Nicolae Sfetcu

Isaac Newton vs. Robert Hooke on the law of universal gravitation

ESSAYS Collection

MultiMedia Publishing

Isaac Newton vs. Robert Hooke on the law of universal gravitation

Nicolae Sfetcu

14.01.2019

Sfetcu, Nicolae, " Isaac Newton vs. Robert Hooke on the law of universal gravitation ", MultiMedia (January 14, 2019), MultiMedia Publishing (ed.), ISBN 978-606-033-204-6, DOI: 10.58679/MM39765, URL = https://www.telework.ro/en/e-books/isaac-newton-vs-robert-hooke-on-the-law-of-universal-gravitation/

Email: nicolae@sfetcu.com

A translation of:
Sfetcu, Nicolae, Controversa dintre Isaac Newton și Robert Hooke despre prioritatea în legea gravitației", SetThings (29 noiembrie 2017), MultiMedia Publishing (ed.), DOI: 10.13140/RG.2.2.24577.97122, ISBN: 978-606-033-133-9, URL = https://www.telework.ro/ro/e-books/controversa-dintre-isaac-newton-si-robert-hooke-despre-prioritatea-legea-gravitatiei/

Abstract

One of the most disputed controversy over the priority of scientific discoveries is that of the law of universal gravitation, between Isaac Newton and Robert Hooke. Hooke accused Newton of plagiarism, of taking over his ideas expressed in previous works. In this paper I try to show, on the basis of previous analysis, that both scientists were wrong: Robert Hooke because his theory was basically only ideas that would never have materialized without Isaac Newton's mathematical support; and the latter was wrong by not recognizing Hooke's ideas in drawing up the theory of gravity. Moreover, after Hooke's death and taking over the Royal Society presidency, Newton removed from the institution any trace of the former president Robert Hooke. For this, I detail the accusations and arguments of each of the parts, and how this dispute was perceived by the contemporaries of the two scientists. I finish the paper with the conclusions drawn from the contents.

Keywords: Isaac Newton, Robert Hooke, law of gravity, priority, plagiarism

Introduction

Since ancient times, Aristotle has represented the universe as transparent concentric spheres, with the Earth in the center, then, outwardly, the spheres of the Moon, the planets, and the fixed stars. But he did not try to give any explanation to the power that provided stability to this cosmic system. He just stated that there is something, somewhere, a primal energy, later interpreted as a belief in a creative God. Aristotle considers that each sphere has an equal number of gods for which they care for it. Then Copernicus replaced the geocentric cosmological system with a heliocentric system, and Kepler systematized mathematically the laws of the planets movement around the Sun. But neither of them has said a word on the force that holds this huge system in balance. Descartes tried to answer these questions mechanistically, through the force of impact and the existence of an invisible substance - the Cartesian vortex.

During the second half of the seventeenth century there was a plethora of thinkers of the Scientific Revolution, such as Robert Boyle, Christiaan Huygens, Robert Hooke, Isaac Newton, Gottfried Wilhelm Leibniz, etc., starting many controversies about intellectual property and disputes about the scientific priority on new discoveries and concepts. (Guicciardini 2005)

The modern theory of gravity began with the work of Galileo Galilei, with his famous experiments of the balls falling from the tower of Pisa and left to slip on an inclined plane. He found that gravity is the same for all objects, the differences occurring only due to different resistances to the air during the fall. (Bongaarts 2014)

Based on Galileo's experiments, Newton develops the theory of gravity in his first book *Philosophiæ Naturalis Principia Mathematica* ("*Principia*") of 1686. Immediately after, Robert Hooke accused Newton of plagiarism, claiming that he unduly assumed his "notion" of "the rule of the decrease of Gravity, being reciprocally as the squares of the distances from the Center". But, according to Edmond Halley, Hooke agreed that "the demonstration of the curves generated by it" belongs entirely to Newton. (Nauenberg 2005)

Thus, the question arises as to the extent to which Isaac Newton was "inspired" by Robert Hooke's previous works, and to whom the priority of universal gravity law should be given. Some historians of science highlight Newton's mathematical genius without which the law of gravity would never be finalized, while others noted the contribution of the "mechanical genius" (Hooke) to whom the Westminster Abbey place was denied by a puritan tyrant (Newton).

A long debate from then on to our day.

Robert Hooke's contribution to the law of universal gravitation

Robert Hooke published his ideas about gravity in the book "*The System of the World*" in 1660, and then read before the Royal Society in 1666 a work "*On gravity*", "inflection of a direct motion [inertial motion] into a curve by a supervening attractive principle," developing it in another work in 1674. (Hooke 1674) He announced that he intended to "explain a system of the world very different from any yet received." (Purrington 2009) Thus, he presented in a clear way the reciprocal attractions between the Sun and planets, inversely proportional to the distance between the bodies, together with a principle of linear inertia.

But Hooke's exposure was not universal, and he did not offer mathematical demonstrations. Hooke himself stated in 1674: "Now what these several degrees [of attraction] are I have not yet experimentally verified" ... "This I only hint at present," " having my self many other things in hand which I would first compleat, and therefore cannot so well attend it " ("prosecuting this Inquiry"). (Hooke 1674) On January 6, 1679[1], writing to Newton, Hooke expressed "supposition

[1] Calendar (New Style) Act 1750

... that the Attraction always is in a duplicate proportion to the Distance from the Center Reciprocal, and Consequently that the Velocity will be in a subduplicate proportion to the Attraction and Consequently as Kepler Supposes Reciprocal to the Distance." (Newton, Correspondence of Isaac Newton, Vol 2 (1676-1687) 1960) (Inference of speed was incorrect. (Wilson 1989)) Hooke mentioned in this correspondence, on November 24, 1679, an approach of "compounding the celestial motions of the planets of a direct motion by the tangent and an attractive motion towards the central body." (Newton 1960)

Isaac Newton's contribution to the law of universal gravitation

In 1687, Isaac Newton published *Principia*, where he demonstrates that the force of attraction between two bodies is proportional to the product of the masses and inversely proportional to the distance between them, namely the law of universal gravitation: "I deduced that the forces which keep the Planets in their Orbs must be reciprocally as the squares of their distances from the centres about which they revolve : and thereby compared the force requisite to keep the Moon in her Orb with the force of gravity at the surface of the Earth, and found them to answer pretty nearly.": (Chandrasekhar 2003)

$$\mathbf{F = G \cdot m_1 m_2 / r^2}$$

where F is the force, m_1 and m_2 are the masses of the objects that interact, r is the distance between the mass centers and G is the gravitational constant.

Robert Hooke's claim of his priority on the law of universal gravitation

In a memo titled "*A True state of the Case and Controversy between Sr Isaak Newton and Dr Robert Hooke as the Priority of that Noble Hypothesis of Motion of ye Planets about ye Sun as their Centers*," (Gunther 1920) not published during his life, Hooke described his theory of gravity. To support his "priority," Hooke cites his lectures on planetary movements of May 23, 1666, "*An* *attempt to prove the motion of the earth from observations*" published in 1674, and the correspondence with Isaac Newton in 1679. (Newton 1960) Edmond Halley asked him to produce a different demonstration from Newton. It can be seen from Figure 1 that Hooke's geometric construction is practically the same as that described by Newton (see Figure 2). (Newton, n.d.)

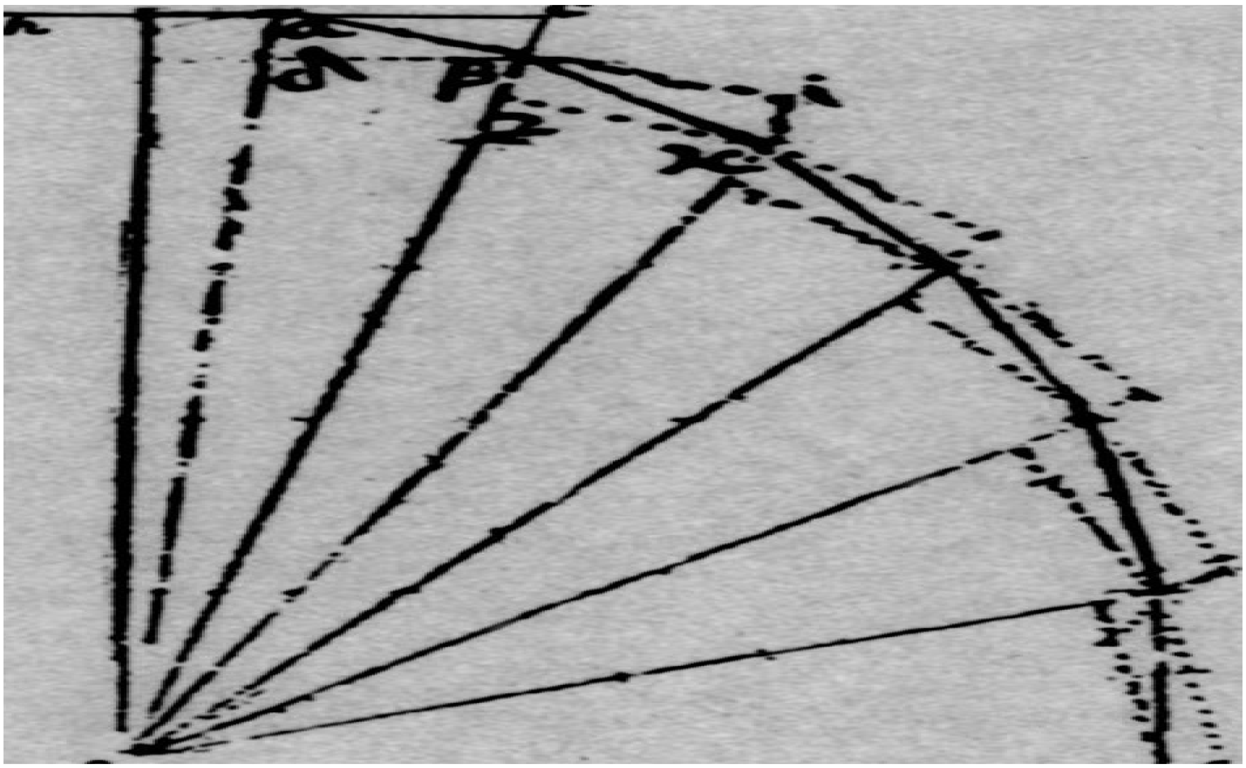

Figure 1: Hooke's partial diagram of Sept. 1685 for a discrete approximation to an elliptical orbit.

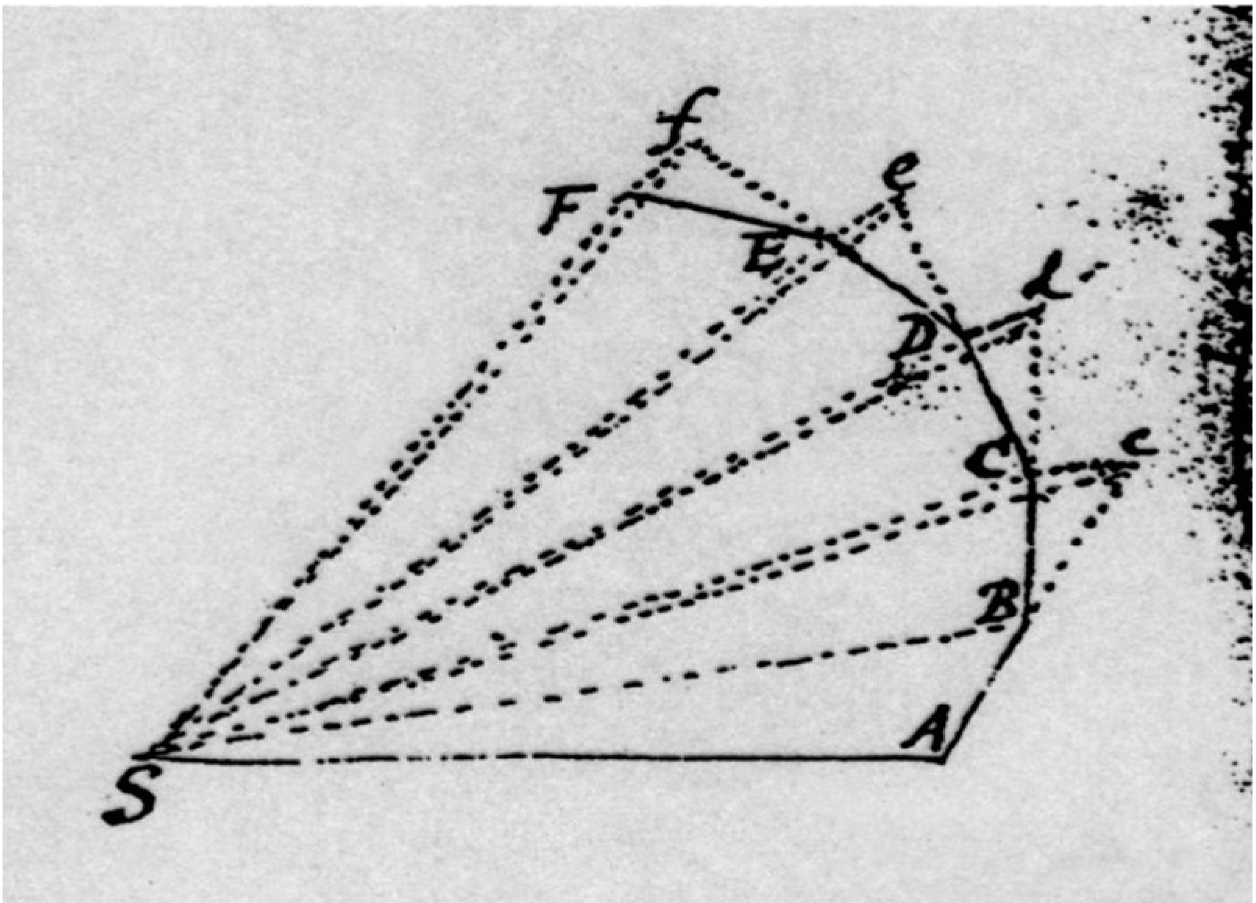

Figure 2: De Motu's diagram associated with Newton's proof showing the construction of a discrete orbit.

In his memoir, Hooke said that he already suggested in 1666 that the motion of planets around the sun can be understood by the "inflection of a direct motion [inertial motion] into a curve by a supervening attractive principle," the gravitational attraction of the sun. (Hooke 1686) In his monography of 1674, Hooke stated the assumption of universal gravitation law as well:

> "all celestiall bodys whatsoever have an attraction or a gravitating power towards their own Centers, whereby they attract not only their own parts, & keep them from flying from them, as we may observed the Earth to do, but that they do also attract all the other Celestiall Bodies which are within the sphere of their activity.",

assuming that

> "... not only the Sun and Moon have an influence upon the body and motion of the Earth and the Earth upon them, but that Mercury, also Venus, Mars, Saturn and Jupiter by their attractive

> powers, have considerable influence upon its motion as in the same manner the corresponding attractive power of the Earth hath a considerable influence upon every one of their motions also."2 (Hooke 1686)

Newton's defense

Newton denied that Hooke had to be credited as the author of the idea. Among the reasons, Newton reminded that the idea was discussed with Sir Christopher Wren before Hooke's letter of 1679. (Newton 1960)

Newton said that even if he had previously heard of Hooke's inverse proportion, he would still have certain rights in his demonstrations with accuracy. Hooke, without evidence in support of his assumption, could only guess that the law of squares is roughly valid at great distances from the center.(Newton 1960)

In addition, the manuscripts written by Newton in the 1660s show that Newton himself, until 1669, came to evidence of the reverse-square relationship with the distance from the center. (Whiteside 1991)

On the other hand, Newton acknowledged in *Principia* Hooke's contribution along with other scientists: "yet am I not beholden to him for any light into that business but only for the diversion he gave me from my other studies to think on these things & for his dogmatism in writing as if he had found the motion in the Ellipsis, which inclined me to try it ..." (Newton 1960)

The controversy in the opinion of other contemporary scientists

A presentation of Hooke's 1674 monograph introducing the idea of universal gravity was included in the *Philosophical Transactions* (Royal Society 1775) and subsequently several letters

[2] This book is titled *The System of the World*, which are the same words Hooke used to introduce his theory of universal gravity into his 1674 tract, *An Attempt to Prove the Motion of the Earth by Observations*.

containing observations, including one of Huygens. But obviously, after the publication of *Principia* in 1687, Hooke's priority in proposing universal gravitation was forgotten.

After hearing about Hooke's request to acknowledge his priority, Newton removed the numerous references to Hooke in the *Principia* (Nauenberg 2005) In a letter to Halley, Newton said,

> "... he [Hooke] knew not how to go about it. Now is not this very fine? Mathematicians that find out, settle & and do all the business must content them- selves with being nothing but dry calculators & drudges & and another that does nothing but pretend & grasp at all things must carry away all the invention as well as those who were to follow him as of those that went before." (Newton 1960)

According to David Gregory, who visited Newton at Cambridge in 1694, "I saw a manuscript [written] before 1669 ... where all the foundations of his philosophy are laid down: namely the gravity of the Moon to the Earth, and of the planets to the Sun. And in fact all these even then are subject to calculation." (Herivel 1965) This manuscript shows that Newton had gone further than Hooke, rediscovering mathematical relationship that Huygens had been discovered earlier, but was not published until 1673. As Nauenberg noted further, in Newton's correspondence from 1686 with Halley, he rejected allegations that he learned about the inverse square dependence from Hooke, noting that "Mr. Hook without knowing what I have found since his letters to me, can know no more than the proportion was duplicate quam proxime [approximately] at great distances from the center, 8 only guessed it to be so accurately, & guess amiss in extending that proportion down to the very center.." (Newton 1960)

Newton used the word "guess" to indicate that Hooke did not provide any mathematical evidence for his assumption that "attraction always is in a duplicate proportion to the distance from the center reciprocally," as Hooke had written. (Nauenberg 2005) In a letter to Halley, Newton stressed that in this sense

"Theory I am plainly before Mr Hook. For he, about a year after [1673], in his Attempt to prove the Motion of the Earth, declared expressely that the degrees by which gravity decreased he had not then experimentally verified, that is he knew not how to gather it from phenomena, 8c therefore he there recomends it to the prosecution of others." (Newton 1960)

What the supporters of Isaac Newton say

Scientists from the seventeenth century have reasonably rejected Hooke's claim, but historians of science have not forgotten this controversy, continuing the debate today. The judgment Lohne quotes with Vavilov's approval states that in the seventeenth century only Newton could write the *Principia*; however, Hooke was the first to sketch his work, (Lohne 1960), but Hooke received more than he needed. (Westfall 1967) Due to the lack of demonstrations, historians were prone to interpret his words in light of Newton's demonstrations. (Koyré 1851)

Hooke was attacked on topics that were part of the Royal Society's ideology and which were defended by people like Boyle, Joseph Glanvill and Thomas Sprat.

What the supporters of Robert Hooke say

Hooke's friend, journalist John Aubrey, pleaded for Hooke's case, writing desperately to antiquarian Anthony à Wood, who then composed his theory of *Athenae Oxonies*. More recent papers by P. E. B. Jourdain, A. Koyré, J. Lohne, F. F. Centore, R. S. Westfall, H. Erlichson, O. Gal, J. Bennett and others, highlight Hooke's important contributions to gravity and planetary theory.

Hooke, considered as a "mechanical genius" rather than a scientist," (Gal 2002) was often at a social disadvantage to Newton, the noble theorist, (Vickers 1987) or Huygens. Hooke's inferior social status did not allow him to identify with "free and unconfin'd" gentlemen such as Boyle, for example. (Guicciardini 2005)

The mathematician and philosopher Newton seemed to many colleagues what Glanvill called a "dogmatist" who "betrays poverty and a narrowing of the spirit," and being "too confident in opinion," showing ""ill manners and immodesty." (Guicciardini 2005) (Bechler 1974)

Due to Pugliese's works and the interpretations offered by Michael Nauenberg, Hooke has now been re-evaluated as a good mathematician. (Pugliese 1989) (Nauenberg 2005)

Hooke can be understood, as Gal pointed out, only by placing his work on planetary theory in the broad context of his multiple interests. (Bennett 1986)

Schopenhauer noted that in Michaud's *Biographie universelle*, the article "Newton" contains the representation of the universe according to the law of gravitation, literally and in extenso, according to *An Attempt to Prove the Motion of the Earth from Observations* of Robert Hooke. The article states that the main idea, that gravitation extends to all the celestial bodies, had already been expressed in Borelli's *Theoria motus planetarum e causis physicis deducta*, 1666. Schopenhauer recognizes Hooke's contribution to the gravitational conception, and left Newton merely checking by means of calculations. According to this view, Hooke evolved as bad as Columbus: the continent is called "America," and gravity is called "Newton's theory" (Schopenhauer 2013)

Conclusions

As Nauenberg noted, the question remains, to what extent Newton inspired from his correspondence with Hooke in 1679. Newton's notebook, "*Waste book*", shows that in 1664 he was already analyzing the uniform circular motion by the action of a pulse sequence on a moving body to the center of the circular orbit. (Herivel 1965) If we consider this aspect, Newton had not learned the orbital approach of Hooke. (Westfall 1983, 383) But in his letter to Hooke on Nov. 28, Newton claimed he did not know that Hooke had similar views on the orbital movement, although he read Hooke's monograph in 1674. But without Hooke's ideas expressed in 1679, it is very likely that Newton would not have focused on gravity. (Nauenberg 2005)

The controversy remains, too, if Hooke's 1679 statement of "compounding the motions" helped Newton. However, several authors have stated that Newton has taken over many ideas from Hooke[3]. Unfortunately, most of Hooke's personal documents are destroyed or missing.

Many historians of the controversy between Hooke and Newton on the gravity law priority agreed with Newton's invectives to Hooke. But they also recognize that Hooke had a qualitative understanding of gravity as a cause of planetary movements, even though Newton was able to build a quantitative mathematical structure based on Hooke's hypothesis. Basically, it's an evolution in the elaboration of the universal gravity law, from Hooke's "simple intuition" to Newton's synthesis.

Eighteenth-century French mathematician Alexis-Claude Clairaut summed up this controversy: "the example of Hooke... show what a distance there is between a truth that is glimpsed and a truth that is demonstrated." (Nauenberg 2005)

[3] Excerpts from the discussion are exemplified in the following papers: N Guicciardini, "Reconsidering the Hooke-Newton Discussion on Gravitation: Recent Results," in Early Science and Medicine, 10 (2005), 511-517; (Guicciardini 2005) Ofer Gal, "The Invention of Celestial Mechanics", in Early Science and Medicine, 10 (2005), 529-534; (Gal 2005) M Nauenberg, "Hooke's and Newton's Contributions to the Early Development of Orbital Mechanics and Universal Gravitation," in Early Science and Medicine, 10 (2005), 518-528.(Nauenberg 2005)

Bibliography

Bechler, Zev. 1974. "Newton's 1672 Optical Controversies: A Study in the Grammar of Scientific Dissent." In *The Interaction Between Science and Philosophy*, edited by Yehuda Elkana and Samuel Sambursky, 115–142. Atlantic Highlands, N.J., Humanities Press.

Bennett, J. A. 1986. *The Mechanics' Philosophy and the Mechanical Philosophy*.

Bongaarts, Peter. 2014. *Quantum Theory: A Mathematical Approach*. https://books.google.com/books?id=Cc6lBQAAQBAJ&pg=PA11.

Chandrasekhar, Subrahmanyan. 2003. *Newton's Principia for the Common Reader*. Oxford University Press.

Gal. 2002. *Meanest Foundations*.

———. 2005. "The Invention of Celestial Mechanics." *Early Science and Medicine*, 529–34.

Guicciardini, Niccolo. 2005. "Reconsidering the Hooke-Newton Debate on Gravitation: Recent Results." *Early Science and Medicine* 10: 510–17. http://www.jstor.org/stable/4130420.

Gunther, R. T. 1920. *Early Science În Oxford*.

Herivel, John. 1965. *The Background to Newton's Principia*.

Hooke, Robert. 1674. "An Attempt to Prove the Motion of the Earth from Observations." http://echo.mpiwg-berlin.mpg.de/ECHOdocuView/ECHOzogiLib?mode=imagepath&url=/mpiwg/online/permanent/library/XXTBUC3U/pageimg.

———. 1686. "A True State of the Case and Controversy between Sr Isaak Newton and Dr Robert Hooke as the Priority of That Noble Hypothesis of Motion of Ye Planets about Ye Sun as Their Centers." In .

Koyré. 1851. "Gravitația Universală de La Kepler La Newton." *Arhivele Internationale de Istorie a Științelor*, 638–53.

Nauenberg, Michael. 2005. "Hooke's and Newton's Contributions to the Early Development of Orbital Dynamics and the Theory of Universal Gravitation." *Early Science and Medicine* 10: 518–28. http://www.jstor.org/stable/4130421.

Newton, Isaac. 1960. "Correspondence of Isaac Newton, Vol 2" 2: 431–48.

———. n.d. *Mathematical Principles*.

Pugliese, P.J. 1989. *Robert Hooke and the Dynamics of Motion in a Curved Path*.

Purrington, Robert D. 2009. *The First Professional Scientist: Robert Hooke and the Royal Society of London*. Springer. https://books.google.com/books?id=tJu97S3BtGIC&pg=PA168.

Royal Society. 1775. "Philosophical Transactions (1683-1775)." 1775. https://www.jstor.org/journal/philtran1683177.

Schopenhauer. 2013. "Schopenhauer on Newton and Hooke." *The Monist* 23: 439–45. http://www.jstor.org/stable/27900444.

Vickers, Brian. 1987. *English Science: Bacon to Newton*.

Westfall, Richard S. 1967. "Hooke and the Law of Universal Gravitation: A Reappraisal of a Reappraisal." *The British Journal for the History of Science* 3: 245-261-245-261. http://www.jstor.org/stable/4025050.

———. 1983. *Never at Rest: A Biography of Isaac Newton*. Cambridge University Press.

Whiteside, D. T. 1991. "The Pre-History of the 'Principia' from 1664 to 1686." *Notes and Records of the Royal Society of London*, 11–61.

Wilson, Curtis. 1989. *The Newtonian Achievement in Astronomy*.