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WALLIS (JOHN).

[From the *Encyclopædia Britannica, Ninth Edition,* vol. XXIV. (1888), pp. 331, 332.]

WALLIS, JOHN (1616—1703), an eminent English mathematician, logician, and grammarian, was born on the 23rd November 1616 at Ashford, in Kent, of which parish his father was then incumbent. Having been previously instructed in Latin, Greek, and Hebrew, he was in 1632 sent to Emmanuel College, Cambridge, and afterwards was chosen fellow of Queens' College. Having been admitted to holy orders, he left the university in 1641 to act as chaplain to Sir William Darley, and in the following year accepted a similar appointment from the widow of Sir Horatio Vere. It was about this period that he displayed surprising talents in deciphering the intercepted letters and papers of the Royalists. His adherence to the Parliamentary party was in 1643 rewarded by the living of St Gabriel, Fenchurch Street, London. In 1644 he was appointed one of the scribes or secretaries of the Assembly of Divines at Westminster. During the same year he married Susanna Glyde, and thus vacated his fellowship; but the death of his mother had left him in possession of a handsome fortune. In 1645 he attended those scientific meetings which led to the establishment of the Royal Society. When the Independents obtained the superiority, Wallis adhered to the Solemn League and Covenant. The living of St Gabriel he exchanged for that of St Martin, Ironmonger Lane; and, as rector of that parish, he in 1648 subscribed the Remonstrance against putting Charles I. to death. Notwithstanding this act of opposition, he was in June 1649 appointed Savilian professor of geometry at Oxford. In 1654 he there took the degree of D.D., and four years later succeeded Dr Langbaine as keeper of the archives. After the Restoration, he was named one of the king's chaplains in ordinary. While complying with the terms of the Act of Uniformity, Wallis seems always to have retained moderate and rational notions of ecclesiastical polity. He died at Oxford on the 28th of October 1703, in the eighty-seventh year of his age.

The works of Wallis are numerous, and relate to a multiplicity of subjects. His *Institutio Logicæ*, published in 1687, was very popular, and in his *Grammatica Linguæ Anglicanæ* we find indications of an acute and philosophic intellect. The mathematical works are published some of them in a small 4to volume, Oxford, 1657, and a complete collection in three thick folio volumes, Oxford, 1695–93–99. The third volume includes, however, some theological treatises, and the first part of it is occupied with editions of treatises on harmonics and other works of Greek geometers, some of them first editions from the MSS., and in general with Latin versions and notes (Ptolemy, Porphyrius, Briennius, Archimedes, Eutocius, Aristarchus, and Pappus). The second and third volumes include also two collections of letters to and from Brouncker, Frenicle, Leibnitz, Newton, Oldenburg, Schooten, and others; and there is a tract on trigonometry by Caswell. Excluding all these, the mathematical works contained in the first and second volumes occupy about 1800 pages. The titles in the order adopted, but with date of publication, are as follows:—"Oratio Inauguralis," on his appointment (1649) as Savilian professor, 1657; "Mathesis Universalis, seu Opus Arithmeticum Philologice et Mathematice Traditum, Arithmeticam Numerosam et Speciosam Aliaque Continens," 1657; "Adversus Meibomium, de Proportionibus Dialogus," 1657; "De Sectionibus Conicis Nova Methodo Expositis," 1655; "Arithmetica Infinitorum, sive Nova Methodus Inquirendi in Curvilineorum Quadraturam Aliaque Difficiliora Matheseos Problemata," 1655; "Eclipsis Solaris Observatio Oxonii Habita 2nd Aug. 1654," 1655; "Tractatus Duo, prior de Cycloide, posterior de Cissoide et de Curvarum tum Linearum Εὐθύνσει tum Superficierum Πλατυσμῷ," 1659; "Mechanica, sive de Motu Tractatus Geometricus," three parts, 1669–70–71; "De Algebra Tractatus Historicus et Practicus, ejusdem originem et progressus varios ostendens," English, 1685; "De Combinationibus Alternationibus et Partibus Aliquotis Tractatus," English, 1685; "De Sectionibus Angularibus Tractatus," English, 1685; "De Angulo Contactus et Semicirculi Tractatus," 1656; "Ejusdem Tractatus Defensio," 1685; "De Postulato Quinto, et Quinta Definitione, Lib. VI. Euclidis, Disceptatio Geometrica," ? 1663; "Cuno-Cuneus, seu Corpus partim Conum partim Cuneum Representans Geometrice Consideratum," English, 1685; "De Gravitate et Gravitatione Disquisitio Geometrica," 1662 (English, 1674); "De Æstu Maris Hypothesis Nova," 1666—69.

The *Arithmetica Infinitorum* relates chiefly to the quadrature of curves by the so-called method of indivisibles established by Cavalieri, 1629, and cultivated in the interval by him, Fermat, Descartes, and Roberval. The method is substantially that of the integral calculus; thus, e.g., for the curve $y=x^2$ to find the area from $x=0$ to $x=1$, the base is divided into n equal parts, and the area is obtained as

$$=\frac{1}{n^3}(1^2+2^2+\ldots+n^2),\ =\frac{1}{6n^3}n(n+1)(2n+1),$$

which, taking n indefinitely large, is $=\frac{1}{3}$. The case of the general parabola $y=x^m$ (m a positive integer or fraction), where the area is $\frac{1}{m+1}$, had been previously solved. Wallis made the important remark that the reciprocal of such a power of x could be regarded as a power with a negative exponent $\left(\frac{1}{x^m}=x^{-m}\right)$, and he was thus enabled to extend the theorem to certain hyperbolic curves, but the case m a negative value larger than 1 presented a difficulty which he did not succeed in overcoming. It should be noticed that Wallis, although not using the notation x^m in the case of a positive or negative fractional value, nor indeed in the case of a negative integer value of m, deals continually with such powers, and speaks of the positive or negative integer or fractional value of m as the index of the power. The area of a curve, $y =$ sum of a finite number of terms Ax^m, was at once obtained from that for the case of a single term; and Wallis, after thus establishing the several results which would now be written $\int_0^1 (x - x^2)^0\, dx = 1$, $\int_0^1 (x - x^2)^1\, dx = \frac{1}{6}$, $\int_0^1 (x - x^2)^2\, dx = \frac{1}{30}$, $\int_0^1 (x - x^2)^3\, dx = \frac{1}{140}$, &c., proposed to himself to interpolate from these the value of $\int_0^1 (x - x^2)^{\frac{1}{2}}\, dx$, which is the expression for the area $(= \frac{1}{8}\pi)$ of a semicircle, diameter $= 1$; making a slight transformation, the actual problem was to find the value of $\square \left(= \frac{4}{\pi}\right)$, the term halfway between 1 and 2, in the series of terms 1, 2, 6, 20, 70,...; and he thus obtained the remarkable expression $\pi = \frac{2.4.4.6.6.8.8\ldots}{3.3.5.5.7.7.9\ldots}$, together with a succession of superior and inferior limits for the number π.

In the same work, Wallis obtained the expression which would now be written $ds = dx\sqrt{1 + \left(\frac{dy}{dx}\right)^2}$ for the length of the element of a curve, thus reducing the problem of rectification to that of quadrature. An application of this formula to an algebraical curve was first made a few years later by W. Neil; the investigation is reproduced in the "Tractatus de Cissoide, &c." (1659, as above), and Wallis adds the remark that the curve thus rectified is in fact the semicubical parabola.

The *Mathesis Universalis* is a more elementary work intended for learners. It contains copious dissertations on fundamental points of algebra, arithmetic, and geometry, and critical remarks.

The *De Algebra Tractatus* contains (chapters 66—69) the idea of the interpretation of imaginary quantities in geometry. This is given somewhat as follows: the distance represented by the square root of a negative quantity cannot be measured in the line backwards or forwards, but can be measured in the same plane above the line, or (as appears elsewhere) at right angles to the line either in the plane, or in the plane at right angles thereto. Considered as a history of algebra, this work is strongly objected to by Montucla, on the ground of its unfairness as against the early Italian algebraists and also Vieta and Descartes, and in favour of Harriot; but De Morgan, while admitting this, attributes to it considerable merit.

The two treatises on the cycloid and on the cissoid, &c., and the *Mechanica* contain many results which were then new and valuable. The latter work contains elaborate investigations in regard to the centre of gravity, and it is remarkable also for the employment of the principle of virtual velocities. The cuno-cuneus is a highly interesting surface; it is a ruled quartic surface, the equation of which may be written $c^2y^2 = (c - z)^2 (a^2 - x^2)$.

Among the letters in volume III., there is one to the editor of the Leipsic *Acts*, giving the decipherment of two letters in secret characters. The ciphers are different, but on the same principle: the characters in each are either single digits or combinations of two or three digits, standing some of them for letters, others for syllables or words,—the number of distinct characters which had to be deciphered being thus very considerable.

For the prolonged conflict between Hobbes and Wallis, see the article Hobbes, [*Encyclopædia Britannica, ninth edition,*] vol. XII. pp. 36—38.

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