

Roger Cotes and Newton's Principia Mathematica



Roger Cotes (1682-1716)

On July 10, 1682, English mathematician **Roger Cotes** was born. Cotes is well known for working closely with Isaac Newton by proofreading the second edition of his famous book, the *Philosophiae Naturalis Principia Mathematica*,[\[4\]](#) before publication. He also invented the quadrature formulas known as Newton–Cotes formulas and first introduced what is known today as Euler's formula.

“If he had lived we would have known something.”, Remark of Issac Newton on the early death of Roger Cotes.

Roger Cotes – Early Years

Cotes was born in Burbage, Leicestershire, England, as the second son to Reverend Robert Cotes, the rector of Burbage, and his wife Grace née Farmer. He attended Leicester School and by the age of twelve his teachers had already realized that he had an exceptional mathematical talent.[3] His aunt Hannah had married Reverend John Smith, and Smith took on the role of tutor to encourage Roger’s talent. The Smiths’ son, Robert Smith, would become a close associate of Roger Cotes throughout his life. Cotes later studied at St Paul’s School in London, still exchanging letters with his uncle on mathematical subjects, before he entered Trinity College, Cambridge in 1699 as a pensioner, meaning that he did not have a scholarship and paid for his own keep in College. He graduated BA in 1702, and was elected to a fellowship in 1705, even before he finished his MA in 1706.

An Extraordinary Mathematical Talent

In January 1706 he was nominated to be the first Plumian Professor of Astronomy and Experimental Philosophy. This was a remarkable achievement for Cotes who, at that time, was on 23 years of age. His extraordinary mathematical talent had been recognized by Isaac Newton as well as by Richard Bentley who was master of Trinity College. Both had recommended him for the chair, supported by William Whiston, Newton’s successor as Lucasian professor, despite the heavy opposition by John Flamsteed, astronomer royal,[5] who wanted his former assistant John Witty to be appointed.[3] It is not entirely clear how successful Cotes was in his role as an observational astronomer.[1]

A Focus on Astronomy

Cotes began his educational career with a focus on astronomy. On his appointment to professor, he opened a subscription list in an effort to provide an observatory for Trinity. Unfortunately, the observatory still was unfinished when Cotes died, and was demolished in 1797.[2] In correspondence with Isaac Newton, Cotes designed a heliostat telescope with a mirror revolving by clockwork. He recomputed the solar and planetary tables of Giovanni Domenico Cassini [6] and John Flamsteed, and he intended to create tables of the moon’s motion, based on Newtonian principles. Cotes was elected a fellow of the Royal Society in 1711, and was ordained in 1713.

Newton’s Principia

Cotes’ mathematical abilities put him second only to Newton from his generation in England.[1] From 1709 until 1713 much of Cotes’ time was taken up editing the second edition of Newton’s *Philosophiæ Naturalis Principia Mathematica*, originally published 1687 in the first edition only with a few printed books, where Newton described his principles of universal gravitation. In 1694 Newton did further work on his lunar and planetary theories, but illness and a dispute with Flamsteed postponed any further publication.[2] Cotes did not simply proof-read the work, rather he conscientiously studied it, gently but persistently arguing points with Newton.[1] The first edition of *Principia* had only a few copies printed and was in need of revision to include Newton’s works and principles of lunar and planetary theory. Newton at first had a casual approach to the revision, since he had all but given up scientific work. However, through the

vigorous passion displayed by Cotes, Newton's scientific hunger was once again reignited. The two spent nearly three and half years collaborating on the work, in which they fully deduce, from Newton's laws of motion, the theory of the moon, the equinoxes, and the orbits of comets.

"But shall gravity be therefore called an occult cause, and thrown out of philosophy, because the cause of gravity is occult and not yet discovered? Those who affirm this, should be careful not to fall into an absurdity that may overturn the foundations of all philosophy. For causes usually proceed in a continued chain from those that are more compounded to those that are more simple; when we are arrived at the most simple cause we can go no father.... These most simple causes will you then call occult and reject them? Then you must reject those that immediately depend on them." (from Roger Cotes' Preface to Isaac Newton's Principia)

Further Collaboration

Although Newton and Cotes seemed to have been at rather friendly terms in the beginning of their collaboration, his friendship seemed to have calmed down over time. In particular although Newton thanked Cotes in the first draft of a preface he wrote to this edition, he deleted these thanks for the final publication. Cotes formed a school of physical sciences at Trinity in collaboration with William Whiston. The two performed a series of experiments beginning in May 1707, the details of which can be found in a post-humous publication, *Hydrostatical and Pneumatical Lectures by Roger Cotes* (1738). [2]

Original Work in Mathematics

Cotes's major original work was in mathematics, especially in the fields of integral calculus, logarithms, and numerical analysis. He published only one scientific paper in his lifetime, titled *Logometria*, published in the *Philosophical Transactions of the Royal Society* for March 1714, in which he successfully constructs the logarithmic spiral. After his death, many of Cotes's mathematical papers were hastily edited by his cousin Robert Smith, the successor on Cotes' chair in Cambridge, and published in a book, *Harmonia mensurarum*, ensuring that he wasn't forgotten, at least by the mathematical community.[3] Cotes's additional works were later published in Thomas Simpson's *The Doctrine and Application of Fluxions*. Although Cotes's style was somewhat obscure, his systematic approach to integration and mathematical theory was highly regarded by his peers. Cotes discovered an important theorem on the n th roots of unity, foresaw the method of least squares, and he discovered a method for integrating rational fractions with binomial denominators. He was also praised for his efforts in numerical methods, especially in interpolation methods and his table construction techniques.

Cotes, who never married, died from a "Fever attended with a violent Diarrhoea and constant Delirium" in Cambridge in 1716 at the early age of 33. Isaac Newton remarked, *"If he had lived we would have known something."*

References and Further Reading:

- [1] O'Connor, John J.; Robertson, Edmund F., "[Roger Cotes](#)", MacTutor History of Mathematics archive, University of St Andrews. (2005)
- [2] "[Cotes, Roger](#)." Complete Dictionary of Scientific Biography. 2008. Encyclopedia.com
- [3] Thony Christie, "[If he had lived, we might have known something](#)", in The Renaissance Mathematicus, July 10, 2013.

- [4] [Sir Isaac Newton and the famous Principia](#), SciHi Blog
- [5] [John Flamsteed – Astronomer Royal](#), SciHi Blog
- [6] [Giovanni Cassini and the Saturn Moon Rhea](#), SciHi Blog
- [7] [Roger Cotes at Wikidata](#)
- [8] *Edleston, J. (ed.) (1850). [Correspondence of Sir Isaac Newton and Professor Cotes](#)*, via Internet Archive
- [9] [Roger Cotes](#) at the Mathematics Genealogy Project
- [10] [Roger Cotes at zbMATH](#)
- [11] Robin Wilson, *[Pi and e and the most beautiful theorem in mathematics](#)*, 2017, [Gresham College](#) @ youtube
- [12] [Timeline of Mathematical Analysts](#), via DBpedia and Wikidata