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(*b*. Kilmodan, Scotland, February 1698; *d*. Edinburgh, Scotland, 14 January 1746)

mathematics.

Maclaurin was the youngest of the three sons of John Maclaurin, minister of the parish of Kilmodan and a man of profound learning. John, the eldest son, followed in his father's footsteps and became a noted divine. The father died when Maclaurin was only six weeks old and after the death of his mother nine years later, Maclaurin was cared for by an uncle, Daniel Maclaurin, a minister of Kilfinaan.

In 1709 Maclaurin entered the University of Glasgow where he read divinity for a year. At Glasgow he became acquainted with Robert Simson, professor of mathematics. Simson, who tried to revive the geometry of the ancients, particularly the *Elements* of Euclid, stimulated Maclaurin's interest in this aspect of mathematics.

In 1715 Maclaurin defended the thesis "On the Power of Gravity," for which he was awarded a master of arts degree. It led to his appointment, in 1717, as professor of mathematics at Marischai College, Aberdeen, although he was still only in his teens. This appointment marked the beginning of a brilliant mathematical career which was to continue without interruption until the end of his life.

In 1719 Maclaurin visited London, where he was well received in the scientific circles of the capital and where he met Newton. On a second visit he met and formed a lasting friendship with Martin Folkes, who became president of the Royal Society in 1741, Maclaurin was meanwhile actively working on his *Geometrica organka*, which was published in 1720 with Newton's imprimatur.

Geometrica organica, sive descripth linearum cwvantm universalis dealt with the general properties of conies and of the higher plane curves. It contained proofs of many important theorems which were to be found, without proof, in Newton's work, as well as a considerable number of others which Maclaurin had discovered while at the university. Following traditional geometrical methods, Maclaurin showed that the higher plane curves, the cubic and the quartic, could be described by the rotation of two angles about their vertices. Newton had shown that the conic sections might all be described by the rotation of two angles of fixed size about their vertices S and C as centers of rotation. If the point of intersection of two of the arms lie on a fixed straight line, the intersection of the other two arms will describe a conic section which will pass through *S* and *C*.

In 1722 Maclaurin left Scotland to serve as companion and tutor to the son of Lord Polwarth, plenipotentiary of Great Britain at Cambrai. They visited Paris, then went on to Lorraine, where Maclaurin, during a period of intense mathematical activity, wrote *On the Percussion of Baches*. It won him the prize offered by the French Academy of Sciences in 1724.

In the same year, the sudden death of Maelaurin's pupil caused him to return to Aberdeen. As a result of three years' absence, however, his chair had been declared vacant, Maclaurin then moved to Edinburgh, where he acted as deputy for the elderly James Gregory. There is no doubt that Maclaurin owed his appointment to a strong recommendation from Newton, who wrote to him:

I am very glad to hear that you have a prospect ol* being joined to Mr. James Gregory in the Professorship of the Mathematics at Edinburgh, not only because you are my friend, but principally because of your abilities, you being acquainted as well with the new improvements of mathematics as with the former state of these sciences. I heartily wish you good success and shall be very glad of hearing of your being elected.

In a further letter to the lord provost of Edinburgh, Newton wrote:

I am glad to understand that Mr. Maclaurin is in good repute amongst you, for I think he deserves it very well: And to satisfy you that I do not flatter him, and also to encourage him to accept the place of assisting Mr. Gregory, in order to succeed him, 1 am ready (if you will please give me leave) to contribute twenty pounds per annum towards a provision for him till Mr. Gregory's place becomes void, if I live so long.

Maclaurin was appointed to the Edinburgh chair when it fell vacant. He assumed its duties in 1725, lecturing on a wide range of topics that included twelve books of Euclid, spherical trigonometry, the conies, the elements of fortification, astronomy, and perspective, as well as a careful exposition of Newton's *Principia*

Maclaurin was elected a fellow of the Royal Society in 1719. He was also influential in persuading the members of the Edinburgh Society for Improving Medical Knowledge to widen its scope. The society's name was thus changed to the Philosophical Society and Maclaurin became one of its secretaries. (In 1783 the organization was granted incorporation by George III as the Royal Society of Edinburgh.) In 1733 Maclaurin married Anne, daughter of Walter Stewart, solicitor general for Scotland. Of their seven children, two sons and three daughters survived him.

Maelaurin's *Treatise of Fluxions* (1742) has been described as the earliest logical and systematic publication of the Newtonian methods. It stood as a model of rigor until the appearance of Cauchy's *Coursd'analyse* in 1821. Maclaurin, a zealous disciple of Newton, hoped to silence criticism of the latter's doctrine of "prime and ultimate ratios" which proved something of a stumbling block to even Newton's staunchest supporters. In the *Treatise* Maclaurin tried to provide a geometrical framework for the doctrine of fluxions; in this way he hoped to refute his critics, the most vociferous of whom was George Berkeley, Bishop of Cloyne. In 1734 Berkeley had published *The Analyst. A Letter Addressed to an Infidel Mathematician*, in which he derided Newton's conception of "prime and ultimate ratiordquo; (The "infidel mathematician" himself was Halley, who had piloted the first edition of the *Principia* through the press,) Berkeley maintained that it was not possible to imagine a finite ratio between two evanescent quantities. "What are these fluxions?" he asked. "The velocities of evanescent increments? They are neither finite quantities, nor quantities infinitely small, nor yet nothing. May we not call them the ghosts of departed quantities?"

In the preface to the *Treatise*, Maclaurin gave his reasons for replying to Berkeley:

A Letter published in the year 1734 under the Title of *The Analyst*, first gave occasion to the ensuing Treatise, and several Reasons concurred to induce me to Write on the subject at so great length. The Author of that piece had represented the Method of Fluxions as founded on false Reasoning, and full of Mysteries. His objections seemed to have been occasioned by the concise manner in which the Elements of this method have been usually described, and their having been so much misunderstood by a Person of his abilities appeared to me to be a sufficient Proof that a fuller account of the grounds of this was required.

He took up the question of fluxions almost immediately and defended Newton's methods:

In explaining the notion of Fluxions I have followed Sir Isaac Newton in the First Book imagining there can be no difficulty in conceiving Velocity wherever there is motion, nor do I think I have departed from his sense in the Second Book, and in both 1 have endeavoured to avoid several expressions which though convenient, might be liable to exceptions and perhaps occasion disputes...

There were some who disliked the making much use of infinites and infinitesimals in geometry. Of this number was Sir Isaac Newton (whose caution was almost as distinguishing a part of his character as his invention) especially after he saw that this liberty was growing to so great a height. In demonstrating the grounds I of the method of fluxions he avoided them, establishing I it in a way more agreeable to the strictness of geometry.

Maclaurin followed Newton in abandoning the view that variable quantities were made up of in finitesimal elements and in approaching the problem from kinematical considerations. Moreover, he consistently followed the Newtonian notation, although the Leibnizian notation was by this time well established on the Continent. Thus he wrote (in the *Treatise*, p. 738), "The fluxion of *xy is xy* + *xy*"

The *Treatise* is otherwise noteworthy for the solution of a great number of problems in geometry, statics, and the theory of attractions. It contains an elaborate discussion on infinite series, including Maclaurin's test for convergence, as well as a remarkable investigation of curves of quickest descent and various isoperimetrical problems. It describes his series for the expansion of a function of x, namely,

Maclaurin also elaborated many of the principles enunciated by Newton in the Principia in this work, including problems in applied geometry and physics, founded on the geometry of Euclid.

Maclaurin's discussion of the attraction of an ellipsoid on an internal point is particularly significant. His interest in this subject began in 1740 when he j submitted an essay "On the Tides" (*De causa physica fluxus et refluxus maris*) for a prize offered by the Academic des Sciences. Maclaurin shared the award with Daniel Bernoulli and Euler; all three men based their work upon proposition 24 of the Principia, on the flux and reflux of the sea. Maclaurin's original essay was hastily assembled, but he developed his ideas much further in the *Treatise* (II, article 686). He showed that a homogeneous fluid mass revolving uniformly about an axis under the action of gravity must assume the form of an ellipsoid of revolution. ; Clairaut was so impressed with Maclaurin's exposition that in his *Théorie de la figure de la terre* (1743), he abandoned analytical techniques and attacked the problem of the shape of the earth by purely geometrical methods.

In the *Treatise* Maclaurin presented for the first time the correct theory for distinguishing between maximum and minimum values of a function; he further indicated the importance of this distinction in the theory of multiple points of curves. In Chapter IX of Volume I, article 238, "Of the Greatest and Least Ordinates, of the points of contrary flexion and reflexion of various kinds, and of other affections of curves that are defined by a common or by a fluxional equation," he wrote that "There are hardly any speculations in Geometry more useful or more entertaining than those which relate to the *Maximum* and *Minimum*"

Maclaurin's persistent defense of the Newtonian methods was not without harmful consequences for the progress of mathematics in Great Britain. National pride induced Englishmen to follow the geometrical methods which Newton had employed in the *Principia*, and to neglect the analytical methods which were being pursued with such conspicuous success on the Continent As a result, English mathematicians came to think that the calculus was not really necessary. This unfortunate neglect persisted for a century or more. It was said that during the eighteenth century Maclaurin and Matthew Stewart, who succeeded him in the mathematical chair at Edinburgh, were the only prominent mathematicians in Great Britain. Writing toward the end of the century, J. Lalande, in his *Life of Condorect*, maintained that in 1764 there was not a single first-rate analyst in the whole of England.

Maclaurin's advice was sought nevertheless on many topics, not all of them mathematical. He was a skilled experimentalist, and he devised a variety of mechanical appliances. He made valuable astronomical observations and did actuarial computations for the use of insurance societies. He also took an active part in improving maps of the Orkney and Shetland Islands, with a view to discovering a northeast polar passage from Greenland to the southern seas, and prepared an extensive memorial upon this subject for the government. (Since the government was at that time primarily interested in finding a northwest passage, the matter was dropped.)

When a Highland army marched upon Edinburgh in the uprising of 1745, Maclaurin wholeheartedly organized the defenses of the city. With tireless energy, he planned and supervised the hastily erected fortifications, and, indeed, drove himself to a state of exhaustion from which he never recovered. The city fell to the Jacobites and Maclaurin was forced to flee to England. He reached York and sought refuge with Thomas Herring, the archbishop. He returned Edinburgh once it became clear that the Jacobites were not going to occupy the city, but the rigors he had endured had very severely undermined his health. He died soon after, at the age of forty-eight. Only a few hours before his death he dictated the concluding passage of his work on Newton's philosophy, in which he affirmed his unwavering belief in a future life.

At the meeting of the university following Maclaurin's death, his friend, Alexander Munro, professor of anatomy at the University of Glasgow, paid tribute to him: "Me was more nobly distinguished from the bulk of mankind by the qualities of the heart: his sincere love of God and men, his universal benevolence and unaffected piety together with a warmth and constancy in his friendship that was in a manner peculiar to himself."

BIBLIOGRAPHY

I. Original Works. Maclaurin's works are *Geometrica organica, sive descriptio linearum curvarum universalis* (London, 1720); *The Treatise of Fluxions*, 2 vols. (Edinburgh, 1742); and *A Treatise of Algebra* (1748), a somewhat elementary posthumous work on the application of algebra to geometry, to which is joined a Latin tract, "De linearum geomctricarum proprietatibus generalibus" (1756), printed from a manuscript written and corrected in Maelaurin's own hand. *An Account of Sir Isaac Newton's Philosophical Discoveries* (London, 1748) has a prefatory memoir on Maclaurin, "An Account of the Life and Writings of the Author," by Patrick Murdoch.

Maelaurin's papers published in the *Philosophical Transactions of the Royal Society* are: "Of the Construction and Measure of Curves," no. 356 (1718); "A New Universal Method of Describing All Curves of Every Order by the Assistance of Angles and Right Lines," no. 359 (1719); "A Letter… to Martin Folkes Esq. Concerning Equations with Impossible Roots (May 1726)" no. 394; "A Second Letter … to Martin Folkes Concerning the Roots of Equations, With the Demonstration of Other Rules in Algebra" no, 408 (1729); "On the Description of Curve Lines With an Account of Further Improvements, and a Paper Dated at Nancy, 27 Nov. 1722," no. 439; and "An Abstract of What Has Been Printed Since the Year 1721, as a Supplement to a Treatise Concerning a Description of Curve Lines, Published in 1719, and to Which the Author Proposes to Add to That Supplement," **39** .

Further papers published in the *Philosophical Transactions* are "An Account of the Treatise of Fluxions," no. 467 and continued in no. 469; "A Rule for Finding the Meridional Parts to a Spheroid With the Same Exactness as a Sphere," no. 461 (1711); "A Letter From Mr. Colin Maclaurin … to Mr. John Machin Concerning the Description of Curve Lines. Communicated to the Royal Society December 21. 1732"; "An Observation of the Eclipse of the Sun, on February 18, 1737 Made at Edinburgh, in a Letter to Martin Folkes," **40** , 177; "Of the Basis of Cells Wherein Bees Deposit Their Honey," no. 471 (1743).

Maclaurin also left a large number of manuscripts and unfinished essays on a variety of subjects, mathematical and nonmathematical.

II. Secondary Literature. Further information on Maclaurin's life and work may be found in W. W. R. Ball, A *Short Account of the History of Mathematics* (1912), 359-363; Florian Cajori, *History of Mathematics* (1919); Moritz Cantor, *Vorksungen über Geschichte o'er Mat hematite* (1884–1908); J. P. Montucla, *Histoire des Mathmatiques*, 4 vols. (1799–1802); H. W. Turnbull, "Colin Maclaurin," in *American Mathematical Monthly*,**54** , no. 6 (1947).

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