INSTRUCTIONS

FOR THE USE OF "GRAPHOPLEX" SLIDE RULES

GRAPHOPLEX

(BRITISH PATENT No. 607,871)

The slide-rule is an instrument by means of which all problems including multiplications, divisions, proportions, raising to powers, root extractions, trigonometrical or algebrical reckonings, etc., may quickly and easily be performed with a quite sufficient accuracy.

DESCRIPTION OF THE RULE

The GRAPHOPLEX slide-rule is made of a synthetical resin (methyl methacrylate). This resin is neither affected nor distorted by water, with still more reason, atmospheric dampness does not spoil it, neither in its chemical constitution nor its shape.

The process of engraving which is used to obtain strokes of the logarithmic graduations of the different scales, is a patented process. Light has no effect on these strokes, they only disappear by wearing out of the matter, therefore, they cannot be spoiled or faded by a normal use.

Extensive tests were made to ascertain the wear of the contacting surfaces between the slide and the rule. After 1,500,000 continual motions of the slide, without any lubricating product, at the rate of 37 motions per minute, no appreciable wear could be observed.

SCALES

When the rule is placed in front of the user, the marks 1 on his left, the following scales are distinguished from the upper edge to the lower one.

On the front face

1° *The scale of cubes.*

This scale consists of three identical scales placed end to end.

2° *The scale of squares.*

This scale consists of two identical scales placed end to end.

3° *The reciprocal scale.*

This scale is the same as the scale of numbers but is read from right to left.

4° *The scale of numbers.*

This scale is the same as one scale of squares but is twice longer.

5° *The scale of logarithms mantissae.*

This scale is divided into equal parts.

As the scale of numbers, the scale of squares is divided into two parts, the one is engraved on the rule, the other on the slide.

READING OF THE GRADUATIONS

At first, it is advisable to know how to read correctly the numbers indicated by the scales graduations.

SCALE OF SQUARES

Each of both identical parts of this scale is divided into nine principal parts. They are numbered from 1 to 10 in the first part, and from 10 to 100 in the second one.

The graduations of this scale represent the squares of the corresponding graduations on the scale of numbers.

The sections 1-2 on the first part and 10-20, on the second part are each divided into ten graduations which are themselves **subdivided into five parts ;** they are read thus :

On the first part : 1, 1.02, 1.04..... 1.96, 1.98, 2.
On the second part : 10, 10.2, 10.4..... 19.6, 19.8, 20.

The sections 2-3, 3-4, 4-5, 20-30, 30-40, 40-50 are each divided into ten parts, **which are themselves subdivided into two parts ;** they are read thus :

On the first part : 2, 2.05, 2.10, 2.15..... 4.90, 4.95, 5.
On the second part : 20, 20.5, 21, 21.5..... 49, 49.5, 50.

The sections 5-6, 7-8, 9-10, 50-60, 60-70, 70-80, 90-100 are each divided into ten parts; they are read thus :

5, 5.1, 5.2..... 97, 98, 99.

SCALE OF NUMBERS

Being the longest one, this scale is the most often used, because it is more readable and more accurate.

As the preceding ones, it is divided into nine principal parts which are numbered from 1 to 10.

Each of these principal parts is first divided into ten parts.

The figure 1 which is engraved on the left of the scale can represent : 1, 10, 100 or 0.1, 0.01, 0.001, according to the value given to the unit.

The section 1-2 is divided into ten parts which are numbered 1, 1.1, 1.2, etc. Each of these parts is again subdivided into ten parts, and the graduations are read thus : 1.01, 1.02, 1.03..... 1.97, 1.98, 1.99, 2, or 10.1, or 101, etc.

The sections 2-3 and 3-4, are divided into ten unnumbered parts. They are read thus : 2.1, 2.2..... 3.8, 3.9, 4.

Each of these new parts is subdivided into five parts. The graduations are read thus : 2, 2.02, 2.04..... 3.96, 3.98, 4.00.

The sections between 4 and 10 are divided into ten unnumbered parts, subdivided themselves into two parts. They are read thus : 4, 4.05, 4.10..... 9.85, 9.9, 9.95, 10.

RECIPROCAL SCALE

This scale is read in the same manner as the scale of numbers, but from right to left.

OPERATIONS

MULTIPLICATION

By preference we shall use the scale of numbers (lower scales).

For instance : 21×4.

We bring number 1 of the slide opposite the graduation representing one of the factors and we read the result : 84, on the rule opposite the other factor read on the slide scale.

If during this operation, the graduation corresponding to the other factor read on the slide lies beyond the rule, we must use the mark 10 on the right of the slide scale.

For instance : $33 \times 5 = 165$.

We bring mark 10 of the slide opposite 33 on the rule scale and we read the product : 165, opposite graduation 6 on the slide scale.

DIVISION

The divisor (read on the slide scale) is brought opposite the dividend read on the rule scale. The quotient is read on the rule scale opposite the slide mark 1 or 10.

Example : $122 : 5 = 24.4$.

We bring the slide 5 opposite 122 on the rule and we read the quotient : 24.4, on the rule scale opposite the slide mark 10.

PROPORTIONS

Example : 6 is in 42 as 4 is in x.

We bring 6 (slide graduation) opposite 42 (rule graduation) and we read the result : 28, on the rule scale opposite the slide graduation 4.

HOW TO USE THE RECIPROCAL SCALE

Successive multiplications :

Example : $24 \times 2 \times 4$.

1° We bring the middle line of the cursor on the graduation 24 read on the rule scale of numbers.

2° We bring the graduation 2 read on the reciprocal scale of the slide under the middle line of the cursor.

3° The product : 192, is read on the rule opposite graduation 4 on the slide scale of numbers.

Successive multiplications and divisions :

$$\textit{Example} : \frac{75 \times 60 \times 15}{\pi \times 0.065 \times 1{,}200}.$$

1° We bring the graduation π, read on the slide scale of numbers opposite 75 on the rule scale.

2° We bring the middle line of the cursor on the graduation 65 of the reciprocal scale of the slide.

3° We bring the graduation 60 of the reciprocal scale under the middle line of the cursor.

4° We bring the middle line of the cursor on the graduation 15 read on the slide scale of numbers.

5° We bring the graduation 1,200 (slide scale of numbers) under the middle line of the cursor.

The result : 275.46, is read on the rule scale opposite the slide mark 1.

RECIPROCALS

Suppose we have to find the reciprocal of $\frac{1}{a}$: for instance $\frac{1}{8.3}$.

We bring the middle line of the cursor on the graduation 8.3 on the slide scale of numbers and we read the result : 0.1204, on the reciprocal scale.

Suppose we have to find $\frac{1}{a^2}$: for instance $\frac{1}{4^2}$.

We bring the middle line of the cursor on the graduation 4 of the reciprocal scale and we read the result under the line of the cursor on the slide scale of squares, this result is 0.0625.

Suppose we have to find : $\frac{1}{a^3}$: for instance $\frac{1}{4^3}$.

We bring the middle line of the cursor on the graduation 4 read on the reciprocal scale and we read the result 0.0156 under the line of the cursor on the rule scale of cubes.

Suppose we have to find $\frac{1}{\sqrt[3]{a}}$ or $\frac{1}{\sqrt[3]{64}}$.

We bring the middle line of the cursor on graduation 64 read on the scale of cubes and we read the result : 0.25, under the line of the cursor on the reciprocal scale.

N. B.—To effect these two last operations, we must first bring the rule and slide marks 1 into coincidence.

SCALE OF SQUARES

The numbers of this scale are the squares of the corresponding numbers of the scale of numbers,

For instance : 15^2.

We bring the line of the cursor on the graduation 15 read on the scale of numbers and we read the result : 225, on the scale of squares.

Second example : Extract the square root of 289.

We bring the line of the cursor on the graduation 289 read on the scale of squares and we read the result : 17, on the scale of numbers.

N. B.—The rule scales can be used to effect these reckonings as well as the slide ones, but we must use either both rule scales or both slide scales if the rule and slide marks 1 do not coincide.

SCALE OF CUBES

The numbers of this scale represent the cubes of the corresponding graduations on the scale of numbers.

Example : Find the cube of 15.

We bring the middle line of the cursor on the graduation 15 read on the rule scale of numbers and we read the cube : 3,375, under the line on the scale of cubes which lays at the upper edge of the rule.

Example : Find the cube root of 15,625.

We bring the middle line of the cursor on the graduation 15,625 read on the scale of cubes and we read the root : 25, on the rule scale of numbers.

SCALE OF SINES OF ANGLES FROM 5° 42′ to 90°

This scale is on the reverse face of the slide and is indicated by the letter S.

Example : What is the sine of an angle of 25° ?

We turn the rule over and move the slide **towards the right** till the graduation 25 comes opposite the stroke engraved on the upper edge of the aperture. We read the result on the front of the slide on the scale of numbers opposite the rule mark 10, namely 0.423.

SCALES OF SINES AND TANGENTS OF ANGLES FROM 0° 34′ 27″ to 5° 42′ 38″

We proceed as above, but we bring the division of the proposed angle opposite the stroke engraved on the lower edge of the aperture.

Example : Sine or tangent of 5° 10′ = 0.090.

SCALE OF TANGENTS OF ANGLES FROM 5° 42′ to 45°

This scale is on the lower edge of the reverse face of the slide and is indicated by the letter T.

Example : What is the tangent of an angle of 9° 15′ ?

We turn the rule over and move the slide **to the left** till the graduation 9° 15′ comes opposite the stroke engraved on the lower edge of the left aperture. We read the result on the front side of the slide on the scale of numbers opposite the rule mark 1, namely 0.1628.

MANTISSAE SCALE

Example : Find the logarithm of 760.

We bring the line of the cursor on graduation 760 of the scale of numbers. We read the mantissa of the logarithm : .880, under the line of the cursor on the log scale. We add the characteristic 2, the result is 2.880.

THREE-LINE CURSOR

The spaces between the lines represent the following values :

1° The space between the right hand line and the middle line equals $\sqrt{\frac{4}{\pi}}$, or 1.128, which makes it possible to find the area of a circle from its diameter or inversely.

Example : What is the area of a circle of 1.3 m. diameter.

We bring the line near the right end of the cursor on graduation 1.3 on the rule scale of numbers and we read the result : 1.327 sq. m. on the rule scale of squares, under the middle line of the cursor.

When we bring the middle line of the cursor on a number *n* read on the rule scale of numbers, we obtain immediately its square, its cube and its logarithm.

Example : $n = 4$.

We bring the middle line of the cursor on graduation 4 read on the rule scale of numbers. Read under this line :

The square : 16, on the rule scale of squares ;

The cube : 64, on the scale of cubes ;

The logarithm : .602, on the log scale.

2° The whole space between the line at the right end and the one at the left end of the cursor represents the value 736. It makes it possible to find the watt consumption of electric motors, the power of which is given in H.P. and inversely.

Example : Calculate the hourly consumption of a motor of 5 H. P.

We bring the line at the right end of the cursor on graduation 5 read on the rule scale of numbers.

Read the result : 3,680 watts, on the same scale, under the line at the left end of the cursor.

DIVISORS

Divisor ρ'.—Its value is $\frac{360 \times 60}{2\pi} = 3{,}437.746$.

It is used to find the length of arcs given in minutes.

Example : 28′ angle ; 32 m. radius.

We bring the divisor ρ' read on the slide, opposite the rule graduation 32. We read the result on the rule scale opposite graduation 28 read on the slide, namely .26.

Divisor ρ''.—Its value is $\rho' \times 60 = 3{,}437.746 \times 60 = 206{,}265$.

It is used to find the length of arcs given in seconds. Proceed as above.

Divisor C.—Its value is $\sqrt{\frac{4}{\pi}} = 1.128$.

It is used to find the volume of cylinders.

Example : Suppose we have to find the volume of a 6.5 m. high cylinder, the diameter of which is 1.25 m.

We bring the divisor C on the slide scale opposite the rule graduation 1.25 (diameter). We read the result on the rule scale of squares opposite graduation 6.5 (height) read on the slide scale of squares, namely 7.995 cubic m.

Divisor C1.—Its value is $C\sqrt{10} = 3.568$.

Proceed as for divisor C.

THE DECIMAL POINT IN SLIDE RULE MULTIPLICATION AND DIVISION

We give below a few useful rules to locate the decimal point, although with practice it will be found that decimal points can be located quickly and easily, and with greater appreciation of the significance of the results, by simple inspection.

For the purpose of arriving at simple rules, we define :

a) The characteristic of a number is the number of digits before the decimal point.

b) The characteristic of a decimal position is the number of ciphers immediately after the decimal point and is negative.

(It must be noted that the characteristic of a number is not the same as the characteristic of the logarithm of a number.)

For example, the characteristic of 2.76 and of 5.8 is 1 ; the characteristic of 12.3 and 65 is 2; that of 109.7 is 3 and that of 3,258 is 4.

The characteristic of .7 is zero, that of .059 is — 1 and that of .0027 is — 2, etc.

Using these definitions of the characteristic we can express the following rules to determine the location of the decimal point :

Multiplication :

Rule I.—When the slide projects to the right the characteristic of the product is 1 less than the sum of the characteristics of the factors.

Rule II.—When the slide projects to the left the characteristic of the product equals the sum of characteristics of the factors.

Rule III.—To find the characteristic of the product of several factors add the characteristics of all the factors, and substract 1 for each time that the slide projects to the right in carrying the successive steps of the complete setting.

Division :

Rule IV.—When the slide projects to the left the characteristic of the quotient equals the characteristic of the dividend minus that of the divisor.

Rule V.—When the slide projects to the right the characteristic of the quotient equals the characteristic of the dividend minus that of the divisor, plus 1.

PARIS — IMP. L. HARDY 63961