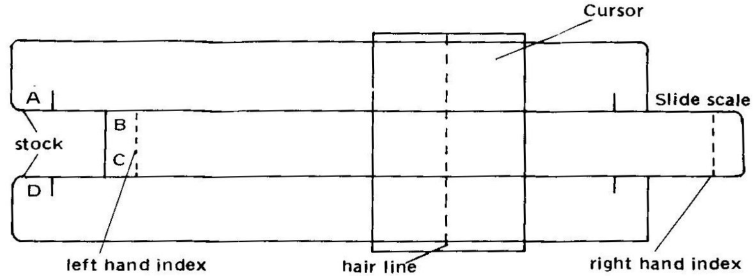
Instructions for the use of Boots RINGPLAN Slide Rules

CONTENTS.

1. GENERAL.

The slide rules are constructed of 2 stocks, one reversible slide scale, and a movable cursor. The cursor has a hair line to assist in finding figures directly below various scales, when calculations are being made.



The more advanced models carry 5 gauge points for immediate recognition.

Thse are: $\pi = 3.1416$ (or 3.142)

and the conversion factors showing the number of seconds, minutes and degrees in a radian.

$$\rho'' = \frac{180 \times 60 \times 60}{\pi} = 206{,}244''$$ i.e. the number of seconds in a radian.

$$\rho' = \frac{180 \times 60}{\pi} = 3{,}437.4'$$ i.e. the number of minutes in a radian.

$$\rho^\circ = \frac{180}{\pi} = 57.29^\circ$$ i.e. the number of degrees in a radian.

$$C = \frac{2}{\sqrt{\pi}} = 1.129$$

2. C AND D SCALES.

Major divisions are 1 to 10

Division 1 is the left hand index (L.H.I.)

Division 10 is the right hand index (R.H.I.)

Between 1 and 10 major divisions are indicated by figures (1, 2, 3, 4, etc.)

Between these major divisions, major subdivisions (e.g. 1.5) are shown by a bold line and minor subdivisions (e.g. 1.54) by a shorter line

Between the minor subdivisions a third decimal place (e.g. 1.575) is estimated by eye

It is necessary to remember that the position of the decimal point has no significance when finding a number on a scale. If you want to find the point on the scale representing 154, then it will fall between the major divisions 1 and 2. This will be 5/10 of the way between 1 and 2, plus a further 2 minor subdivisions representing 4/10 of the way between 15 and 16.

As the scales C and D are graduated logarithmically, the interval between major numbers (1-10) decreases as you proceed towards 10, so that there is insufficient room to provide 100 graduations along the whole length. For example, on a 10" rule there are 100 divisions between 1 and 2, but only 50 between 2 and 3, and 3 and 4 and this decreases further to 20 divisions between the remaining major numbers i.e. 4 to 10. However, one proceeds as if 100 divisions were marked between each and uses the cursor to aid the calculation.

The scales are graduated so that if you add the distance between 1 and 2 to that between 1 and 4, you arrive at the figure 8 which is 2 x 4. Conversely, if you subtract the distance between 1 and 2 from that between 1 and 6, you arrive at the figure 3, which is 6 ÷ 2. Scale C is marked identically to scale D for exactly this purpose.

3. MULTIPLICATION.

Scales C and D.

The index line on scale C is always put over the number to be multiplied on Scale D. Your answer is then read off scale D below the multiplying number on scale C, using the cursor line for ease and accuracy.

e.g., set the 1 on scale C (L.H.I.) over 2 on scale D. You now can read off 4, 6, 8, 10 etc. on scale D under the figures 2, 3, 4, 5 etc. on scale C (Use the cursor line to find the answer).

Then if you slide the 10 on scale C (R.H.I.) over 2 on scale D you can read multiplication answers of 2 x 5, 6, 7, 8, & 9 beneath each number, so completing the scale. [Use the left or right hand index, depending on the numbers to be multiplied.]

Exercise: multiply 13.2 by 2, by 6, by 16, by 9, by 72,
(Answers: 26.4, 79.2, 211.2, 118.8, 950.4)

N.B. The decimal point.

When starting a calculation it is as well to make a mental note of where you expect the decimal point to appear in the answer, or if necessary, do a rough longhand reckoning to find out. For instance, the slide rule's answer to 3.75 x 8.95 is 336. If we "round up" to 4 x 9, we know the answer is 36. Clearly then the correct answer is 33.6.

4. DIVISION.

Scales C and D.

This is very simply achieved by sliding the divisor on scale C over the number to be divided on scale D and reading the answer off on scale D under the left or right hand index.

e.g. 8 ÷ 2 = 4

Slide 2 on scale C over 8 on scale D using the cursor to help. Read off 4 on scale D under the L.H.I.

Exercise: divide 48 by 8, 392 by 14, 110 by 5, 2468 by 3.7
(Answers: 6, 28, 22, 667)

Combined calculations e.g. 31.5 X 4.82 ÷ 19.2

a) 31.5 x 4.82 Find 315 on scale D with the cursor and place the R.H.I. under it. Move the cursor over 482 on scale C and read off 151.8 below on scale D.

b) ÷ 19.2 Leaving the cursor over 1518 move the slide so that 192 is under it and read under the R.H.I. the figure on the D scale—79 Remembering your decimal point, the answer will therefore be 7.9

NB. Scales A & B can also be used for these calculations.

5. THE A AND B SCALES.

Adjacent logarithmic scales, equally divided into two halves.

The operations shown as possible with the C & D scales can be equally well performed using scales A & B with more convenience but less accuracy; for Scale D read A, for C read B and remember that due to duplication of the scales, all the numbers in C and D appear twice in A and B. Scale A being divided into 2 equal halves can be used for finding quickly the square or square root of a number.

6. SQUARES AND SQUARE ROOTS.

Scales A and D.

For squares, place the cursor over the number you wish to square on the D scale, reading the answer on the A scale above.

(e.g. 5 squared reads 25 on the A scale)

For square roots, the reverse procedure is all that is required.

7. CUBES AND CUBE ROOTS.

Scales K and D. K is a logarithmic scale divided into 3 identical sections; each being 1/3 of the length of the C or D scales.

For cubes, place the cursor over the number you wish to cube on D scale, reading the answer on the K scale below.

(e.g. 2 cubed reads 8 on the K scale.)

For cube roots simply reverse this procedure.

8. RECIPROCALS.

Scales CI and D

Take care to remember that CI reads from RIGHT to LEFT, as it is the same logarithmic scale as C, numbered in reverse.

Set the scales together and locate on scale D whatever number is required. The reciprocal of that number is then read off (under the cursor line) on scale CI.

e.g. reciprocal of 2.7 is 0.370(NOT 0.43), or the reciprocal of 2 is 0.5(1/2)

9. PROPORTIONS

Scales C and D.

These Scales are also useful for conversions, proportional allotment and percentages.

1. Proportions. e.g. There are 20 pencils to be allocated in 3 proportions: A—45% B—35%, C-20%. How many pencils will be shared to each?

Set the L.H.I. over 20 on the D scale. Find the numbers 45,35 and 20 on the C scale and the answers can be read below them on the D scale (in this case 9, 7, and 4).

2. Percentages. e.g. there are three piles of bricks with 9, 7 and 4 bricks in each pile. What percentage of the whole does each represent?

Set the L.H.I. over the total number of the bricks (i.e. 20) on the D scale Find the numbers 9, 7, and 4 with the cursor on the D scale and read off the percentages on the C scale. (i.e. 45%, 35%, and 20%) Or another method is to find 9, 7 and 4 in turn on the D scale and, sliding the total figure (20) on the C Scale over each, read off under the appropriate index, (left or right), the answers on the D Scale.

10. INVERSE PROPORTIONS.

Scales CI and D.

e.g. 6 men can do a job in 30 days.

Question i) How many days would it take 4 men to do it?

ii) How many men will be needed to finish it in 20 days?

Solution i) with the cursor, find 6 on the D scale and align 30 on the CI scale with it. Move the cursor to 4 on the D scale and read off the answer aligned with it on the CI scale – in this case 45 (NOT 55; remember the CI scale reads from RIGHT to LEFT.)

ii) leaving the sliding scale where it is, move the cursor over 20 on the CI scale. The answer will be below on the D scale (in this case 9).

11. SINES AND COSINES

Scales S and D.

Sines: reverse the centre slide, put the scales together and set the cursor over the degree on scale S. Read off the decimal answer on scale D. e.g. Sin 35°=0.574

Cosines: are found in the same way, having first translated the Cos into its Sin equivalent (cos $x°$ = Sin 90° – $x°$)

Hence Cos 35° = Sin 55° = 0.819

N.B. This is not necessary with the Slide rules already showing the cos beside the sin on the S scale, (as on the Log Log rules)

12. LOGARITHMS

Scales L and D. The L scale is on the reverse of the slide equally divided into 10

Set the scales together, set the cursor over the number on the D scale of which you wish to find the logarithm and read off the decimal answer on the L scale.

e.g. Log 2.45= 0.389

13. TANGENTS

Scales T and D (or also T_1 and D, T_2 and D, depending on your rule.)

N. B. where the scales are T_1 (and T_2) cotangents are shown with the tangents. Tangents are to the left of the mark, cotangents are to the right. Each has the same answer on the D scale.

Set the scales together, set the cursor over the angle on scale T (or T_1) and read off the decimal answer on scale D.

e.g. Tan 25° (or cotangent 65°) = 0.466

Where there is no T_2 scale (continuing beyond 45°) the tan of angles between 45° and 90° should be obtained by finding the reciprocals of the tangents of the complementary angles: –

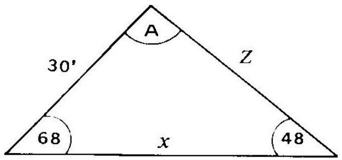
e.g. to find the tan of 55°

The complementary angle is 35°. Therefore find 35 on the T or (T_1 scale) and read 0.7 on the D scale. Referring to your instructions for reciprocals, you will then discover that 0.7 is 1.43, which is the tan of 55°.

14. SOLUTION OF TRIANGLES.

Scales S. and D.

Question: A triangle has two known angles of 48° (B) and 68° (C) and one known side of 30 ft (y). What is the third angle (A) and what are the lengths of the other two sides (x and z)?

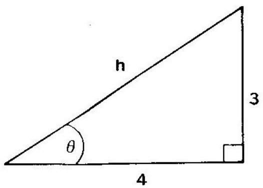


Solution: a) $A = 180° - (48° + 68°) = 64°$

b) $$\frac{\text{Sin A}}{x} = \frac{\text{Sin B}}{y} = \frac{\text{Sin C}}{z}$$

Set 48° on the S scale to 30' on the D and then against 64° and 68° on Scale S you will be able to read off 36.3' and 37.4' on scale D.

Question: A right angled triangle has two known sides. What is the length of the hypotenuse?



i.e. $\tan\theta = \frac{3}{4}$ and $h = \frac{3}{\sin\theta}$

Solution: To find θ slide 4 on the C scale over 3 on the D scale and slide the cursor over the R.H.I. of scale C (75°). The tan of this is then seen to be 36° 52' which is read off on the T_1 scale above (with the scales level). Now slide this figure on the S scale over 3 on the D scale and find 5 under the R.H.I., which is the length of the hypotenuse.

N. B. Do not get confused over the minutes: the T and S scales are divided into 6 to make 60' (1 minute), not decimally.

15. LOG-LOG SCALES.

Characteristic of the log-log rules are the four scales on the stock called $LL_0 : LL_1 : LL_2 : LL_3$.

They are constructed on the principal Log_e (natural Log x) in the same measure as the scales C & D and work in conjunction with them, the initial point "e" being Euler's number (2.718) for the natural logarithm corresponding with 1 on the D scale.

The scales are arranged as follows:

LL_0 1.001 to 1.01
LL_1 1.01 to 1.15
LL_2 1.15 to 2.718 (e)
LL_3 2.788 to 20,000

(N.B. On the 5" rule the LL_0 scale does not appear.)

Unlike C & D scales, LL scales cannot be varied according to any considerations about a decimal point, therefore while 2 on C & D scales can also be 20, 20,000 or 0.0002, on the log-log scales it can only be 2.

Read the scales in conjunction with the D scale as follows: –

for a figure on the D scale (x), the hair line will give e^x on each log-log scale. To read the LL scale correctly, follow the rule shown below:

if x is a number between	1 and 10	each reading of e^x can be found on	LL_3
	0.1 and 1		LL_2
	0.01 and 0.1		LL_1
	0.001 and 0.01		LL_0

e.g. i) $e^{1.96} = 7.10$ (LL_3)

move the cursor to 1.96 on the D scale and read 7.1 on the LL_3 scale.

ii) $e^{0.94} = 2.56$ (LL_2)

iii) $e^{0.056} = 1.0576$ (LL_1)

iv) $e^{0.004} = 1.0041$ (LL_0)

NB i) if $x < 0$ Use $e^{-x} = 1 \div e^x$

e.g. $e^{-0.85} = 1 \div e^{0.85}$

$= 1 \div 2.34$

$= 0.4273$

NB ii) When $\sqrt[n]{e}$ is given, change its form to $e^{1/n}$

With the help of the cursor find η on the CI scale, (scales together) and read off the answer on the appropriate LL scale.

e.g. $\sqrt[4]{e} = e^{1/4} = 1.284$

or $\sqrt{e} = e^{1/2} = 1.649$

The most useful feature of log-log scales is the ease with which all powers and roots can be calculated but their use is varied.

NATURAL LOGARITHMS.

Inversely, $e^x = \alpha$ is the same as $x = \log_e \alpha$

Set the cursor to the given number x on the LL scale and $\log_e \alpha$ can be found on the D scale below.

e.g. $\text{Log}_e\ 5 = 1.609$ (LL_3)

$\text{Log}_e\ 2 = 0.693$ (LL_2)

$\text{Log}_e\ 1.03 = 0.0296$ (LL_1)

$\text{Log}_e\ 1.006 = 0.00598$ (LL_0)

RAISING TO POWERS.

e.g. $1.13^{2.5} = 1.357$

Set the cursor over 1.13 on the LL_2 scale and align the L.H.I. below it. Move the cursor along to 2.5 on the C scale and read off 1.357 on the LL_2 scale above it.

EXTRACTION OF ROOTS.

e.g. i) $\sqrt[4.1]{65} = 2.77$

Set the cursor over 65 on the LL_3 scale and align the figure 4.1 on the C scale with it. Move the cursor to the L.H.I. and read the answer 2.77 on LL_3.

ii) $\sqrt[1.66]{1.8} = 1.425$

Set the cursor over 1.8 on the LL_2 scale and align 1.66 on the C scale with it. Move the cursor to the L.H.I. and read off 1.425 on the LL_2 scale above.

iii) $\sqrt[5]{100} = 2.512$

Set the cursor over 100 on the LL_3 scale and align 5 on the C scale with it. Move the cursor to the R. H. I. and read 2.512 on LL_2.

(N.B. As reading under 1 on the C scale (L.H.I.) is not possible read under 10 (R.H.I.) on $e^{0.1x}$.

iv) $0.92^{-4.8} = \left(\frac{1}{1.087}\right)^{-4.8} = 1.084^{4.8}$

$= 1.492$

(if $\eta < 0$, use $a^{-n} = 1 \div a^n$, as shown above)

HOW TO DEAL WITH DIFFICULT NUMBERS

e.g. i) $0.136^6 = \left(\frac{1.36}{10}\right)^6 = 6.05 \times 10^{-6}$

Change 0.136^6 form to $1.36^6 \times 10^{-6}$ and calculate as decribed in the preceding examples.

ii) $5.3^7 = (5.7^{3.5})^2 = 342.8^2 = 11750$

iii) $3.14^{4.2} \times 100^{4.2} = 122 \times 100^4 \times 100^{0.2}$
$= 122 \times 10^8 \times 2.152 = 306.5 \times 10^8$
$= 3.065 \times 10^{10}$

iv) $\sqrt{\sqrt{\sqrt{3.4}}} = \sqrt{\sqrt{17.72}} = \sqrt{4.21} = 2.052$

v) $18\sqrt{1.515} = 18\sqrt{\frac{15.15}{10}} = \frac{1.163}{1.1366} = 1.023$

HYPERBOLIC FUNCTIONS.

Hyperbolic functions are calculated from the following formulas:

$\cosh x = \frac{e^x + e^{-x}}{2}$

$\tanh x = \frac{e^{2x} - 1}{e^{2x} + 1}$

e.g. $\cosh 0.802 = 1.339$
$\tanh 0.802 = 0.665$
$e^{0.802} = 2.23$

Set the cursor to 802 on D and read off 2.23 on LL_2

$e^{-8.02} = \frac{1}{e^{0.802}} = \frac{1}{2.23} = 0.448$ (see example v)

$e^{2 \times 0.802} = 1.604$

Substituting these values in the preceding formulas we have:

$\cosh 0.802 = \frac{2.23 + 0.448}{2} = 1.339$

$\tanh 0.802 = \frac{4.975 - 1}{4.975 + 1} = 0.665$

COMPOUND INTEREST.

e.g. If £1,400 is invested for 12 years @ 4-3/4% interest p.a., what is the total at the end of the period? In the equation terms this is:

$1,400\ (1 + 0.0475)^{12} = 2,440$

a) Find 1.0475 with the cursor on LL_1 and align the L.H.I. to it, multiplying by 12 (move cursor to 12 on C scale). You will then read 1.745 on LL_2.

b) move the cursor to 1.745 on the D scale and align the L.H.I. to it, multiplying by 1400 (move cursor to 1400 on C scale)

c) the answer, 2440, appears on the D scale.

16. CARE OF THE SLIDE RULE.

When it is necessary to clean the plastic, a minimum of soap and warm (not hot) water should be used. Care should be taken to avoid contact with any chemical solvents, as the plastic may be defaced. Conditions of heat or damp should also be avoided and to prevent undue wear keep the rule in the plastic wallet provided. If these precautions are followed, your Boots slide rule will give you long and accurate service.