

X. A Method of extracting the Root of an Infinite Equation. By A. De Moivre, F. R. S.

Theorem.

If  $ax + bx^2 + cx^3 + dx^4 + ex^5 + fx^6, \&c. = gy + byy + iy^3 + ky^4 + ly^5 + my^6, \&c.$  then will  $x$  be  $= \frac{g}{a} y + \frac{b-bAA}{a} y^2 + \frac{i-2bAB-cA^2}{a} y^3 + \frac{k-bBB-2bAC-3cAAB-dA^3}{a} y^4 + \frac{l-2bBC-2bAD-3cABB-3cAAC-4dA^2B-eA^4}{a} y^5 + \frac{m-2bBD-bCC-2bAE-cB^2-6cABC-3cAAD-6dAAB-4dA^2C-5eA^3B-fA^5}{a} y^6 \&c.$

For the understanding of this Series, and in order to continue it as far as we please; it is to be observed, 1. That every Capital Letter is equal to the Coefficient of each preceding Term; thus the Letter  $B$  is equal to the Coefficient  $\frac{b-bAA}{a}$ .

2. That the Denominator of each Coefficient is always  $a$ .

3. That the first Member of each Numerator, is always a Coefficient of the Series  $gy + byy + iy^3, \&c.$  viz. the First Numerator begins with the first Coefficient  $g$ , the Second Numerator with the Second Coefficient  $b$ , and so on. 4. That in every Member after the First, the Sum of the Exponents of the Capital Letters, is always equal to the Index of the Power to which this Member belongs: Thus considering the Coefficient

$\frac{k-bBB-2bAC-3cAAB-dA^3}{a}$ , which belongs to the

Power  $y^4$ , we shall see that in every Member  $bBB, 2bAC, 3cAAB, dA^3$ , the Sum of the Exponents of the Capital Letters is 4, (where I must take notice, that by the Exponent of

a

a Letter ; I mean the Number which expreffes what Place it has in the Alphabet ; thus 4 is the Exponent of the Letter D) hence I derive this Rule for finding the Capital Letters of all the Members that belong to any Power ; *Combine the Capital Letters as often as you can make the Sum of their Exponents Equal to the Index of the Power to which they belong.* 5. That the Exponents of the small Letters, which are written before the Capitals, exprefs how many Capitals there is in each Member. 6. That the Numerical Figures or *Unciæ* that occur in these Members, exprefs the Number of Permutations which the Capital Letters of every Member are capable of.

For the Demonstration of this ; suppose  $z = Ay + Byy + Cy^3 + Dy^4, \text{ \&c.}$  Substitute this Series in the room of  $z$ , and the Powers of this Series, in the room of the Powers of  $z$  ; there will arife a new Series ; then take the Co-efficients which belong to the feveral Powers of  $y$ , in this new Series, and make them equal to the corresponding Co-efficients of the Series  $gy + hyy + iy^3, \text{ \&c.}$  and the Co-efficients  $A, B, C, D, \text{ \&c.}$  will be found fuch as I have determined them.

But if any one defires to be fatisfied, that the Law by which the Co-efficients are form'd, will always hold, I'll defire 'em to have recourfe to the Theorem I have given for raising an infinite Series to any Power, or extracting any Root of the fame ; for if they make ufe of it, for taking fucceffively the Powers of  $Ay + Byy + Cy^3, \text{ \&c.}$  they will fee that it muft of neceffity be fo. I might have made the Theorem I give here, much more general than it is ; for I might have fuppos'd,

$ax^m + bx^{m+1} + cx^{m+2} \text{ \&c.} = gy^m + hy^{m+1} + iy^{m+2} \text{ \&c.}$  then all the Powers of the Series  $Ay + Byy + Cy^3, \text{ \&c.}$  design'd by the univerfal Indices, muft have been taken fucceffively ; but thofe who will pleafe to try this, my eafily do it, by means of the *Theorem for raising an infinite Series to any Power, \&c.*

This *Theorem* may be applied to what is called the Reversion of Series, fuch as finding the Number from its Logarithm given ; the Sine from the Arc ; the Ordinate of an Ellipse from an Area given to be cut from any Point in the Axis : But to make a particular Application of it, I'll fuppose we have this Problem to folve ; *viz.* The Chord of an Arc being

ing given, to find the Chord of another Arc, that shall be to the first as  $n$  to 1. Let  $y$  be the Chord given,  $z$  the Chord required; now the Arc belonging to the Chord  $y$  is,

$$y + \frac{y^3}{6dd} + \frac{3y^5}{40d^3} + \frac{5y^7}{112d^5} \&c. \text{ and the Arc belonging}$$

to the Chord  $z$  is  $z + \frac{z^3}{6dd} + \frac{3z^5}{40d^3} + \frac{5z^7}{112d^5} \&c.$  the first of these Arcs is to the second as 1 to  $n$ ; therefore multiplying the Extreams and Means together, we shall have this Equation :

$$z + \frac{z^3}{6dd} + \frac{3z^5}{40d^3} + \frac{5z^7}{112d^5} \&c. = ny + \frac{ny^3}{6dd} + \frac{3ny^5}{40d^3} + \frac{5ny^7}{112d^5} \&c.$$

Compare these Two Series with the Two Series of the Theorem, and you will find  $a=1$ ,  $b=0$ ,  $c=\frac{1}{6dd}$ ,  $d=0$ ,

$$e=\frac{3}{40d^3} \quad f=0, \&c. \quad g=n, \quad h=0, \quad i=\frac{n}{6dd}, \quad k=0,$$

$$l=\frac{3n}{40d^3}, \quad m=0, \&c. \text{ hence } z \text{ will be } = ny + \frac{n^3}{6dd} y^3$$

$\&c.$  or  $ny + \frac{1-nn}{2 \times 3dd} nyA$ ,  $\&c.$  Supposing  $A$  to denote the whole preceding Term, which will be the same Series as Mr. Newton has first found.

By the same Method, this general Problem may be solv'd; the Abscisse corresponding to a certain Area in any Curve being given, to find the Abscisse, whose corresponding Area shall be to the first in a given Ratio.

The Logarithmic Series might also be found without borrowing any other Idea, than that Logarithms are the Indices of Powers: Let the Number, whose Logarithm we inquire, be  $1+z$ , suppose its Log. to be  $ax + bx^2 + cx^3$ ,  $\&c.$  Let there be another Number  $1+y$ ; thereof its Logarithm will

be  $ay + byy + cy^3$ ,  $\&c.$  Now if  $1+z = \overline{1+y}^n$ , it follows, that  $ax + bx^2 + cx^3 \&c.$ ,  $ay + byy + cy^3$ ,  $\&c. :: n, 1$ . that is,  $ax + bx^2 + cx^3$ ,  $\&c. = nay + nbyy + ncy^3$ ,  $\&c.$

Therefore

Therefore we may find a Value of  $z$  exprest by the Powers of

$y$ ; again, since  $1 + z = \sqrt[n]{1 + y^n}$ , therefore  $z = \sqrt[n]{1 + y^n} - 1$

that is  $z = ny + \frac{n}{1} \times \frac{n-1}{2} yy + \frac{n}{1} \times \frac{n-1}{2} \times \frac{n-2}{3} y^3,$

&c. Therefore  $z$  is doubly exprest by the Powers of  $y$ . Compare these Two Values together, and the Coefficients  $a, b, c,$  &c. will be determin'd, except the first  $a$  which may be taken at Pleasure, and gives accordingly, all the different Species of Logarithms.

## XI. An Account of the Appearance of an extraordinary Iris seen at Chester, in August last, by E. Halley.

ON the Sixth Day of *August* last, in the Evening, between Six and Seven of the Clock, I went to take the Air upon the Walls of *Chester*, when I was surprized by a sudden Shower, which forced me to take Shelter in a Nich that afforded me a Seat in the Wall, near the North East Corner thereof. As I sat there, I observed an *Iris*, exceedingly vivid, as to its Colours, at first on the South Side only, but in a little Time with an entire Arch; and soon after, the Beams of the Sun being very strong, there appeared a secondary *Iris*, whose Colours were more than ordinary Bright; but inverted, as usually: that is, the Red was inwards, which in the primary *Iris* is outward, and *è contra* for the Blues. But what I took most Notice of was, that with these Two concentrick Arches, there appeared a Third Arch, near upon as bright as the Secondary *Iris*, but coloured in the Order of the Primary, which took its Rise from the Interfection of the Horizon and Primary *Iris*, and went