British Thornton slide rule instructions

To the beginner

Introduction

It is easy to use a slide rule even though it may take practice to become really familiar with it

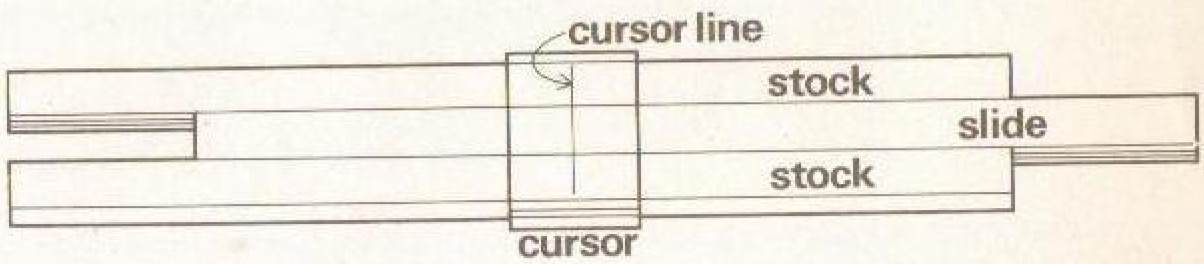
In using the various scales you will find it helpful to work out a simple problem which you can check mentally before going on to more complicated calculations. In this way confidence and an understanding of the scales is built up, together with an appreciation of the very great use which can be made of the slide rule

Do not try to use the more advanced scales before you understand the basic scales and make a practice of rough checking your answer mentally – ask yourself 'does it look right?' – and you will soon join the widening circle of slide rule users

These instructions cover all models in the British Thornton 250 mm range of slide rules – so do not be surprised if your slide rule does not have some of the scales !

Parts of the slide rule

Here are the main parts of the slide rule



The recommended method of use is as follows

a Hold the slide rule at the ends

b When the slide is evenly located between the stocks manipulate the slide by the index fingers

c When the slide is extended to one end hold the rule by the opposite end and move the slide with the free hand

Significant figures

A slide rule can be regarded as giving an answer correct to three significant figures (sometimes a fourth figure can be estimated). Significant figures do not have anything to do with the decimal point and must not be confused with it. If we take 276 as an illustration of three significant figures, then

27 600
276
27.6
0.00276

are all examples of these same three significant figures. Similarly with 408 as our three significant figures, examples are 40 800, 4.08, 0.0408. Thus the number of zeros to the left of the first significant figure or to the right of the third significant figure do not affect the significant figures themselves

Decimal point

Now a word about the position of the decimal point. Usually you know the approximate value of your answer and therefore the position of the decimal point. If you are in any doubt, make a rough calculation and decide the position of the decimal point by estimation

The scales

On the left hand end of your slide rule you will see that the scales are identified by letters. This booklet explains the use of the scales

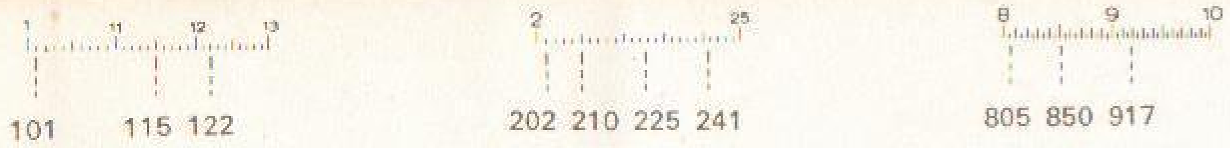
C and D scales

Let us first look only at the scales identified by the letters C and D. The C scale is on the slide and the D scale is on the lower stock

These two scales are the most frequently used on a slide rule and are the basic scales normally used for multiplication and division

You will notice that these two scales are identically marked and are numbered from left to right 1, 11, 12 . . . 2, 25, 3 . . . 45, 5, 6 . . . 10. It will be easier if we regard these numbers as starting at 100 and going up to 1 000 since we are only concerned with the significant figures of calculations

The following illustration shows settings for various three significant figure values



Notice that the various subdivisions on the scales alter as we move along the scale. Between 100 and 200 each subdivision represents a change of 1 in the last figure. Between 200 and 500 each subdivision represents a change of 2 in the last figure; and between 500 and 1 000 each subdivision represents a change of 5 in the last figure

Cursor
A single line cursor is supplied as standard since additional lines on cursors can be confusing

Notation
For simplicity of description in this booklet we shall use the following notation: for 'set the 1 of the C scale against the 3 of the D scale' we shall write 'set C_1 to D_3' – using for our suffices the numbers which are actually involved

Instructions for use

Multiplication – using the C and D scales
Example: To multiply 2.5 by 3.5 (or 250 by 350, or 0.025 by 3 500)
Set C_1 to D_{25}
Move cursor line to C_{35}
and read answer (8.75) on D scale
This setting is shown in the diagram

With the same setting we can read off the product of any other number with the significant figures 25. For example 2.5 × 13: read the answer (32.5) on D at C_{13}. Note that the position of the decimal point has been obtained from a rough check

If however we were asked to multiply 2.5 by any number whose significant figures were greater than 400 there would be no number on the D scale corresponding to these figures on C. In cases like this we adopt the following procedure
To multiply 2.5 by 468
Set C_{10} (instead of C_1) to D_{25}
Move cursor line to C_{468}
and read 117 on D scale
Our rough check tells us that the answer is 1 170
This process is known as 'end-switching', since we are using the other end of the C scale

You are recommended to try further examples of multiplying two numbers together using the C and D scales

Continuous multiplication
Suppose we wish to compute 2.4 × 4.6 × 0.3 × 3.2

A rough check (2 × 5 × ⅓ × 3) tells us that the answer is about 10. We proceed as follows

Set C_{10} to D_{24}
Move cursor to C_{46}
Bring C_1 to cursor line
Move cursor to C_3
Bring C_{10} to cursor line
Move cursor to C_{32} and read 106 on D scale
From our rough check we know that the answer is therefore 10.6 (3 significant figures). From this example you will see that there is no need to write down the answers to the intermediate products but if any of them were required they could be read off easily

Division
This is the inverse process to multiplication so we merely carry out the operations on the slide rule in reverse. For example to divide 84 by 15 (a rough check tells us that the answer is about 5½)
Set cursor to D_{84}
Bring C_{15} to cursor line
and read 56 on D scale at C_1

Our rough check tells us that the answer is 5.60 (3 significant figures)

As in multiplication we sometimes use C_{10} instead of C_1 so the answers to division questions will sometimes be read off on D at C_{10} instead of C_1
Example: 30.6 ÷ 68 (rough check gives approximately ½)
Set cursor to D_{306}
Bring C_{68} to cursor line
and read 45 on D scale at C_{10}
From our rough check we can position the decimal point, giving 0.450 as the answer (3 significant figures)

Compound multiplication and division

Suppose we wish to evaluate $\frac{161 \times 923 \times 152}{258 \times 172}$

There are of course many ways of doing this such as working out the numerator and then working out the denominator and finally carrying out the division. This process involves several movements of both slide and cursor and also the writing down of two intermediate stages – all of which increase the possibility of error

One of the quickest and simplest methods of tackling problems of this kind is to carry out the divisions and multiplications alternately – this reduces considerably the number of slide and cursor movements involved. We shall carry out the operations as shown in this diagram

161 × 923 × 152
↘ ↗ ↘ ↗
258 × 172

and we proceed as follows

Set cursor to D_{161}	
Bring C_{258} to cursor line	(giving division by 258)
Move cursor to C_{923}	(giving multiplication by 923)
Bring C_{172} to cursor line	(giving division by 172)
Read 509 on D scale at C_{152}	(giving the final product)

Using a rough check we see that the answer is 509 (3 significant figures)

Reciprocals
The CI scale (on the slide) is a C scale running from right to left and it provides reciprocals of the corresponding numbers on the C scale. For example C_{52} is

aligned with CI_{192} showing that the reciprocal of 5.2 is 0.192 (decimal point obtained by rough check)

Remember that the numbers on the CI scale increase from right to left. The D and CI scales can be used for division as an alternative to the C and D scales. For example suppose we wish to evaluate 3.4 ÷ 5.6. This is the same as $3.4 \times \frac{1}{5.6}$ and we may proceed as follows
Set cursor to D_{34}
Bring C_1 (or $CI_{1.0}$) to cursor line
Move cursor to CI_{56}
and read answer (606) on D scale (decimal point considered = 0.606)

Displaced C and D scales
(CF and DF scales)
These two scales are simply C and D scales displaced by the factor π. They are particularly useful in multiplication, division, proportions, etc as they virtually eliminate any need for 'end switching' when used in conjunction with C and D scales

Example
Multiply each of the following numbers by 0.263:
12.7, 559, 173, 76.8, 24.6, 9.24 and 35.4

Using the combination DF and CF, C and D scales, all the results can be obtained by a single setting of the slide followed by direct cursor projections, viz
Move slide so that CF_{10} aligns with DF_{263}

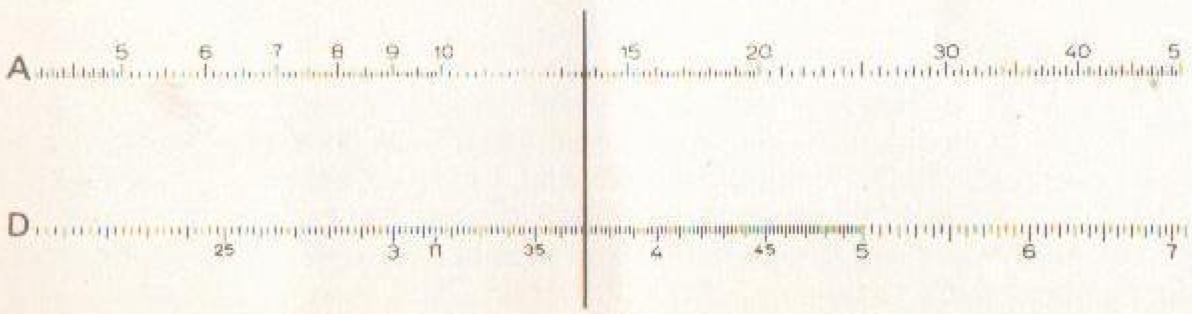
With the slide in this position read from CF to DF scale the products of
559 – answer 147
76.8 – answer 20.2
9.24 – answer 2.43
and from C to D scale read the products of
12.7 – answer 3.34
173 – answer 45.5
24.6 – answer 6.47
35.4 – answer 9.31

Note: since cursor projection from C and D scales to CF and DF is the equivalent of multiplication by π of the C or D scale value then circumference from diameter of circle (and vice versa) can be obtained at a single setting of the cursor

Squares and square roots

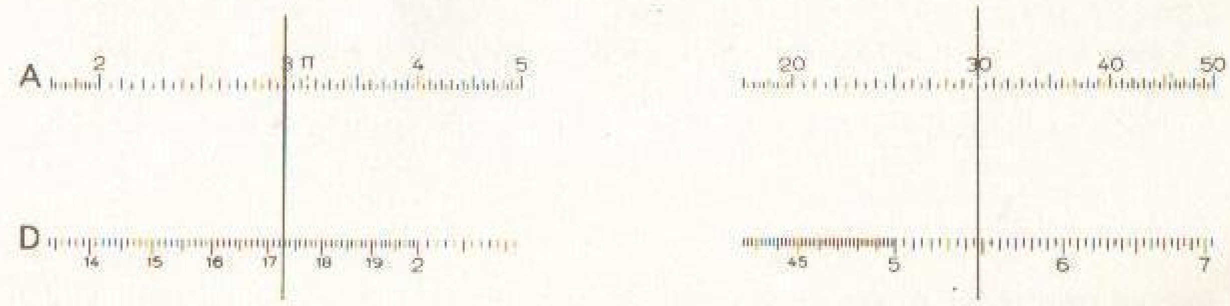
The scales are so positioned on the slide rule that the numbers on the A scale are the squares of the corresponding numbers on the D scale

The following illustration shows how to find the square of 3.7



We can also use the A and D scales to find the square roots of numbers by projecting (using the cursor) from the A scale to the D scale. A rough check will eliminate any possibility of error

The following illustrations show the settings for finding $\sqrt{3}$ and $\sqrt{30}$



To find the square root of a number greater than 100 write it down as the product of a number between 1 and 100 and an even power of 10, ie $300 = 3 \times 10^2$ (see over for example)

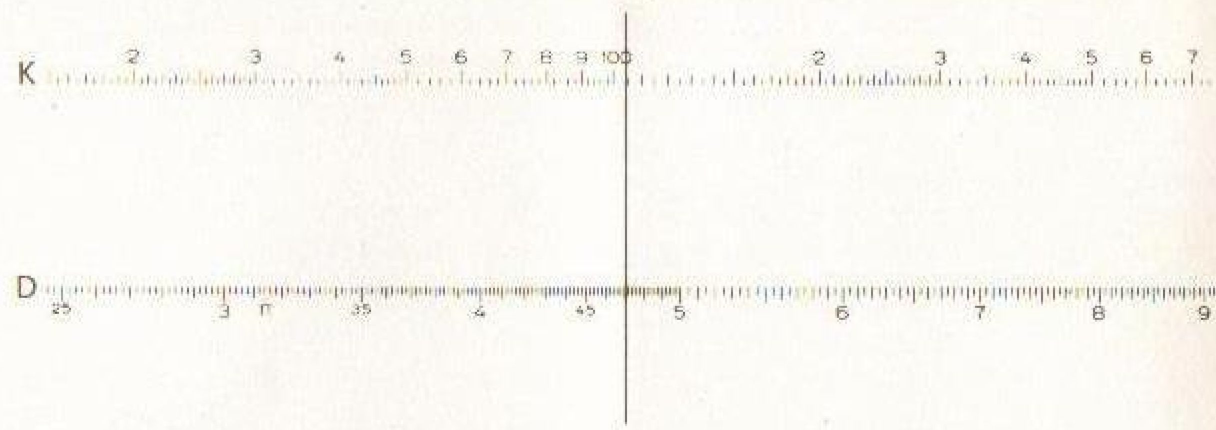
Example: $\sqrt{300} = \sqrt{3} \times \sqrt{10^2} = 1.73 \times 10 = 17.3$
$\sqrt{3\,000} = \sqrt{30} \times \sqrt{10^2} = 5.48 \times 10 = 54.8$
$\sqrt{30\,000} = \sqrt{(3 \times 10^4)} = \sqrt{3} \times \sqrt{10^4} = 1.73 \times 10^2 = 173$

Similarly for the square root of a number less than 1, such as $0.3 = 30 \times 10^{-2}$

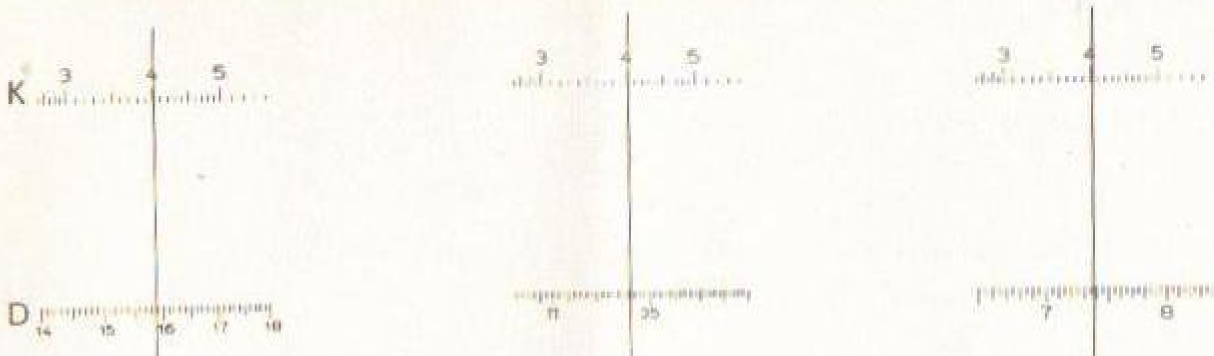
Example: $\sqrt{0.3} = \sqrt{(30 \times 10^{-2})} = \sqrt{30} \times \sqrt{10^{-2}} = 5.48 \times 10^{-1} = 0.548$
$\sqrt{0.03} = \sqrt{(3 \times 10^{-2})} = \sqrt{3} \times \sqrt{10^{-2}} = 1.73 \times 10^{-1} = 0.173$
$\sqrt{0.003} = \sqrt{(30 \times 10^{-4})} = \sqrt{30} \times \sqrt{10^{-4}} = 5.48 \times 10^{-2} = 0.054\,8$

Cubes and cube roots

The K scale is so positioned that it gives the *cubes* of corresponding numbers on the D scale (C scale if the K scale is on the slide). As an example we illustrate the setting for finding $(4.7)^3$. Notice that we use the cursor to project from the D scale on to the K scale



For finding cube roots we project from the K scale on to the D scale. Care must be exercised in selecting the relevant part of the K scale; eg $\sqrt[3]{4}$, $\sqrt[3]{40}$, $\sqrt[3]{400}$ each have different significant figures in their answers. The following illustrations show the settings for each of these cube roots using each of the three parts of the K scale



To find the cube root of a number greater than 1 000 write it down as the product of a number between 1 and 1 000 and a power of 10 so that the power is divisible by 3, ie $4\,000 = 4 \times 10^3$

Example: $\sqrt[3]{4\,000} = \sqrt[3]{(4 \times 10^3)} = \sqrt[3]{4} \times \sqrt[3]{10^3} = 1.59 \times 10 = 15.9$
$\sqrt[3]{40\,000} = \sqrt[3]{(40 \times 10^3)} = \sqrt[3]{40} \times \sqrt[3]{10^3} = 3.42 \times 10 = 34.2$

Similarly for the cube root of a number less than 1 write the number as a product, for example: $0.4 = 400 \times 10^{-3}$

Example: $\sqrt[3]{0.4} = \sqrt[3]{(400 \times 10^{-3})} = \sqrt[3]{400} \times \sqrt[3]{10^{-3}} = 7.36 \times 10^{-1} = 0.736$
$\sqrt[3]{0.04} = \sqrt[3]{(40 \times 10^{-3})} = \sqrt[3]{40} \times \sqrt[3]{10^{-3}} = 3.42 \times 10^{-1} = 0.342$
$\sqrt[3]{0.004} = \sqrt[3]{(4 \times 10^{-3})} = \sqrt[3]{4} \times \sqrt[3]{10^{-3}} = 1.59 \times 10^{-1} = 0.159$

Logarithms

The L scale gives the logarithms of corresponding numbers on the D scale. Readings are obtained by cursor projection. For example to find the logarithm of 2.5 set cursor line to D_{25} and read off log 2.5 on L scale (0.398). Notice that only the mantissa is given and that the characteristic has to be calculated in the usual way

Trigonometrical scales

This group of scales comprises the following:
Sine scale (denoted by S) for the angle range 5.7° to 90°
Tangent scale (denoted by T) for the angle range 5.7° to 45°
Combined sine and tangent scale (denoted by ST) for the angle range 0.57° to 5.7°

All these scales are related to D scale and values are read off directly by cursor projection

Sines

Example: To find sin 20°
Set cursor line over 20° on sine scale
Read on D scale under the cursor line 342
Thus sin 20° = 0.342

Example: To find arc sin 0.432
Set cursor to 432 on D scale
Read on S scale under the cursor line 256
Thus arc sin 0.432 = 25.6°

For values of cosines we use the identity
$\cos \alpha° = \sin (90° - \alpha°)$
eg $\cos 21° = \sin (90° - 21°) = \sin 69°$

Tangents

Example: To find tan 22°
Set cursor line over 22° on tangent scale
Read on D scale under the cursor line 404
Thus tan 22° = 0.404

For tangents of angles in the range 45° to 90° we use the identity

$$\tan \alpha° = \cot (90° - \alpha°) = \frac{1}{\tan (90° - \alpha°)}$$

Example: To find $\tan 75° = \cot 15° = \frac{1}{\tan 15°}$

Set cursor to 15° on tangent scale
See that C and D scales are aligned so that C_1 is over D_1 and C_{10} over D_{10}
Read on CI scale under the cursor line 373
Thus tan 75° = 3.73
(alternatively tan 15° could be read on D scale 0.268 and then the reciprocal obtained 3.73)

Inverse tangents are found by a similar process to inverse sines
For example: To find arc tan 0.7
Set cursor line over D_7
Read on T scale under the cursor line 350
Thus arc tan 0.7 = 35°

Sines and Tangents for angles less than 5.7°

For small angles $\sin \alpha \approx \tan \alpha$ and we use the scale ST for both sines and tangents

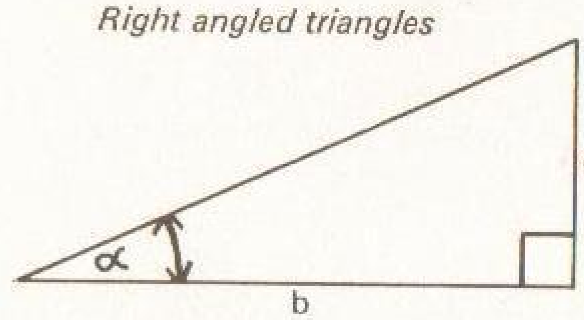
Example: To find sin 3.2° (or tan 3.2°)
Set cursor to ST_{32}
Read on D scale under the cursor line 559
Thus sin 3.2° (or tan 3.2°) = 0.055 9

Note that care is needed in positioning the decimal point and remember that the sines and tangents of angles up to 5.7° are all less than 0.1

Conversion of degrees to radians (and vice versa)

See under 'Constants' for conversions but notice also:
Since $\sin \alpha \approx \alpha$ for small values of α (measured in radians) we can use the ST scale and the D scale for approximate conversions of small angles
Example: 1.2° on the ST scale corresponds with 0.0209 radians on the D scale

Right angled triangles



See example overleaf

Example: Given a = 160 and b = 231. To find angle α

$\frac{a}{b} = \tan \alpha$ ie $\alpha = \arc\tan \frac{a}{b} = \arc\tan \frac{160}{231}$

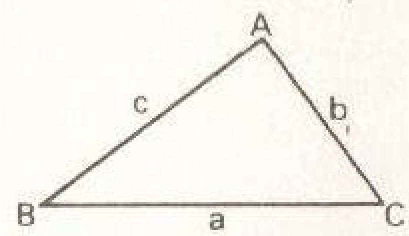
Set cursor to D_{160}
Set C_{231} to cursor
Set cursor to C_{10}
Read α on T scale 34.7°

Sine Rule

The sine rule is a case of direct proportion; we use it for the solution of triangles

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

By setting the value of A on the S scale to correspond with the value of 'a' on the C scale we can then read off the other values



Example: Given a = 24.3, b = 16.5, A = 65°
Set cursor to S_{65}
Set C_{243} to cursor
Set cursor to C_{165} and read on S scale 38° (the value of B)
Then C = 180° — (65° + 38°) = 77°
Set cursor to S_{77} and read on C scale 261 (ie 26.1) and the triangle is solved

Log log scales
These scales are used for calculations involving the exponential form and comprise the following:
LL_3 giving values of e^x
LL_2 giving values of $e^{0.1x}$
LL_1 giving values of $e^{0.01x}$

Thus for values of x on the D scale, cursor projection gives the corresponding e^x values on the log log scales. Furthermore, in the reverse direction we can read on D scale the Naperian logarithm of numbers on the log log scales

Example: To find ln 3.75 ($\log_e 3.75$)
Set cursor to 3.75 on LL_3
Read on D scale 132
Thus ln 3.75 = 1.32

Any positive number N may be expressed as a particular power P of any positive base B

$$N = B^P$$
hence $\log N = P \log B$
and $\log \log N = \log P + \log \log B$
or $\log \log N - \log \log B = \log P$

ie the values B and N on the log log scale are separated by a distance representing log P
Example: Set cursor at 3 on LL_3 scale and set C_1 to the cursor

Notice that
2 on C scale aligns with 9 on LL_3
3 on C scale aligns with 27 on LL_3
4 on C scale aligns with 81 on LL_3
5 on C scale aligns with 243 on LL_3
thus evaluating 3^2, 3^3, 3^4, 3^5

Example: Evaluate $N = 3.5^{2.66}$
Set cursor to 3.5 on LL_3 scale
Set C_1 to the cursor

Move cursor to C_{266} and read the value of N on LL_3 scale at the cursor = 28.0

Cursor projection from LL_1 to LL_2 or LL_2 to LL_3 scales effects the process of raising to the 10th power (or vice versa, extracting the 10th root)
Thus $3.5^{0.266} = 1.395$ the figure in alignment on the LL_2 scale
Note: If the base is less than unity first find the reciprocal (by cursor projection from C to CI scale) and using this as the base make the calculations; then find the reciprocal of the answer obtained

To solve for P when N and B are known ie to determine the log of N to base B
Proceed as in the following example:

Example: To find P if $5.3^P = 92.0$
Set the cursor at 5.3 on LL_3 scale
Move the slide so that C_1 is at the cursor
Move the cursor to 92.0 on the LL_3 scale and read the significant figures of P on the C scale at the cursor 271
then $5.3^{2.71} = 92$ (or $\log_{5.3} 92 = 2.71$)

To determine B when N and P are known
Example: To find B when $B^{2.14} = 40$
Set the cursor at 40 on LL_3
Move the slide so that $C_{2.14}$ is an alignment
Move the cursor to C_1 and note the readings on LL_2 and LL_3 namely 1.188 and 5.6 respectively
Approximation will select 5.6 as the required value
ie $5.6^{2.14} = 40$ (note that $1.188^{21.4} = 40$)

When a 'power' and 'base' are such as to result in a value of N in excess of 2×10^4 as in the following case:
$5.3^{7.8}$, we take the 'power' in parts such as 7.8 = 4 + 3.8
Example: Evaluate 5.3^4 and $5.3^{3.8}$ and obtain
$5.3^4 = 790$ $5.3^{3.8} = 565$
Then $5.3^{7.8} = 790 \times 565 = 446\ 000$

When N is greater than 2×10^4, to determine P for a given B proceed as follows:
Example: To find P when $5.3^P = 446\ 000$
Factorise 446 000 as 1 000 × 446
Then consider $P = q + r$ where $5.3^q = 1\ 000$ and $5.3^r = 446$
Evaluate q and r and obtain q = 4.14 and r = 3.66
ie P = 4.14 + 3.66 = 7.8

Ratio and proportion
The slide rule is an extremely valuable aid for use in problems of ratio and proportion

For direct proportion we use the C and D scales. Any setting of C and D scales gives an infinity of equivalent ratios. For example if we set C_1 to $D_{1.5}$ as shown

we have C:D = 1:1.5 = 2:3 = 3:4.5 = 4.67:7 = 6.67:10 etc. The factor of proportionality (1.5) is given on D at C_1 and its reciprocal (which is sometimes needed) on the C scale at D_{10}

This principle can be easily adapted for percentages. Suppose for example that an examination has been marked out of 93 and it is required to convert all the marks to percentages. This, then, is a problem of direct proportion in which 0 remains 0 and 93 becomes 100
Set C_{93} to D_{10} as shown

All other marks are then immediately converted to percentages: 48 is thus approximately 52%; 64 becomes 69%; 13 becomes 14% etc

For square proportion we follow the same procedure using the C and A scales. If $x \propto y^2$, set values of x on C scale against corresponding values of y^2 on A

scale. For example if we have the following table

x	1	2	3
y^2	2	8	18

We set C_1 to A_2 and see that C_2 corresponds to A_8 and C_3 to A_{18}. Using this setting we can immediately write down any other required values of x and y^2. The constant of proportionality (in this case 2) is on A at C_1

For cube proportion the procedure is the same, this time using C and K (or D and K) scales. If $x \propto y^3$, set values of x on C against values of y^3 on K, the constant of proportionality being read on K at C_1

For inverse proportion use D and CI scales. If $x \propto \frac{1}{y}$, set values of x on D against values of y on CI and read off other values in the same way. The constant of proportionality is read on D at CI_{10} or at CI_1

Constants
The π constant is included on all models

Gauge marks V, U, m and s are provided on the C scale of models with trigonometrical scales. They are conversion constants for use as divisors as follows:

$$V = \frac{\pi}{180} = 0.01746 \text{ for radians to degrees}$$

$$U = \frac{180}{\pi} = 57.2958 \text{ for degrees to radians}$$

$$m = \frac{180 \times 60}{\pi} = 3437.75 \text{ for minutes to radians}$$

$$s = \frac{180 \times 60 \times 60}{\pi} = 206265.0 \text{ for seconds to radians}$$

The L constant is included on the C scale at 2.3026 on models with log log scales. It can be used for converting logs to base e to logs to base 10 since

$$\log_{10}N = \frac{\ln N}{2.3026} = \frac{\ln N}{L} \qquad (\ln N = \log_e N)$$

The conversion is effected by bringing the L mark on C scale in alignment by cursor projection with the N value on the log log scale and reading the value of $\log_{10}N$ on D scale at C_1 (or C_{10})

It will be realised that logarithms to any base can be obtained by making a mark on C scale in the position which aligns with the particular base on the log log scales (with C_1 to D_1 in alignment of course) and by using the position marked on the C scale as a divisor for that base

Example: To find $\log_2 8$
With C_1 and D_1 in alignment move cursor to 2 on log log scale and then make a pencil mark on C scale at the cursor position, namely 693
Transfer cursor to 8 on log log scale
Bring marked position at C_{693} to the cursor and read 3 on D scale at C_{10}
Then $\log_2 8 = 3$ (or $8 = 2^3$)

Differential trigonometrical scales

The group of scales consists of the following:

Sine differential scale (denoted by Sd) of $\frac{\alpha}{\sin \alpha}$ for sine range 0 to 90°

Tangent differential scale (denoted by Td) of $\frac{\alpha}{\tan \alpha}$ for tangent range 0 to 60°

Inverse sine differential scale (denoted by ISd) of $\frac{x}{\sin^{-1} x}$ for inverse of above sine range

Inverse tangent differential scale (denoted by ITd) of $\frac{x}{\text{arc} \tan^{-1} x}$ for inverse of above tangent range

The above four scales are positioned on the slide and together take up the equivalent of one 'scale length'. They are used in conjunction with C and D scales and are very simple to manipulate

The principle is as follows:

$$\text{Since } Sd_\alpha = \frac{\alpha}{\sin \alpha}$$

$$\text{Then } \frac{\alpha}{Sd_\alpha} = \frac{\alpha}{\frac{\alpha}{\sin \alpha}} = \alpha \times \frac{\sin \alpha}{\alpha} = \sin \alpha$$

Thus by setting the α value on D scale and dividing by $Sd\alpha$ (ie the α value on the sine differential scale) the value of $\sin \alpha$ is read on D scale at C_1 (or C_{10})

Example: To find sin 43° treat as $\dfrac{43}{\dfrac{43}{\sin 43^\circ}}$ ie $\dfrac{43}{Sd_{43}}$

Cursor to D_{43}
Set Sd_{43} to the cursor
At C_{10} read answer (0.682) on D

Example: To find tan 36.5°

Cursor to D_{365}
Set $Td_{3.65}$ to the cursor
At C_{10} read answer (0.740) on D

Example: To find the angle whose sine is 0.66 (ie the value of arc sin 0.66)

treat as $\dfrac{0.66}{\dfrac{0.66}{\text{arc sin } 0.66}}$ ie $\dfrac{0.66}{ISd_{0.66}}$

Cursor to D_{66}
Set $ISd_{0.66}$ to the cursor
At C_1 read answer (41.3) on D

Similarly the angle whose tangent is 0.9 is found to be 42° by using the ITd scale in conjunction with D scale

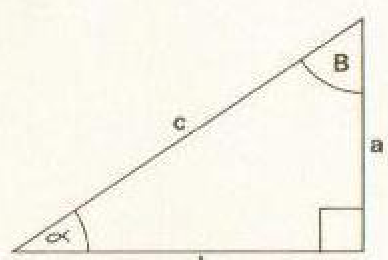
Example: To find the value of 73 sin 52°

Cursor to D_{52}
Set Sd_{52} to the cursor
Cursor to C_{73} and read answer (57.5) on D at the cursor

Vector analysis scales

Ps of $\sqrt{(1 - s^2)}$ and Pt of $\sqrt{(1 + t^2)}$

With the Ps scale of $\sqrt{(1 - s^2)}$ it is possible, by cursor projection to the D scale, to obtain $\cos \alpha$ when $\sin \alpha$ is known or vice versa



The difference between two squares is treated as follows

$$x = \sqrt{(c^2 - a^2)} = c\sqrt{\left[1 - \left(\frac{a}{c}\right)^2\right]}$$

Since $\frac{a}{c} = \sin \alpha = s$

then $x = c\sqrt{(1 - s^2)}$

Example: Evaluate $\sqrt{(5.3^2 - 2.8^2)}$

$$= 5.3\sqrt{\left[1 - \left(\frac{2.8}{5.3}\right)^2\right]}$$

(i) Cursor to D_{28}, C_{53} to cursor and at C_{10} on D read $0.528 = \dfrac{2.8}{5.3}$

(ii) Cursor to 0.528 on Ps scale, C_{10} to cursor, cursor to C_{53} and read 45 on D scale

Then $\sqrt{(5.3^2 - 2.8^2)} = 4.5$

Note: Where s is greater than 0.995 the form $\sqrt{[2(1-s)]}$ may be used as a close approximation

The Pt scale of $\sqrt{(1 + t^2)}$ serves for determination of the square root of the sum of two squares as under:

$$h = \sqrt{(a^2 + b^2)} = b\sqrt{\left[1 + \left(\frac{a}{b}\right)^2\right]}$$

Since $\frac{a}{b} = \tan \alpha = t$

then $h = b\sqrt{(1 + t^2)}$

Example: Evaluate $\sqrt{(3^2 + 4^2)}$

$$= 4\sqrt{\left[1 + \left(\frac{3}{4}\right)^2\right]} = 4\sqrt{[1 + (0.75)^2]}$$

(*i*) Cursor to 0.75 on Pt scale

(*ii*) Bring C_1 to cursor

(*iii*) Cursor to C_4 and read on D scale the value of h = 5

Reciprocal log log scales

On models with reciprocal log log scales, by setting the cursor at 0.3 on the LL_{03} scale and bringing C_1 to the cursor

2 on C scale aligns with 0.09 on LL_{03}

3 on C scale aligns with 0.027 on LL_{03}

4 on C scale aligns with 0.0081 on LL_{03}
thus evaluating $(0.3)^2$, $(0.3)^3$, $(0.3)^4$

Example: Evaluate $(0.35)^{2.66}$

(a) Cursor to 0.35 on LL_{03}, C_1 to cursor and then move cursor to $C_{2.66}$. In alignment at cursor read 0.0612 on the LL_{03} scale
$(0.35)^{2.66} = 0.0612$

(b) Read on the LL_{02} scale in the same alignment the value 0.7563
$(0.35)^{0.266} = 0.7563$

Note: In order to decide which scale provides the value, mental approximation is necessary. It may be said that most students are more at ease with rough approximations of powers of quantities *greater than unity* than with those of quantities *less than unity*

For example, it is easier to mentally appreciate that

$3^{\frac{1}{2}}$ or $\sqrt{3} \approx 1.7$
$3^3 = 27$

than say

$\sqrt{0.4}$ or $0.4^{\frac{1}{2}} \approx 0.63$
$(0.4)^3 = 0.064$

Thus when dealing with the latter type as in the example it is useful to remember that at a particular setting on say the LL_{03} scale, the reciprocal of this value (greater than unity) appears in alignment on the related LL_3 scale. The raising to the 'power' in question may then be observed on the greater than unity scales and the final reading taken on the appropriate reciprocal log log scale

Example: To find $0.452^P = 0.764$

(Obviously the value of P is less than unity)

Set the cursor at 0.452 on the LL_{02} scale. Align C_{10} at the cursor and move the cursor to 0.764 on LL_{02}. On C scale at the cursor read 339 the significant figures of P . . . decimal point considered 0.339

Care and attention

Removing and refitting the cursor

This is sometimes desirable for cleaning purposes and the procedure is as follows:

SINGLE SIDED CURSOR

To remove

1 Move slide to one end of rule
2 Centralise the cursor
3 Compress the rule across its width in the region of the cursor which can now be removed

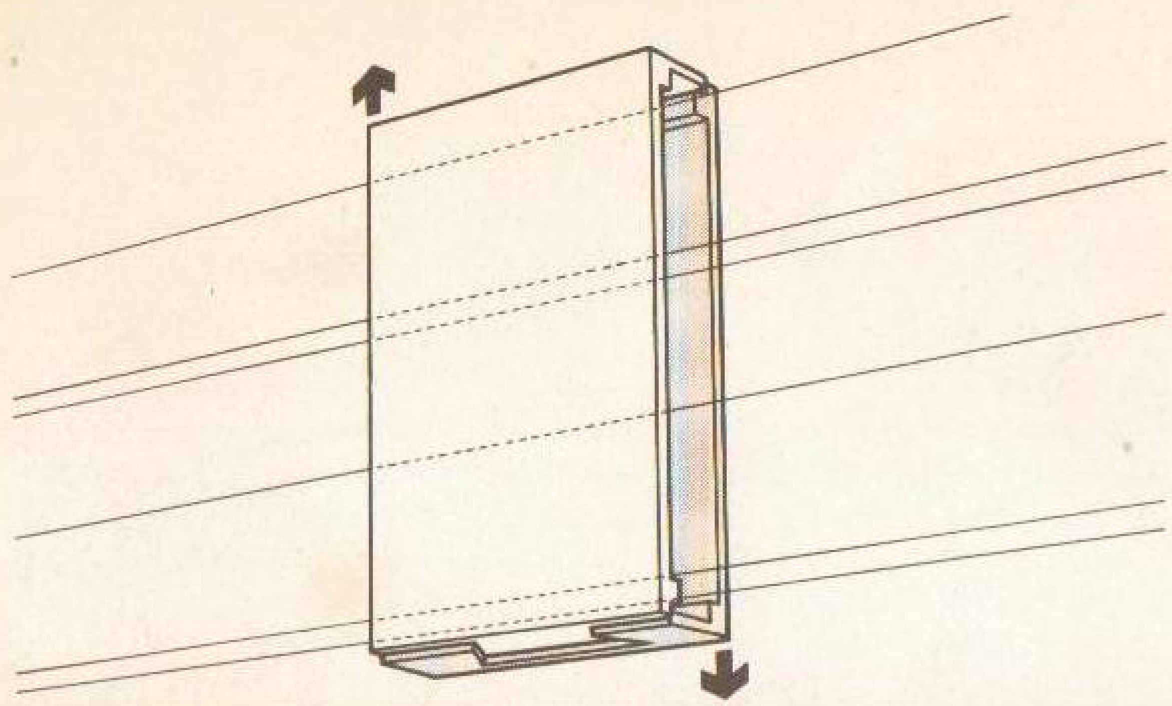
To refit

4 Refitting is the reverse of the above operation — ensure the cursor is completely refitted over the edges of the slide rule *before* moving the slide back

DOUBLE SIDED CURSOR

To remove

1 Hold the rule over a desk or table with the reference number side towards you
2 Move the slide to one end and centralise the cursor
3 With one hand, compress the rule across its width in the region of the cursor
4 Using the other hand, slide the two halves of the cursor away from each other in the directions shown in the diagram overleaf. This will disengage the dove-tail joints at head and foot, and the cursor should come apart



To refit

5 Place the half of the cursor carrying the spring on the desk or table, flat side down, and with the spring to the top
6 Place the rule, reference number side towards you and slide moved to one end, inside this half of the cursor
7 With one hand, compress the rule across its width at the centre
8 Using the other hand, place the remaining half of the cursor squarely over the lower half and engage the dovetail joints, ie reverse direction to 4 above
9 Release pressure on the stocks to provide a secure fitting without the risk of accidental removal

Cleaning the slide rule

The slide rule and cursor may be cleaned simply by washing them in a lukewarm solution of soap and water. Dry thoroughly before re-fitting the cursor. The cursor may be cleaned by sliding a piece of paper under the plates as an alternative to removing it

In this booklet we have set out the main uses of the slide rule. You, the user, will no doubt experiment with combinations of the various scales and make use of your discoveries. It is important to practise use of the various scale combinations using simple numbers to obtain confidence. Patient practice and use will be amply repaid in the time saved over many calculations

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