked in such a manner that when the hairline is set to a number on the LL1 (Ln1) (LL01) scale, the tenth power of that number may be read under the hairline on the (LL2) (Ln2) (LL02) scale, and the hundredth power of the number on the LL1 (LL01) (Ln1) scale may be read on the LL3 scale. Thus, if the hairline is moved to 2 on the LL2 scale, the tenth power of 2 (1028) is read under the hairline on the LL3 scale. Note that the span of distance between these two points, from 2 located near the right end of the LL2 scale and onto the left end of the LL3 scale to 1028 is the equivalent distance of the full C scale length. If the hairline is moved to 1.01 on the LL1 scale to solve the problem $(1.01)^{100}$, the answer is read under the hairline on the LL3 scale. The distance spanned in looking "up" (direction of increasing values) the scales for the answer, is the equivalent of two complete C scales.

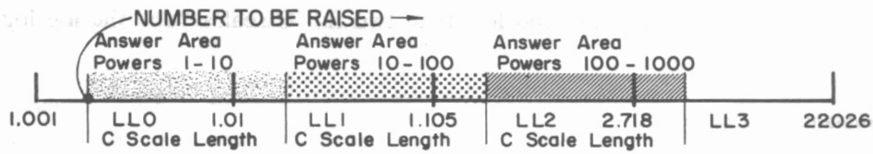


Fig. 16 Locating answers on LL-scales, Powers greater than one.

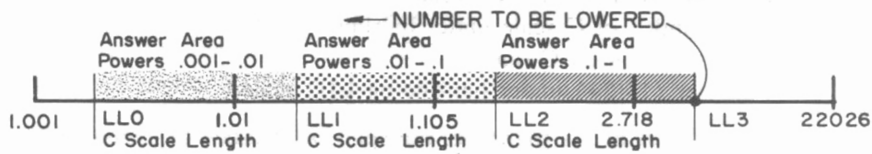


Fig. 17 Locating answers on LL-scales, Powers less than one.

Because the subdivisions of these scales vary over a wide range, the reader should exercise care in making a reading by observing the numbered divisions on each side of the hairline. In certain places on the log log scales, readings may be made to five significant figures and in other places, readings may be made to only two significant figures.

The procedure for raising a number to a power using the log log scales is similar to multiplication by use of the C and D scales except that the D scale is now replaced by the log log scale. The number to be raised is set to on the log log scale and the exponent is set to on the C scale.

Problem: $(5)^3 = ?$

Procedure:

1. Move the hairline to 5 on the LL3 scale.
2. Bring left index of C scale under the hairline.
3. Move hairline to 3 on C scale.
4. Read answer (125) under hairline on LL3 scale.

   Note that power (3) was less than 10 and greater than 1 so distance span between number to be raised and answer is less than the equivalent of 1 complete C scale distance "up" the log log scales.

Problem: $(1.02)^{23.8} = ?$

Procedure:

1. Move hairline to 1.02 on LL1 scale.
2. Bring left index of C scale under hairline.
3. Move hairline to 238 on C scale.
4. Read answer (1.603) under hairline on LL2 scale.

   Note that power (23.8) was less than 100 and greater than 10 so that the distance span between number to be raised and the answer is somewhat greater than one, and less than two full C scales "up" the log log scales.

Problem: $(1.04)^9 = ?$

Procedure:

1. Move hairline to 1.04 on LL1 scale.
2. Bring right index of C scale under hairline.
3. Move hairline to 9 on C scale.
4. Read answer (1.424) under hairline on LL2 scale.

When the exponent is less than one, the span of distance to locate the answer will be "down" the log log scales.

Problem: $(1.04)^{.9} = ?$

Procedure:

1. Move hairline to 1.04 on LL1 scale.
2. Bring right index of C scale under hairline.
3. Move hairline to 9 on C scale.
4. Read answer (1.0359) under hairline on LL1 scale.

The obtaining of roots of numbers by use of the log log scales is similar to the technique of division with the C and D scales. The number whose root is to be obtained is set to on the log log scale and the number outside the radical is set to on the C scale.

Problem: $\sqrt[3]{125.} = ?$

Procedure:

1. Move hairline to 125. on the LL3 scale.
2. Bring 3 on the C scale under hairline.
3. Move hairline to left index of C scale.
4. Read answer (5) under hairline on LL3 scale.
   Note that if root is greater than one, answer must be read "down" the log log scales from the number whose root is being sought; if the root is less than one, the answer must be read "up" the log log scales.

Problem: $\sqrt[35.2]{100} = ?$

Procedure:

1. Move hairline to 100 on LL3 scale.
2. Bring 352 on C scale under hairline.
3. Move hairline to left index of C scale.
4. Read answer (1.14) under hairline on LL2 scale.

Problem: $\sqrt[.32]{1.5} = ?$

Procedure:

1. Move hairline to 1.5 on LL2 scale.
2. Bring 32 on C scale under hairline.
3. Move hairline to left index of C scale.
4. Read answer (3.55) under hairline on LL3 scale.

Problems which necessitate going beyond the range of the log log scales may be solved by the use of logarithms.

Problem: $\sqrt[1.5]{(1.02)^{32}} = ?$

Procedure:

1. Move hairline to 1.02 on LL1 scale.
2. Bring 1.5 on C scale under hairline.
3. Move hairline to index of C scale.
4. Read 1.0133 on LL1 scale.
5. Move hairline to 32 on C scale.
6. Read answer (1.526) under hairline on LL2 scale.

Problem: $(12)^X = 1728 \quad X = ?$

Procedure:

1. Move hairline to 12 on LL3 scale.
2. Bring left index of C scale under hairline.
3. Move hairline to 1728 on LL3 scale.
4. Read answer (3) on C scale under hairline.

   Note that distance span from 12 to 1728 on LL3 scale is the equivalent of part of a C scale length and direction is to right; power is greater than 1 and between 1 and 10.

Problem: $\sqrt[X]{2.50} = 1.03 \quad X = ?$

Procedure:

1. Move hairline to 1.03 on LL1 scale.
2. Bring left index of C scale under hairline.
3. Move hairline to 2.5 on LL2 scale.
4. Read 31 under hairline on C scale.

   Note that distance span from 2.5 along log log scales to 1.03 is to the left and includes distance span equivalent to one and part of another C scale. Root is greater than 1 and is between 10 and 100. Answer is 31.

PROBLEMS—LOG LOG SCALES (1-50)
POWERS AND ROOTS GREATER THAN ONE

Suggested Time: 35 Min.

1. $(1.05)^{167}$ = 3450
2. $(723)^{0.34}$ = 9.40
3. $\sqrt[3.3]{2.15}$ = 1.261
4. $\sqrt[6]{1.7856}$ = 1.1014
5. $(989)^{0.35}$ = 11.2
6. $(1.52)^{21}$ = 6,600.
7. $(1.056)^{0.85}$ = 1.0474
8. $(5.27)^{0.044}$ = 1.0759
9. $\sqrt[3.6]{156}$ = 4.07
10. $\sqrt[1.7]{93.7}$ = 14.4
11. $(1.111)^{3.33}$ = 1.42
12. $(6.93)^{0.333}$ = 1.907
13. $\sqrt[0.21]{1.42}$ = 5.31
14. $\sqrt[610]{3200}$ = 1.0133
15. $(21.5)^{0.19}$ = 1.792
16. $(1400)^{0.1}$ = 2.063
17. $\sqrt[15.1]{1538}$ = 1.626
18. $(157.5)^{0.77}$ = 49.4
19. $\sqrt[3.82]{1.11}$ = 1.0277
20. $(1.28)^{23}$ = 290.

21. $(22.4)^{1.88} = 346.$

22. $\sqrt[6.6]{412} = 2.49$

23. $\sqrt[1.7]{195} = 22.2$

24. $(1.0216)^{337} = 1320$

25. $\sqrt[722]{11200} = 1.0131$

26. $\sqrt[3.2]{5.12} = 1.665$

27. $(5.77)^{2.88} = 156.$

28. $\sqrt[3.42]{365} = 5.61$

29. $\sqrt[18.3]{1.67} = 1.0284$

30. $(57.5)^{0.67} = 15.0$

31. $(108)^{0.131} = 1.847$

32. $\sqrt[1.25]{199} = 68.5$

33. $(2,500)^{0.468} = 39.$

34. $(6.31)^{4.288} = 2700$

35. $\sqrt[5.06]{(99.9)^{2.42}} = 9.02$

36. $\sqrt[2.37]{(3.03)^{0.86}} = 1.495$

37. $\sqrt[2.66]{(1.26)^{9.01}} = 2.188$

38. $(47.5)^{0.041} = 1.1715$

39. $(17.7)^{2.37} = 900$

40. $(6.63)^{1.75} = 27.4$

41. $\sqrt[0.8]{1431}$ = 8,900

42. $\sqrt[3.9]{73.2}$ = 3.01

43. $\sqrt[1.7]{1.7}$ = 1.366

44. $(1.063)^{100}$ = 450.

45. $(1.372)^{10}$ = 23.6

46. $(5.47)^{X} = 213$ X = 3.16

47. $(37.3)^{X} = 1.95$ X = 0.1845

48. $(X)^{17.4} = 20.9$ X = 1.191

49. $\sqrt[X]{2.47} = 1.243$ X = 4.16

50. $\sqrt[2.43]{X} = 1.64$ X = 3.32

UNIT 14—POWERS & ROOTS OF NUMBERS LESS THAN 1

A second group of log log scales has a scale range from approximately .000045 to .99 (3 scales) or .999 (4 scales) and its major calibrations on many rules are indicated with red numbers. These scales are used in finding roots and powers of numbers less than 1. This group of scales may also be thought of as one scale split into three or four parts and stacked. However, this group of scales, contrary to the group of scales studied in Unit 13 reads from right to left. When a number on one of these scales is raised by a power greater than one, the distance spanned along the scales to find the answer is in the same direction as applied to the log log scales used in Unit 13.

Problem: $(.2)^2 = ?$

Procedure:

1. Move hairline to .2 on LL3 scale (red).
2. Bring left index of C scale under the hairline.
3. Move hairline to 2 on C scale.
4. Read answer (.04) under hairline on LL3 scale.

When the power is less than one, the distance span from the number originally set to on the log log scale is to the *left*.

Problem: $(.60)^{.5} = ?$

Procedure:

1. Move hairline to .60 on LL2 scale.
2. Bring right index to hairline.
3. Move hairline to 5 on C scale.
4. Read answer (.774) under hairline on LL2 scale.

To obtain roots of numbers by use of these scales, the procedure is similar to division on the C & D scales. If the root is greater than one, the distance span from the original number to the answer is to the *left*.

Problem: $\sqrt[2]{.40} = ?$

Procedure:

1. Move hairline to .4 on LL2 scale.
2. Bring 2 on C scale under hairline.
3. Move hairline to left index.
4. Read answer (.632) under hairline on LL2 scale.

Problem: $\sqrt[.23]{.55} = ?$

Procedure:

1. Move hairline to .55 on LL2 scale.
2. Bring 23 on C scale under hairline.
3. Move hairline to left index of C scale.
4. Read answer (.0741) under hairline on LL3 scale.

In a problem in which the root is less than one, the distance span along the scales from the original number for which the root is to be taken is to the *right*.

Problem: $\sqrt[30]{.72}$

Procedure:

1. Move hairline to .72 on LL2 scale.
2. Bring 3 on C scale under hairline.
3. Move hairline to left index of C scale.
4. Under hairline on LL1 scale read answer (.9891).

Problem: $\sqrt[X]{.846} = .98158 \quad X = ?$

Procedure:

1. Move hairline to .98158 on LL1 scale.
2. Bring right index of C scale under hairline.
3. Move hairline to .846 on LL2 scale.
4. Read 9 on C scale under hairline.

PROBLEMS—LOG LOG SCALES (1-50)

Powers and Roots of numbers less than one.

Suggested Time: 40 Min.

1.	$(0.80)^{15.3}$	=	0.0330
2.	$\sqrt[0.51]{0.087}$	=	0.0084
3.	$(0.983)^{535}$	=	0.000103
4.	$(0.94)^{5.4}$	=	0.716
5.	$\sqrt[2.4]{0.403}$	=	0.685
6.	$\sqrt[7.2]{0.927}$	=	0.98952
7.	$\sqrt[300]{0.0114}$	=	0.98519
8.	$(0.224)^{3.1}$	=	0.0096
9.	$(0.944)^{0.462}$	=	0.9737
10.	$(0.883)^{0.254}$	=	0.9689
11.	$\sqrt[0.3]{0.52}$	=	0.113
12.	$\sqrt[0.7]{0.9}$	=	0.860
13.	$(0.87)^{0.73}$	=	0.9033
14.	$(0.25)^{2.08}$	=	0.0560
15.	$(0.57)^{0.39}$	=	0.8032
16.	$\sqrt[X]{0.037} = 0.241$	X =	2.32
17.	$(X)^{6.12} = 0.431$	X =	0.8715
18.	$\sqrt[0.39]{0.935}$	=	0.8418
19.	$\sqrt[0.42]{0.0883}$	=	0.0031
20.	$(0.135)^{0.41}$	=	0.440

21.	$(0.92)^{0.3}$	=	0.9753
22.	$(0.83)^{1.5}$	=	0.756
23.	$\sqrt[0.53]{0.582}$	=	0.360
24.	$\sqrt[6.8]{0.927}$	=	0.98890
25.	$\sqrt[X]{0.157} = 0.667$	X =	4.57
26	$(0.9811)^{10}$	=	0.826
27.	$(0.984)^{100}$	=	0.199
28.	$\sqrt[3.1]{0.0689}$	=	0.422
29.	$\sqrt[113]{0.028}$	=	0.9689
30.	$(0.05)^{2.5}$	=	0.00056
31.	$(0.81)^{0.51}$	=	0.898
32.	$\sqrt[5.5]{0.101}$	=	0.659
33.	$(0.56)^{1.1}$	=	0.528
34.	$\sqrt[3.2]{(0.933)^{23.6}}$	=	0.5995
35.	$\sqrt[4.3]{X} = 0.868$	X =	0.544
36.	$(0.65)^{0.71}$	=	0.7365
37.	$(0.056)^{2.81}$	=	0.000305
38.	$\sqrt[0.63]{0.63}$	=	0.480
39.	$\sqrt[6.3]{0.435}$	=	0.8762
40.	$(0.98)^{261}$	=	0.00515

41.	$\sqrt[1.7]{(X)^{4.91}} = 0.9295$	$X =$	0.9750
42.	$(X)^{6.41} = 0.00026$	$X =$	0.276
43.	$(0.9735)^{X} = 0.025$	$X =$	137.2
44.	$(0.842)^{X} = 0.507$	$X =$	3.95
45.	$\sqrt[0.42]{0.0883}$	$=$	0.0031
46.	$(0.55)^{9.3}$	$=$	0.00385
47.	$(0.561)^{1.063}$	$=$	0.5405
48.	$(0.004)^{0.013}$	$=$	0.9308
49.	$\sqrt[0.85]{0.926}$	$=$	0.9135
50.	$\sqrt[21.3]{0.707}$	$=$	0.98385

UNIT 15—RECIPROCALS, NEGATIVE POWERS, AND ROOTS, POWERS OF e

The two groups of log log scales, one representing numbers greater than one and the other representing numbers less than one, were treated separately in preceding units. In the introduction to the CI scale in an earlier unit, it was noted that the reciprocal of a number could be found by setting the hairline to the number on the C scale and reading the reciprocal under the hairline on the CI scale with the decimal point to be determined by the operator. The log log scales may also be used to find reciprocals with the need for locating decimal points eliminated. The two groups of log log scales are paired in such a manner that when the hairline is set to a number on the LL1 scale beginning with 1.01, the reciprocal of that number may be read under the hairline on the opposite LL1 scale beginning with .99.

Problem: Find the reciprocal of 2

Procedure:

1. Move hairline to 2 on LL2 scale (black).
2. Under hairline on opposite paired LL2 scale read .5.

Problem: Find the reciprocal of 20

Procedure:

1. Move hairline to 20 on LL3 scale.
2. Under hairline on opposite paired LL3 scale read .05.

Problem: Find the reciprocal of .96.

Procedure:

1. Move hairline to .96 on LL1 scale.
2. Under hairline on opposite paired LL1 scale read 1.0418.

A number raised to a negative power is the reciprocal of the number raised to the positive power. Likewise, the negative root of a number is the reciprocal of the positive root of the number. In work done thus far, the log log scales were used to find reciprocals AND raise numbers to positive powers. It is, therefore, convenient to use these scales for finding the negative powers and roots of numbers.

Problem: $(1.25)^{-3} = ?$

Procedure:

1. Move hairline to 1.25 on LL2 scale.
2. Bring left index of C scale under hairline.

3. Move hairline to 3 on C scale.
4. Read positive power (1.952) under hairline on LL2 scale.
5. Read negative power (reciprocal) (.512) under hairline on opposite paired LL2 scale.

Problem: $(.841)^{-42} = ?$

Procedure:

1. Move hairline to .841 on LL2 scale.
2. Bring left index of C scale under hairline.
3. Move hairline to 42 on C scale.
4. Read positive power (.9298) under hairline on LL1 scale.
5. Read negative power (1.0755) under hairline on opposite LL1 paired scale.

Problem: $\sqrt[-.31]{2.1} = ?$

Procedure:

1. Move hairline to 2.1 on LL2 scale.
2. Bring 31 on C scale under hairline.
3. Move hairline to left index of C scale.
4. Read positive root (11) under hairline on LL3 scale.
5. Read negative root (.091) under hairline on paired LL3 scale.

Problem: $\sqrt[X]{200} = .85 \qquad X = ?$

Procedure:

1. Move hairline to .85 on LL2 scale.
2. Bring left index of C scale under hairline.
3. Move hairline to 200 on LL3 scale.
4. Under hairline on C scale read 326.

   Note that reciprocal of .85 is 1.177, distance span is from 200 to 1.177, movement is to left from 200—root is greater than one, distance span is somewhat more than equivalent of full C scale, root must be between 10 and 100. Answer is 32.6.

The constant e (approximately 2.718) is calibrated at the right end of the LL2 scale and at the left end of the LL3 scale. This constant is the base of the system of natural logarithms and has many applications in the mathematics of science and engineering. To raise this base, the hairline is set to the exponent on the D scale and the result is read on one of the log log scales. Legends at the right end of the log log scales indicate on which log log scale the power is to be read. Thus the 1-10 at the end of the LL3 scale means that when exponents within the limits of 1-10 are used the result is to be read on LL3 scale.

Problem: $(e)^3 = ?$

Procedure:

1. Move hairline to 3 on D scale.
2. Read answer (20) under hairline on LL3 scale.

Problem: $(e)^{.02} = ?$

Procedure:

1. Move hairline to 2 on D scale.
2. Read answer (1.0202) under hairline on LL1 scale.

Problem: $(e)^{-.15} = ?$

Procedure:

1. Move hairline to 15 on D scale.
2. Read answer (.861) on LL2 scale (red).

PROBLEMS—RECIPROCALS, NEGATIVE POWERS and ROOTS, POWERS of e (1-50)

Suggested Time: 35 Min.

1. $(0.875)^{-7.2} = 2.62$

2. $(1.027)^{-0.49} = 0.98708$

3. $(10.16)^{-2.16} = 0.0067$

4. $\sqrt[-4.62]{7.43} = 0.648$

5. $\sqrt[-4.92]{(0.933)^{2.47}} = 1.0354$

6. $\sqrt[-X]{0.0037} = 4.26 \quad X = 3.86$

7. $(1.0375)^{-46.4} = 0.182$

8. $\sqrt[-7.83]{15.75} = 0.703$

9. $(2400)^{-0.0059} = 0.95515$

10. $(0.0165)^{-0.333} = 3.92$

11. $\sqrt[-2.47]{0.556} = 1.268$

12. $(0.9476)^{-8.22} = 1.556$

13. $(1.0182)^{X} = 0.661 \quad X = -23.0$

14. $(1.25)^{-4.31} = 0.382$

15. $(293)^{-0.162} = 0.398$

16. $\sqrt[-12.2]{1.567} = 0.9638$

17. $\sqrt[-4.56]{(6.93)^{3.62}} = 0.215$

18. $(0.9875)^{-11.7} = 1.1588$

19. $\sqrt[-1.94]{(0.202)^{6.27}} = 176.$

20. $(0.9892)^{-57.6} = 1.87$

21. $(e)^{3}$ = 20.1

22. $(e)^{-3}$ = 0.0498

23. $(e)^{0.035}$ = 1.03562

24. $(e)^{-1.342}$ = 0.2613

25. $(e)^{4}$ = 54.

26. $(e)^{0.43}$ = 1.537

27. $(e)^{2.12}$ = 8.33

28. $(e)^{-.0212}$ = 0.9790

29. $(e)^{-0.4}$ = 0.670

30. $(e)^{-0.035}$ = 0.9656

31. $(e)^{-2.46}$ = 0.0854

32. $(e)^{-0.0264}$ = 0.9740

33. $(e)^{8.2}$ = 3600.

34. $(e)^{0.0212}$ = 1.0214

35. $(e)^{-0.0185}$ = 0.98168

36. $(e)^{X} = 0.3362$ X = −1.090

37. $(e)^{X} = 0.346$ X = −1.061

38. $(e)^{X} = 1.974$ X = 0.680

39. $(e)^{X} = 6.54$ X = 1.879

40. $(e)^{X} = 0.945$ X = −0.0566

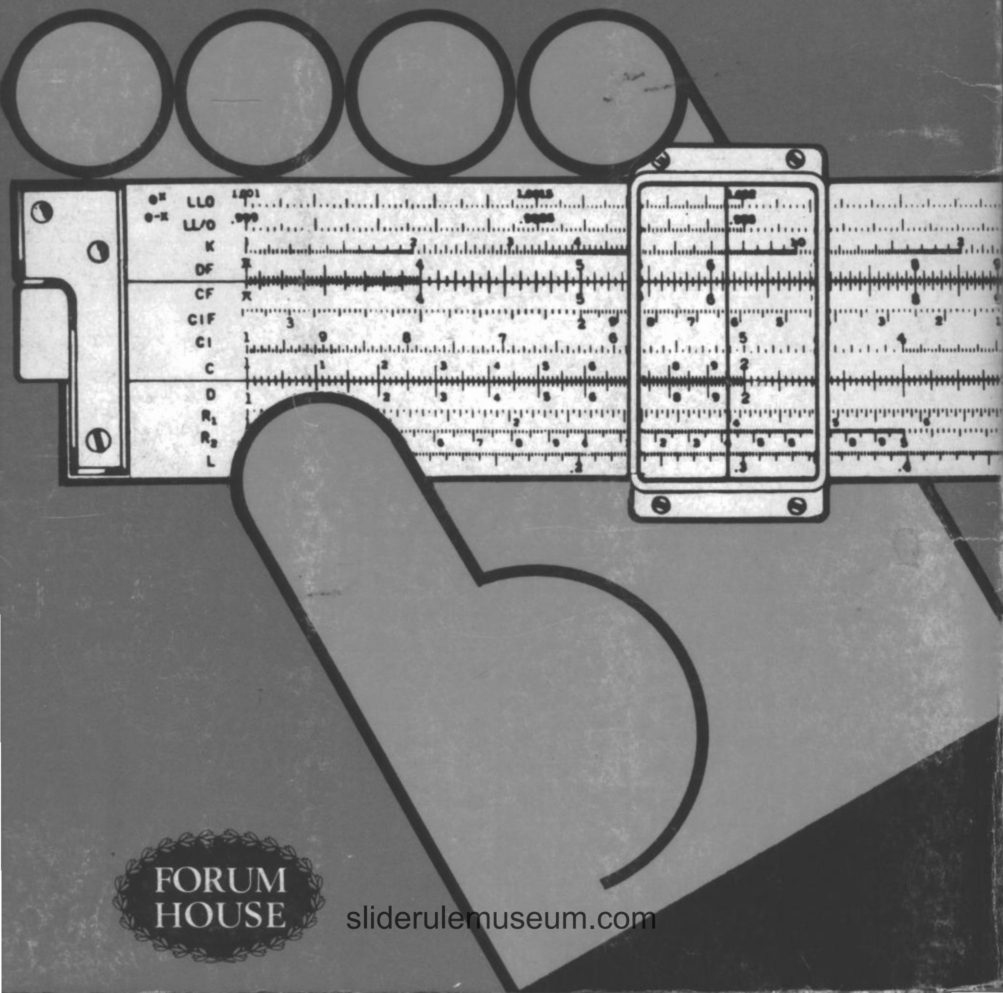
Find reciprocals, using paired log log scales

41.	13.74	=	0.0730
42.	0.0010236	=	980.
43.	8173	=	0.000122
44.	0.98635	=	1.0138
45.	0.02964	=	33.8
46.	1.653	=	0.605
47.	1.0557	=	0.9472
48.	576	=	0.00173
49.	0.009555	=	105.
50.	2453	=	0.00041

INDEX

1.25

HOW TO USE THE SLIDE RULE



FORUM HOUSE