ISAAC NEWTON

When Isaac Newton was born the day was December 25, 1642 by the Julian calendar that was still in use in England at the time. (With the adoption of the Gregorian calendar, the birthday of the individual many hail as the *Man of the Millennium* became January 4, 1643 (and by that calendar he died on March 20, 1727). Newton was born in Woolsthorpe, Lincolnshire, a premature infant not expected to live. His father (also named Isaac) died three months earlier. His mother, Hannah Ayscough Newton, remarried when Isaac was three, and left him with his grandmother until her second husband died when Newton was 11. He attended King's School, Grantham, and it was assumed he would continue the family tradition by taking up farming. But his mother decided that he should attend college. In 1661 Newton entered Trinity College, Cambridge. His performance was unimpressive, but his mathematics teacher, Isaac Barrow, saw something in the lad that others missed and greatly encouraged him. Still, Newton took his degree without distinction in 1665.

During the Great (Bubonic) Plague of 1665 - 66, the University closed for nearly two years. Newton made good use of the time. During this period he invented the method of fluxions (the calculus) and discovered the law of universal gravitation. By 1666 he had developed early versions of his laws of motion. When he returned to Cambridge, Newton became a Fellow of Trinity College, and took his master's degree in 1668. The following year, Barrow, recognizing that his pupil was his mathematical superior, resigned his Lucasian chair so it might go to Newton. Newton was greatly interested in the question of how the effects of light were produced. By the end of 1675 he had constructed the corpuscular or emission theory, which he expounded in memoirs communicated to the Royal Society.

During the year 1676, Newton and Gottfried von Leibniz corresponded about their work with the expansion of series and the applications to finding areas and volumes. The work is related to today's integration. Newton did not mention the calculus specifically but at the end of his second letter (October 1676) to Leibniz, he alludes to the solution of the "inverse problems of tangents," and handling maxima and minima problems,

"The foundations of these operations is evident enough; but I cannot proceed with the explanation of it now. I have preferred to conceal it thus: *6accdae13eff 7i319n4o4qrr4s8t12vx*."

Newton's anagram gives the number of different letters in following the Latin sentence: *Data aequatione quotcunque fluentes quantitates involvente, fluxiones invenire: et vice versa.* The *u*'s and *v*'s are grouped together totaling 12 letters, the diphthong *ae* is counted as a separate character, and strangely the Latin sentence contains nine, not eight, *t*'s. It translates to Newton's version of the fundamental theorem of calculus: "Given an equation involving any number of fluent quantities, to find the fluxions: and vice versa." Apparently with this code Newton believed he established his publishing priority. It took 8 months for Newton's second letter to reach Leibniz. In his reply, dated June 21, 1677, Leibniz explained his methods of drawing tangents to curves, and speaks of his notation of *dx* and *dy* for the infinitesimal differences between the coordinates of two points on a curve. Leibniz wrote that his approach was "not by fluxions of lines, but by the differences of numbers."

The *Universal Arithmetic*, which deals with algebra, theory of equations, and miscellaneous problems, contains the substance of Newton's lectures during the years 1673 to 1683. He rather reluctantly allowed it to be published in 1707. In 1684, Newton gave a series of lectures on the laws of motion. By 1685, he had incorporated these lectures into what was to be the first of three books of his masterpiece, the *Philosophiae Naturalis Principia Mathematica.* The second book of the *Principia* was completed in 1686, but not published until 1687. These might not have been published at all had it not been for Edmund Halley. Robert Hooke, Christiaan Huygens, Christopher Wren and Halley had all conjectured that the force of the attraction of the sun or earth on an external object varied inversely as the square of the distance between them. Halley visited Newton in August 1684 and explained that they could not deduce their findings from the law of the orbits of the planets. Halley asked Newton if he could find out what the orbit of a planet would be if the law of attraction was that of the inverse square. Without hesitation, Newton said the orbit was an ellipse. Asked how he knew, he replied that he had calculated it in 1679. It was only through Halley's urging that Newton agreed to attack the whole problem of gravitation and pledged to publish his findings. The cost of the printing of the results, which gave the world Newton's law of universal gravitation, was borne by Halley, who also corrected the proofs.

In 1696, Newton was appointed warden of the Mint and three years later to the mastership at a handsome salary. This essentially brought his scientific work to an end, although it was only after this time that many of his previous investigations appeared in print. In 1696, Newton resigned his Lucasian chair at Cambridge and moved to London. In 1703 he was elected president of the Royal Society and the next year his *Optics* was printed. It contained two appendices; the second, *De Quadratura Curvarum*, gave a brief description of Newton's method of fluxions, which was described more completely in his *Methodus Differentialis* (1711).

Newton conceived of a line as being generated by a moving point. He thought of a line as a "flowing quantity," and called it the *fluent*. The velocity with which the line "flowed," he called its *fluxion*. To Newton the fluxion of a fluent was "infinitely small." He then considered two kinds of problems. The object of the first was to find the fluxion of a given quantity, or more generally, "the relation of the fluents being given, to find the relation of their fluxions." In today's language this was equivalent to finding the derivative of a function. The object of the second or inverse method of fluxions was given the fluxion, or some relations involving it, to determine the fluent, or more generally "an equation being proposed exhibiting the relation of the fluxions of quantities, to find the relations of these quantities, or fluents, to one another." In modern translation, the problem was to find an antiderivative of a function.

Saying that Newton invented calculus is a bit of a stretch. At the very least he must share the glory with the German genius Gottfried Wilhelm Leibniz. Neither Newton nor Leibniz actually produced a calculus, that is, a classified collection of rules, although Leibniz came close in his "Nova methodus pro maximis et minimis, itemque tangentibus, quae nec fractas, nec irrationales quantitates moratur, et singulare pro illis calculi genus" ("New Method for the Greatest and the Least, as well as tangents, which is neither impeded by fractional nor irrational quantities," 1684). Newton had only invented "fluxions" to find the tangent and the radius of curvature of any point on a curve that enabled him to build up his law of universal gravitation. Neither Newton nor Leibniz could have made their discoveries had it not been for the earlier work of the likes of John Napier, Johann Kepler, Francesco Cavalieri, Blaise Pascal, Pierre de Fermat, John Wallis and Newton's teacher Isaac Barrow. They set the table at which Newton (and Leibniz) feasted on a discovery whose time had come. Even Newton, who was not known for sharing credit, acknowledged in a letter to Hooke "If I have seen further (than you and René Descartes) it is by standing upon the shoulders of Giants."

Unfortunately, a controversy developed over who should be credited for the invention of the infinitesimal calculus. The debate showed Newton at his worst, as he and those he encouraged to do so, belittled and dismissed the contributions of Leibniz, even to the extent of suggesting that Leibniz was guilty of plagiarism. The supporters of the two kept the controversy alive even after their deaths. The question as to who had invented calculus became a matter of national pride. English mathematicians so stubbornly adhered to the work of their master that their mathematical accomplishments suffered in comparison with those of mathematicians of the continent for a very long period thereafter.

The oft-told story that Newton claimed the idea of the law of gravity came to him when an apple fell on his head is surely a myth. Some people, aware of Newton's unpleasant disposition, have suggested that some clod, whom the great man considered his intellectual inferior (which included almost everybody), asked Newton how the idea came to him, and Sir Isaac responded with a contemptuous answer the dull one could understand. As Newton was very secretive, anti-social, and did not tolerate fools, it is more likely that no one would have dared ask such a question, and if one had, Newton would not have responded to it.

Although he will always be remembered for his contributions to mathematics and science, Newton seemed to have had greater interest in his studies of alchemy, chronology and theology. He was a stubborn man who had to be coaxed and cajoled into publishing the results of his research. Novelist Aldous Huxley claimed that Newton paid for his supreme intellect by being incapable of friendship and love. Huxley asserted that as a man Newton was a failure, but as a monster he was superb.

Quotation of the Day: "I do not know what I may appear to the world; but to myself I seem to have been only like a boy playing on the seashore, and diverting myself in now and then finding a smoother pebble or a prettier shell than ordinary, whilst the great ocean of truth lay all undiscovered before me." - Sir Isaac Newton