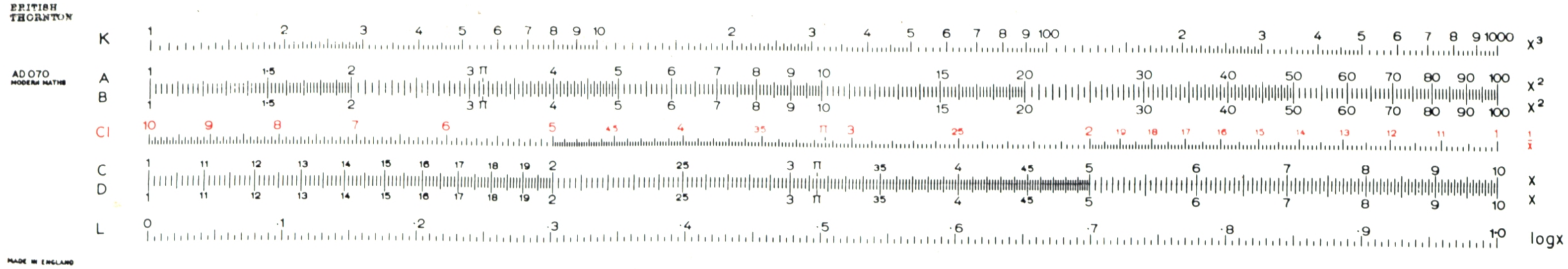
British Thornton
Slide rule model AD 070
Instructions for use



To the beginner

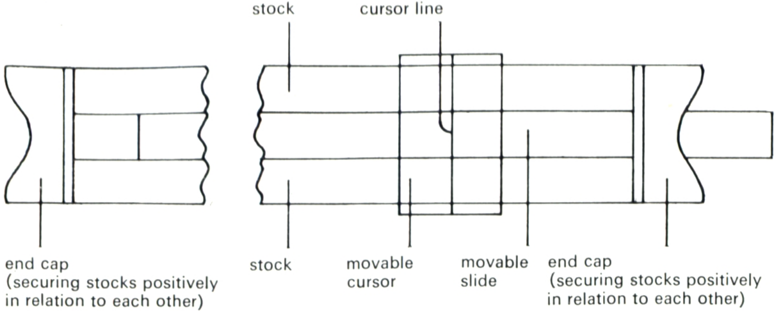
Introduction

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

Parts of the slide rule

To ensure that we understand the terminology here are the main parts of the slide rule



The recommended method of use is as follows

a Hold the slide rule by the end caps

b When the slide is virtually fully contained in the two stocks manipulate the slide by the index fingers

When the slide is extended to one end hold the rule by the end cap at the opposite end and manipulate the slide with the free hand

In this way pressure across the width of the slide rule is avoided and highest practicable accuracy maintained

If treated with reasonable care and attention your slide rule will give you many years of good service

Significant figures

A slide rule can be regarded normally as giving the answer to a calculation correct to three significant figures (sometimes a fourth figure can be read off). 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 seven scales are each denoted by a letter – K, A, B, CI, C, D, L. This booklet explains the use of each of these scales

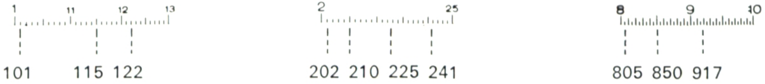
C and D scales

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

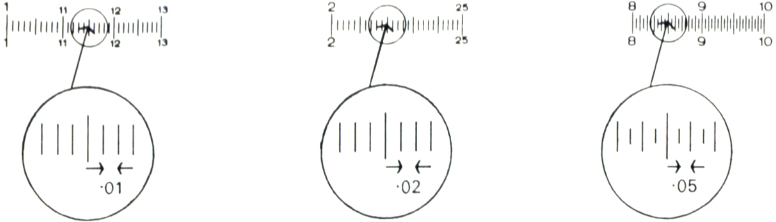
These two scales are the most frequently used on a slide rule and are the basic scales normally used for multiplication and division

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 1000 since we are only concerned with the significant figures of any calculations

The following illustration shows settings for various three significant figure values



It is important to 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 1000 each subdivision represents a change of 5 in the last figure as shown



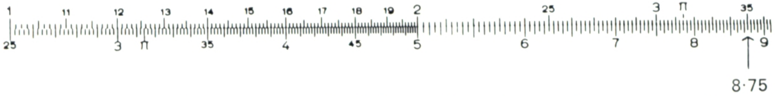
Notation

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 3500)
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 answer (1170) on D scale
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 ($2 \times 5 \times \frac{1}{3} \times 3$) 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 answer (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 $5\frac{1}{2}$)
Set cursor to D_{84}
Bring C_{15} to cursor line
and read answer (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 $\frac{1}{2}$)
Set cursor to D_{306}
Bring C_{68} to cursor line
and read answer (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 $\dfrac{161 \times 923 \times 152}{258 \times 172}$

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

$$\frac{161 \times 923 \times 152}{258 \times 172}$$

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 answer (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)

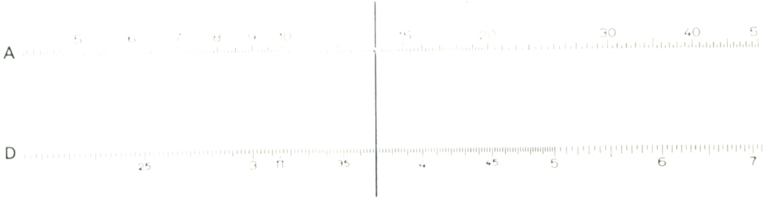
Squares and square roots – using the A and B scales

You will notice that the A scale (on the upper stock) and the B scale (on the slide) are identical. They are each two C scales reduced to half length and placed together, giving a range from 1 to 100

The A and B scales may be used for multiplication and division in exactly the same way that you have learnt to use the C and D scales

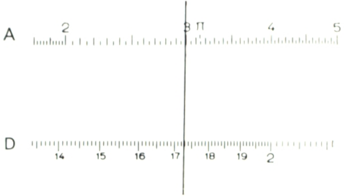
These scales are so positioned on the slide rule that the numbers on the A scale are the squares of the corresponding numbers on the D scale. We can therefore use the A scale to write down the squares of numbers on the D scale. Use your cursor to ensure accuracy

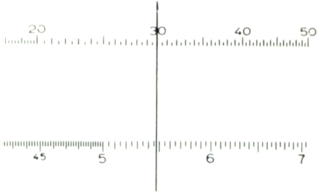
The following illustration shows how to find the square of 3·7 (the slide has been removed here for clarity)



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. Care is essential when finding square roots and 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 $300 = 3 \times 10^2$

Example: $\sqrt{300} = \sqrt{3} \times \sqrt{10^2} = 1{\cdot}73 \times 10 = 17{\cdot}3$
$\sqrt{3000} = \sqrt{30} \times \sqrt{10^2} = 5{\cdot}48 \times 10 = 54{\cdot}8$
$\sqrt{30\,000} = \sqrt{(3 \times 10^4)} = \sqrt{3} \times \sqrt{10^4} = 1{\cdot}73 \times 10^2 = 173$

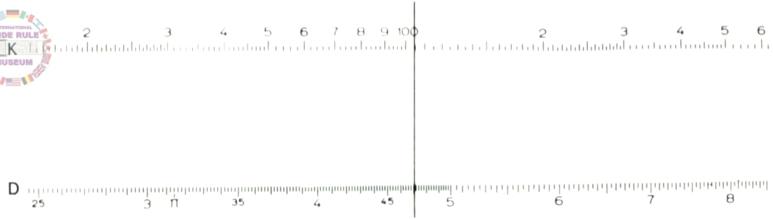
Similarly for the square root of a number less than 1, such as $\cdot 3 = 30 \times 10^{-2}$

Example: $\sqrt{\cdot 3} = \sqrt{(30 \times 10^{-2})} = \sqrt{30} \times \sqrt{10^{-2}} = 5{\cdot}48 \times 10^{-1} = \cdot 548$
$\sqrt{\cdot 03} = \sqrt{(3 \times 10^{-2})} = \sqrt{3} \times \sqrt{10^{-2}} = 1{\cdot}73 \times 10^{-1} = \cdot 173$
$\sqrt{\cdot 003} = \sqrt{(30 \times 10^{-4})} = \sqrt{30} \times \sqrt{(10^{-4})} = 5{\cdot}48 \times 10^{-2} = \cdot 0548$

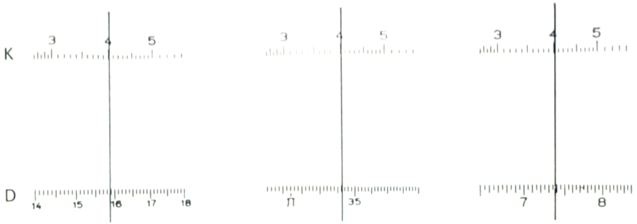
Cubes and cube roots – using the K scale

You will notice that the K scale (on the upper stock) is made up of three C scales each reduced to one third length and placed together, giving a range from 1 to 1000

This scale is so positioned that it gives the *cubes* of corresponding numbers on the D scale. As an example we illustrate overleaf the setting for finding $(4{\cdot}7)^3$. Notice that again we use the cursor to project from the D scale onto the K scale



For finding cube roots we project from the K scale on to the D scale. Care must again 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 1000 write it down as the product of a number between 1 and 1000 and a power of 10 so that the power is divisible by 3, ie $4000 = 4 \times 10^3$

Example: $\sqrt[3]{4000} = \sqrt[3]{(4 \times 10^3)} = \sqrt[3]{4} \times \sqrt[3]{10^3} = 1{\cdot}59 \times 10 = 15{\cdot}9$

$\sqrt[3]{40\,000} = \sqrt[3]{(40 \times 10^3)} = \sqrt[3]{40} \times \sqrt[3]{10^3} = 3{\cdot}42 \times 10 = 34{\cdot}2$

Similarly for the cube root of a number less than 1 write the number as a product, for example: $\cdot 4 = 400 \times 10^{-3}$

Example: $\sqrt[3]{\cdot 4} = \sqrt[3]{(400\times 10^{-3})} = \sqrt[3]{400}\times\sqrt[3]{10^{-3}} = 7{\cdot}36\times 10^{-1} = {\cdot}736$
$\sqrt[3]{\cdot 04} = \sqrt[3]{(40\times 10^{-3})} = \sqrt[3]{40}\times\sqrt[3]{10^{-3}} = 3{\cdot}42\times 10^{-1} = {\cdot}342$
$\sqrt[3]{\cdot 004} = \sqrt[3]{(4\times 10^{-3})} = \sqrt[3]{4}\times\sqrt[3]{10^{-3}} = 1{\cdot}59\times 10^{-1} = {\cdot}159$

Reciprocals – using the CI scale

This scale (on the slide) is a C scale printed from right to left and it provides reciprocals of the corresponding numbers on the C scale. For example $C_{5\cdot2}$ is aligned with CI_{192} showing that the reciprocal of 5·2 is ·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

$3{\cdot}4 \times \frac{1}{5{\cdot}6}$ and we may proceed as follows

Set cursor to D_{34}
Bring C_1 (or CI_{10}) to cursor line
Move cursor to CI_{56}

and read answer (606) on D scale (decimal point considered = ·606)

This is sometimes a more convenient way of carrying out complex calculations such as the example shown on page 5

Logarithms – using the L scale

This scale, on the lower stock, 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 $D_{2\cdot5}$ and read off log 2·5 on L scale (·397). Notice that only the mantissa is given and that the characteristic has to be calculated in the usual way

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 $D_{1\cdot5}$ 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 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

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. The rewards of patient practice and use will be manifest in the time saved over many calculations

Care and attention

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

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

Cleaning the slide rule
The slide rule may be cleaned simply by washing it in a lukewarm solution of soap and water

Major historical developments in the evolution of the slide rule

1614 Invention of logarithms by John Napier, Baron of Merchiston, Scotland

1617 Development of logarithms 'to base 10' by Henry Briggs, Professor of Mathematics, Oxford University

1620 Interpretation of logarithmic scale form by Edmund Gunter, Professor of Astronomy, London

1630 Invention of slide rule by the Reverend William Oughtred, London

1657 Development of the moving slide/fixed stock principle by Seth Partridge, Surveyor and Mathematician

1775 Development of the slide rule cursor by John Robertson of the Royal Academy

1815 Invention of the log log scale principle by P. M. Roget of France

1900 Re-introduction of log log scales by Professor Perry, Royal College of Science, London

1933 Differential trigonometrical and log log scales invented by Hubert Boardman, Radcliffe, Lancashire

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