Worksheet 14

TITLE Who Invented Calculus? Newton v. Leibniz: Math's Most Famous *Prioritätsstreit*
CURRENT READING: Katz §16 (pp. 543-575) Boyer & Merzbach (pp 358-372, 382-389)

SUMMARY
We will analyze the debate over who should get credit for the invention of Calculus: Isaac Newton or Gottfried Leibniz.

Who Invented Calculus?
Modern historians now almost universally agree that both Newton and Leibniz should get credit for developing the mathematical topic we now regard as the calculus. There's no question that Newton developed his version first, in 1666 but that Leibniz published his version first, in 1684.

Katz (p. 574-575) on the Newton-Leibniz *Prioritätsstreit*

It should be clear that although the two men discovered essentially the same rules and procedures that today are collectively called the calculus, their approaches to the subject were entirely different. Newton's approach was through the ideas of velocity and distance while Leibniz's was through those of differences and sums. Nevertheless, since Newton's work was not published until the early eighteenth century, although it was well known in England much earlier, the successes of Leibniz and the Bernoulli brothers in applying their version caused certain English mathematicians to accuse Leibniz of plagiarism, particularly because he had read some of Newton's material during his brief visits to London in the 1670s and had received two letters from Newton through Henry Oldenburg, the secretary of the Royal Society, in which Newton himself discussed some of his results. Conversely, precisely because Newton had not published, the Bernoullis accused Newton of plagiarism from Leibniz. In 1711, the Royal Society, of which Newton was then the president, appointed a commission to look into the charges. Naturally, the commission found Leibniz guilty as charged. The unfortunate result of the controversy was that the interchange of ideas between English and Continental mathematicians virtually ceased. As far as the calculus was concerned, the English all adopted Newton's methods and notation, while on the Continent, mathematicians used those of Leibniz. It turned out that Leibniz's notation and his calculus of differentials proved easier to work with. Thus, progress in analysis was faster on the Continent. To its ultimate detriment, the English mathematical community deprived itself for nearly the entire eighteenth century of the great progress.

The Leibniz-Newton Calculus Controversy (Wikipedia)

Newton claimed to have begun working on a form of calculus (which he called "the method of fluxions and fluents") in 1666, at the age of 23, but did not publish it except as a minor annotation in the back of one of his publications decades later (a relevant Newton manuscript of October 1666 is now published among his mathematical papers). Gottfried Leibniz began working on his variant of calculus in 1674, and in 1684 published his first paper employing it, "Nova Methodus pro Maximis et Minimis". L'Hôpital published a text on Leibniz's calculus in 1696 (in which he recognized that Newton's Principia of 1687 was "nearly all about this calculus"). Meanwhile, Newton, though he explained his (geometrical) form of calculus in Section I of Book I of the Principia of 1687 did not explain his eventual fluxional notation for the calculus in print until 1693 (in part) and 1704 (in full).

The Calculus Controversy (found at http://www.angelfire.com/md/byme/mathsample.html)

As the renowned author of *Principia* (1687) as well as a host of equally esteemed published works, it appears that Newton not only went much further in exploring the applications of calculus than Leibniz did, but he also ventured down a different road. Leibniz and Newton had very different views of calculus in that Newton's was based on limits and concrete reality, while Leibniz focused more on the infinite and the abstract (Struik, 1948). However, regardless of the divergent paths these two scholars chose to venture down, the question of who took the first step remained the primary issue of debate.

Unaware that Newton was reported to have discovered similar methods, Leibniz discovered "his" calculus in Paris between 1673 and 1676 (Ball, 1908). By 1676, Leibniz realized that he was onto something "big"; he just didn't realize that Newton was on to the same big discovery because Newton was remaining somewhat tight lipped about his breakthroughs. In fact, it was actually the delayed publication of Newton's findings that caused the entire controversy. Leibniz published the first account of differential calculus in 1684 and then published the explanation of integral calculus in 1686 (Boyer, 1968).

Newton did not publish his findings until 1687. Yet evidence shows that Newton discovered his theories of fluxional calculus in 1665 and 1666, after having studied the work of other mathematicians such as Barrows and Wallis (Struik, 1948). Evidence also shows that Newton was the first to establish the general method called the "theory of fluxions," was the first to state the fundamental theorem of calculus and was also the first to explore applications of both integration and differentiation in a single work (Struik, 1948). However, since Leibniz was the first to publish a dissertation on calculus, he was given the total credit for the discovery for a number of years. This later led, of course, to accusations of plagiarism being hurled relentlessly in the direction of Leibniz.

There was speculation that Leibniz may have gleaned some of his insights from two of Newton's manuscripts on fluxions, and that that is what sparked his understanding of calculus. Many believed that Leibniz used Newton's unpublished ideas, created a new notation and then published it as his own, which would obviously constitute plagiarism. The rumor that Leibniz may have seen some of Newton's manuscripts left little doubt in most people's minds as to whether or not Leibniz arrived at his conclusions independently. The rumor was, after all, believable because Newton had admittedly bounced his ideas off a handful of colleagues, some of who were also in close contact with Leibniz (Boyer, 1968).

It is also known that Leibniz and Newton corresponded by letter quite regularly, and they most often discussed the subject of mathematics (Boyer, 1968). In fact, Newton first described his methods, formulas and concepts of calculus, including his binomial theorem, fluxions and tangents, in letters he wrote to Leibniz (Ball, 1908). However an examination of Leibniz' unpublished manuscripts provided evidence that despite his correspondence with Newton, he had come to his own conclusions about calculus already. The letters may then have merely helped Leibniz to expand upon his own initial ideas.

The question of the date at which these extracts were made is therefore all important. It is known that a copy of Newton's manuscript had been sent to Tschirnhausen in May, 1675, and as in that year he and Leibniz were engaged together on a piece of work, it is not impossible that these extracts were made then. It is also possible that they may have been made in 1676, for Leibniz discussed the question of analysis by infinite series with Collins and Oldenburg in that year, and it is a priori probable that they would have then shown him the manuscript of Newton on that subject, a copy of which was possessed by one or both of them. On the other hand it may be supposed that Leibniz made the extracts from the printed copy in or after 1704. Leibniz shortly before his death admitted in a letter to Conti that in 1676 Collins had shown him some Newtonian papers, but implied that they were of little or no value, - presumably he referred to Newton's letters of June 13 and Oct. 24, 1676, and to the letter of Dec. 10, 1672, on the method of tangents, extracts from which accompanied the letter of June 13, - but it is remarkable that, on the receipt of these letters, Leibniz should have made no further inquiries, unless he was already aware from other sources of the method followed by Newton (Ball, 1908).

While Newton had many allies rallying in his favor, Leibniz had only one: John Bernoulli, who in a letter, tried to cast doubt upon Newton's credibility. When Bernoulli was later asked to comment on the letter, he denied ever writing it, which caused Newton to aver:

> I have never grasped at fame among foreign nations, but I am very desirous to preserve my character for honesty, which the author of that epistle, as if by the authority of a great judge, had endeavored to wrest from me. Now that I am old, I have little pleasure in mathematical studies, and I have never tried to propagate my opinions over the world, but I have rather taken care not to involve myself in disputes on account of them (Ball, 1908).

In 1715, just a year before Leibniz death, the Royal Society handed down their verdict crediting Sir Isaac Newton with the discovery of calculus. It was also stated that Leibniz was guilty of plagiarism because of certain letters he was supposed to have seen (Ball, 1908). It later became known that these accusations were false, and both men were then given credit, but not until after Leibniz had already died. In fact, the controversy over who really deserved the credit for discovering calculus continued to rage on long after Leibniz' death in 1716 (Struik, 1948).

Newton and his associates even tried to get the ambassadors of the London diplomatic corps to review his old manuscripts and letters, in the hopes that they would endorse the finding of the Royal Society that Leibniz had plagiarized his findings regarding calculus. Another argument on the side promoting the idea of Leibniz as a plagiarist was the fact that he used an alternate set of symbols. Leibniz specifically set out to develop a more meticulous notation system than Newton's, and he developed the integral sign ($\int$) and the 'd' sign, which are still used today (O'Connor, 1996). However this action was argued by many to be merely a way for Leibniz to "cover his tracks" so as not to get accused of stealing Newton's material (Boyer, 1968). The fact that the method was more efficient was considered to be an ancillary benefit. The fact is that Leibniz sent letters to Newton outlining his own presentation of his own methods, and these letters focused quite stringently upon the subject of tangents and curves. Because Newton had been approaching calculus primarily in regards to its applications to physics, he purported curves to be the creation of the motion of points while perceiving velocity to be the primary derivative. Conversely, the calculus of Leibniz was applied more to discoveries in geometry made by scholars such as Descartes and Pascal. Since "Leibniz' approach was geometrical," the notation of the differential calculus and many of the general rules for calculating derivatives are still used today, while Newton's approach, which has in many aspects, fallen by the wayside, was "primarily cinematical" (Struik, 1948).

Despite the ruling of the Royal Society, mathematics throughout the eighteenth century was typified by an elaboration of the differential and integral calculus in which mathematicians generally discarded Newton's fluxional calculus in favor of the new methods presented by Leibniz. Nevertheless, in England, the controversy was viewed as an attempt to pilfer Newton's glory simply because of international egotism. Consequently, as a matter of "national pride," England refused to teach anything but Newton's discoveries of geometrical and fluxional methods for over a century. So while other countries were integrating various findings that occurred over time and were progressing in their discoveries, England remained essentially stagnant in the realm of mathematic discovery. In fact, it wasn't until 1820 that England finally agreed to recognize the work of mathematicians from any other countries (Ball, 1908).

With modern controversies covering such volatile topics as abortion and gun control, a debate over who discovered calculus may seem somewhat trivial by contemporary standards. However at the time, this was a serious issue that not only involved matters of mathematical discovery but also matters of national pride and allegiance. What is important to keep in perspective is that no matter who actually discovered calculus first, both Newton and Leibniz made great contributions to the advancement of mathematical processes, and both deserve credit for that.

Works Cited

Ball, Rouse. A Short Account of the History of Mathematics'. 4th edition, 1908

Boyer, Carl. A History of Mathematics: 2nd Edition. New York, New York: John Wiley and Sons, 1968

O'Connor, John J. The Rise of Calculus. St Andrews, Scotland, 1996.

Struik, Dirk. A Concise History of Mathematics. New York, New York: Dover Publications, Inc., 1948