HISTORY OF MATHEMATICS

On the following pages we include brief biographies of three of the most famous Irish mathematicians. They are reprinted by kind permission of the Royal Irish Academy from the joint RIA/NBST publication "Some People and Places in Irish Science and Technology", edited by Charles Mollan, William Davis and Brendan Finucane.

We are interested in establishing a collection of such articles devoted entirely to Irish mathematicians (in their various guises). Readers are invited to contribute biographies to this collection, which should conform as closely as possible to the format illustrated. Also, we would be pleased to hear from anyone who can provide us with brief outline information on prominent Irish mathematicians.

Some suggestions have already been received for the first half of the 19th century: James Thomson (1786-1849), Matthew O'Brien (1814-1855), Robert Murphy (1806-1843), John Thomas Graves (1806-1870), James McCullagh (1809-1847).

We will be happy to provide editorial advice and assistance in this project if necessary.

Pat Fitzpatrick
Martin Stynes

Sir William Rowan Hamilton with one of his sons (circa 1845)
Courtesy Trinity College Dublin

Born: Dublin, Midnight 3-4 August 1805.

Died: Dunsink Observatory, 2 September 1865.

Family:
Married: Helen Bayly, 1833 (she died in 1869).

Children: Two sons and one daughter.

Distinctions:
Andrews Professor of Astronomy, Trinity College, Dublin, and Royal Astronomer of Ireland, Dunsink Observatory (these appointments were made while Hamilton was still an undergraduate at Trinity College) 1827;
Member of the Royal Irish Academy 1832;
Cunningham Medal of the Royal Irish Academy 1834, 1848;
Knighted 1835;
Royal Medal of the Royal Society for his work in optics 1836;
President of the Royal Irish Academy 1837-1846;
First Foreign Associate of the American National Academy of Sciences 1863.

Addresses:
1805-1808 Dominick Street, Dublin;
1808-1823 Trim, Co. Meath;
1823-1827 South Cumberland Street, Dublin;
1827-1865 Dunsink Observatory.

A line with a direction in space is called a *vector*. A *scalar*, on the other hand, is a magnitude without direction. It was William Rowan Hamilton who introduced these terms. He is best known for his method of *quaternions,* which was a solution to the problem of multiplying vectors in three dimensional space. His method, which employs the imaginary number $\sqrt{-1}$, involves three unit imaginaries i, j, k (with $i^2 = j^2 = k^2 = -1$) such that each of them is perpendicular to the others. The product of any two of them corresponds to a 90° rotation of one about the other in a direction depending on the order in which they are multiplied. Thus:

$$ij = k \quad jk = i \quad ki = j$$
$$\text{but} \quad ji = -k \quad kj = -i \quad ik = -j$$

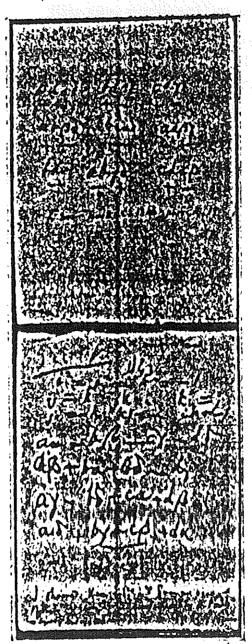
The product of two vectors consists therefore of a real scalar part plus three terms in i, j, and k. Thus it has four terms in all, hence the name *quaternion* (from the Latin *quaternio*, a set of four).

The revolutionary aspect of Hamilton's discovery, which deeply influenced later developments in algebra, is that it does not correspond with traditional multiplication. If we multiply a real number a by another real number b, the product is ab. If we multiply b by a, the answer is the same; that is ab = ba. However, in the case of Hamilton's imaginaries i, j, k, we find that ij = -ji, jk = -kj, and ki = -ik (see above).

Quaternions played a seminal role in the invention of vector analysis, and have found applications in physics. Hamilton's major treatises on the subject are *Lectures on Quaternions* (Dublin, 1853) and *Elements of Quaternions* (London, 1866).

Dunsink Observatory, Hamilton's home from 1827-1865 Courtesy P.A. Wayman

Among Hamilton's other important works are his early optical researches, in which he sought to make optics a mathematical science based on general principles. This work enabled him to predict (1832) that under certain conditions a light ray undergoes an unusual kind of refraction, called 'conical refraction', on passing through biaxial crystals (see entry no. 12). Hamilton's search for general principles extended to dynamics. His reformulation of the equations of motion of Joseph-Louis Lagrange (1736-1813) became — and remains — a powerful tool in classical mechanics and in modern wave mechanics.



Hamilton had quite extraordinary linguistic gifts. Under his uncle's special tuition at Trim, he could read Greek, Latin, and Hebrew at the age of 3 or 4, and it seems he had acquaintance with some 15 languages by the time he was 10. When at Trinity College he was unbeaten in every examination in both Classics and Science in which he entered, achieving the highest grade in every case. He could also perform prodigious feats of mental calculation.

He was a habitual scribbler: he would scribble his ideas on literally anything — scraps of paper (he always carried a notebook with him), his fingernails, even the shell of his morning egg! His most famous 'scribble' came on 16 October 1843, while walking to the Royal Irish Academy with his wife along the Royal Canal. As he was passing Brougham Bridge, the idea of quaternions suddenly came to him. He stopped, took out his penknife, and on the stone parapet of the bridge scratched the fundamental formulae of his quaternion algebra.

His personal life was burdened with anguish: the real, unattained love of Hamilton's life was Catherine Disney, whom he first met on 17 August 1824, but who married a Rev. William Barlow in May 1825.

The pocket book in which Hamilton first entered the fundamental formulas of quaternions Courtesy Trinity College Dublin

Further reading:
Thomas L. Hankins: *Sir William Rowan Hamilton*, Johns Hopkins University Press, Baltimore and London, 1980.

Alan Gabbey,
Department of History and Philosophy of Science,
The Queen's University,
Belfast.

Born: Lincoln, 2 November 1815.
Died: Cork, 8 December 1864.

Family:
Married: Mary Everest (1832-1916). Her uncle George was the surveyor after whom Mount Everest is called.

Children: Five daughters including

Alicia (1860-1940) a notable mathematician;
Lucy (1862-1905) the first woman professor of chemistry in England;
Ethel (1864-1960) a novelist whose book *The Gadfly* has sold more copies than any other book written by an Irish-born author.

Boole's grandson, Geoffrey Taylor F.R.S., was a noted applied mathematician who worked on the development of the atomic bomb. His great-grandson, Howard Hinton F.R.S., was one of the world's foremost entomologists.

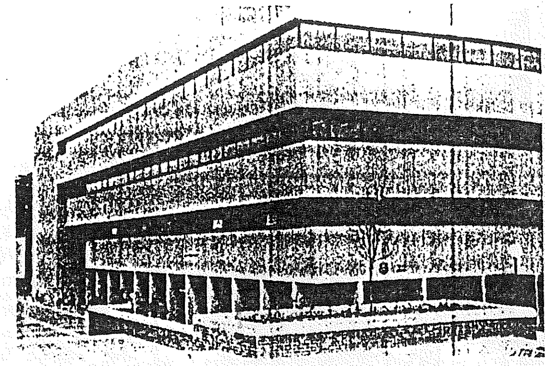
Addresses:
1849-1855 5 Grenville Place, Cork;
1855-1857 Sunday's Well, Cork;
1857-1862 Castle Road, Blackrock, Cork;
1862-1864 Lichfield Cottage, Ballintemple, Cork.

Distinctions:
Awarded the first ever gold medal for mathematics by the Royal Society 1844;
Awarded honorary LL.D. by Trinity College, Dublin 1851;
Elected president of the Cuvierian Society 1855;
Elected Fellow of the Royal Society 1857;
Awarded the Keith prize by the Royal Society of Edinburgh 1857;
Elected member of the Cambridge Philosophical Society 1858;
Honorary degree of D.C.L. from Oxford University 1859.

Boole was a pioneer in mathematics whom Bertrand Russell described as the 'founder of pure mathematics'. He invented a new branch of mathematics — invariant theory — and made important contributions to operator theory, differential equations and probability. However, his most significant discoveries were in mathematical logic. Boole was a deeply religious man, a Unitarian, whose ambition was to understand the workings of the human mind and to express the 'laws of thought' in mathematical form. He invented a new type of algebra, called boolean algebra, which today's engineers and scientists have found to be ideal for the design and operation of electronic computers. Perhaps in some uncanny way Boole foresaw that the human brain behaves like a very complicated computer. Boolean algebra is also essential for the design and operation of the electronic hardware responsible for today's technology. Much of the 'new mathematics' now taught in schools can be traced back to Boole's work — for example, set theory, binary numbers and probability.

George Boole's family — Mary Boole (seated), their five daughters (standing) and some grandchildren

Boole was the eldest son of a struggling Lincoln shoemaker who was more interested in building microscopes than mending shoes. When his father's business failed, George left school at fourteen and became a junior teacher to support his family. Later he opened a school in Lincoln, helped by his sister and brothers. In his spare time he taught himself Latin, Greek, French, Italian and German. Later he studied optics and astronomy and finally he turned to mathematics. In addition, he read and wrote poetry and supported movements for adult education and social reform.



The Boole Library, University College, Cork

In 1849 Boole was appointed first professor of mathematics at Queen's College (now University College) Cork, despite being almost entirely self-taught and having neither secondary schooling nor a university degree. While in Cork he produced his greatest work *The Laws of Thought* which earned him the title 'Father of Symbolic Logic'. This book contains the mathematics of today's computer technology. Boole was an excellent and devoted teacher and met his death after walking in the pouring rain to give a lecture. He is buried beside St Michael's Church of Ireland in Blackrock near Cork City.

Further reading:
George Boole: *The Laws of Thought,* Dover, 1958 (Reprint of 1854 publication by Walton and Maberley, London).
Desmond MacHale: Boolean Algebra, in *The Handbook of Applicable Mathematics,* Ledermann Wiley (ed.), Wiley, 1980.
Desmond MacHale: *George Boole — his Life and Work,* Boole Press, Dublin, 1985. Illustrations are taken, with kind permission, from this publication.

Desmond MacHale,
Department of Mathematics,
University College,
Cork.

Born: Dublin, 1 July 1840.

Died: Cambridge, 25 November 1913.

Family:
Married: Francis Elizabeth Steele, 1868.

Children: Four sons and two daughters, including his biographer W. Valentine Ball.

Nephew of Mary Ball — see entry no. 18.

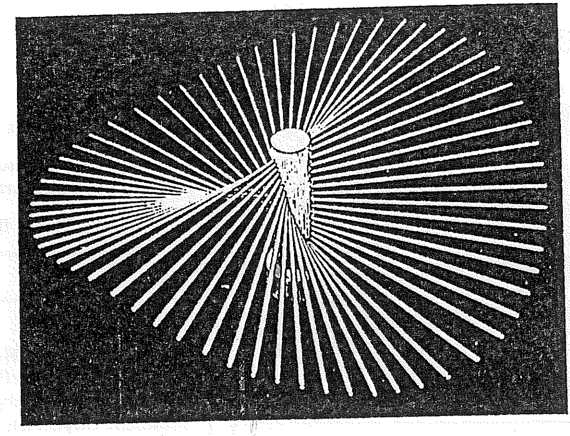
Addresses:
1840-1854 3 Granby Row, Rutland Square, Dublin;
1865-1867 Birr Castle, Co. Offaly;
1874-1892 Dunsink Observatory.

Distinctions:
Member Council Royal Irish Academy 1870 (Secretary 1877-1880; Vice-President 1885-1892);
Fellow Royal Society 1873 (Council Member 1897-1898);
President Royal Astronomical Society 1897-1899;
President Mathematical Association 1899-1900;
President Royal Zoological Society, Ireland 1890-1892;
Cunningham Medal of Royal Irish Academy (for mathematical research) 1879;
Knighted 1886.

Son of a distinguished Cork naturalist, Robert Stawell Ball received his early education at a school kept by Dr J. Lardner Burke in North Great George's Street, Dublin, and at Abbotsgrange, Tarvin, near Chester. In 1857 he entered Trinity College, Dublin where, in a distinguished career, he gained a scholarship, the Lloyd Exhibition, a University Studentship, two gold medals, and prizes in three successive fellowship examinations, 1863-1865.

In the latter year, he accepted a post as tutor to the younger sons of the Earl of Rosse, on the understanding that he would be allowed to observe with the great six-foot reflector at Birr Castle, then the largest telescope in the world. Between 1866 and 1867 he made observations with this instrument of the positions of many faint nebulae, correcting his measurements for instrumental errors to an accuracy not previously achieved by other users of this telescope. In 1867, on the recommendation of the Earl of Rosse, he was appointed Professor of Applied Mathematics at the then new Royal College of Science in Dublin. A compendium of his excellent lectures to College students on Experimental Mechanics was published in 1871.

In 1874 he was appointed Royal Astronomer of Ireland and Andrews Professor of Astronomy in the University of Dublin at Dunsink Observatory. In this dual capacity, he sought to develop the existing Dunsink tradition of measuring stellar distances, using a large sample of stars rather than specially selected objects. Although the method he adopted was later found to be inappropriate for the task, his findings served to identify special problems in making extensive sky surveys and anticipated the later development of more accurate investigative methods. In 1892 he was appointed Lowndean Professor of Astronomy and Geometry at Cambridge but the sad circumstance of the deterioration of his eyesight from 1883, culminating in the loss of his right eye in 1897, gradually brought a halt in this period to his activity as a visual observer.



Ball's cylindroid: a model for screw motions

The work for which he is chiefly remembered, his classic researches on screw motions, was developed over more than thirty years in a series of important communications, contributed in great part to the Royal Irish Academy from 1871. He developed a powerful geometrical method to treat the problem of small movements in rigid dynamics, investigating in particular the behaviour of rigid bodies having different degrees of freedom. In the case where there are two degrees of freedom, he demonstrated that the cylindroid shown in the figure represents the cubic surface locus of the screw axis for all possible twists. Thereafter, he took a special interest in exploring the detailed properties of this kind of surface. In the course of his investigations he made independent discovery of certain theorems concerned with the theory of linear complexes in line geometry, a topic which, in his day, was only in its infancy, and he is now ranked among the leaders of nineteenth century mathematics for his contributions to the geometry of motion and force.

Of genial temperament, he was an outstanding public lecturer and his popular works on astronomy (thirteen volumes published between 1877 and 1908), including *The Story of the Heavens* and a university textbook *A Treatise on Spherical Astronomy*, enjoyed a considerable vogue.

Further reading:
W. Valentine Ball (ed.): *Reminiscences and Letters of Sir Robert Ball*, Cassell and Co. Ltd, London, 1915.
Sir Robert S. Ball: *A Treatise on the Theory of Screws*, Cambridge University Press, 1900.
O. Henrici: *The Theory of Screws*, Nature No. 1075, 42, 127-132, 1890. (Review of 'Theoretische Mechanik Starrer System' by H. Gravelius, published Berlin, Reimer, 1889, an important German treatise based mainly on Ball's work.)

Susan McKenna-Lawlor,
Experimental Physics Department,
Maynooth College,
Co. Kildare.

BOOK REVIEWS

"MEASURE AND INTEGRATION FOR USE"

By *H.R. Pitt, FRS*

Published by *Clarendon Press*, Oxford, 1985. Stg £9.95.
ISBN 0-19-853608-9

Integration is an essential tool for doing mathematics, yet its teaching leaves much to be desired. We are told that the Lebesgue integral is 'too heard' and any analyst knows that the Riemann theory has poor manipulative properties. One solution is that of Henstock*; but prejudice against such simplicity seems too strong. The only other solution is to teach Lebesgue's integral.

This book goes some way towards convincing me that this is possible and desirable. Indeed the main difficulty is that the treatment stays too close to the Riemann integral, presumably so that the reader feels secure. The author sets out to show that the Lebesgue integral is not so difficult to learn, and is of such importance in applications that it simply cannot be ignored. He concentrates on the applications of the theory; notably to harmonic analysis and to probability theory where its ubiquity is most impressive. The point is that one uses the Lebesgue integral for its economy, for its structural integrity and because it unifies.

The book is divided into two parts. The first concerns the theory of integration. Formulated initially in an abstract setting, it focuses mainly on reaching the main results needed to integrate in Euclidean space. There is little digression on measure theoretic pathology. An irritating feature is the constant comparison with the Riemann integral, but this is mostly excusable on cultural grounds. In fact he takes care to answer many of the questions I remember worrying about

* R. Henstock: *Theory of Integration*, Butterworths, 1963