Newton's Calculus

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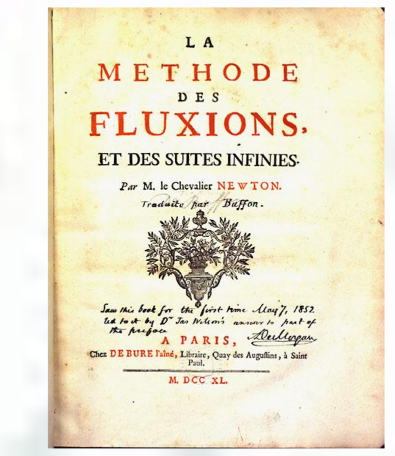

Abstract

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This research project is an exploration of Isaac Newton's life, the mathematical advances leading up to calculus, Newton's formulation of calculus, and the Calculus Controversy. Newton was a very intelligent man who made a lot of mathematical and scientific advances. His creation of calculus was not only due to his mathematical genius, but the synthesis of many pieces that other mathematicians had worked on before Newton. These mathematicians had come close to discovering calculus, but did not have the foresight that Newton had to combine all of the information cohesively. Unfortunately, Newton had a habit of delaying the publishing of his works to avoid controversy, which ironically led to one of the biggest controversies in the history of mathematics. Although Newton developed and wrote down his ideas much earlier, Gottfried Wilhelm Leibniz published his own version of calculus before Newton. Since it was unclear as to whether or not Leibniz had read Newton's work, there was a question of plagiarism. But the main debate was of priority - which would receive the credit for discovering calculus?

Isaac Newton's Life

- **Born in Woolsthorpe, Lincolnshire, England on December 25, 1642 (or Janary 4, 1643 by corrected calendar)**
- **Poor farmer's son**
- **Poor family life**
- **Attended Free Grammar School in Grantham, England**
  - **"idle" and "inattentive"**
- **Studied law at Trinity College Cambridge (1661)**
- **Studied math on his own, mastering *Elements*, *Clavis Mathematica*, and *La Geometrie***
- **Studied under Isaac Barrow**
- **Became Lucasian chair at Cambridge (1663)**
- **Developed calculus at home while avoiding the plague (1666)**
- **Wrote his method of fluxions (1671)**
- **Elected in Royal Society (1672)**
- **Elected as President of Royal Society (1703)**
- **Calculus controversy**
- **Passed away (1727)**

Mathematical advances leading up to calculus

Newton - "If I have seen farther than others, it is because I have stood on the shoulders of giants" (Burton).

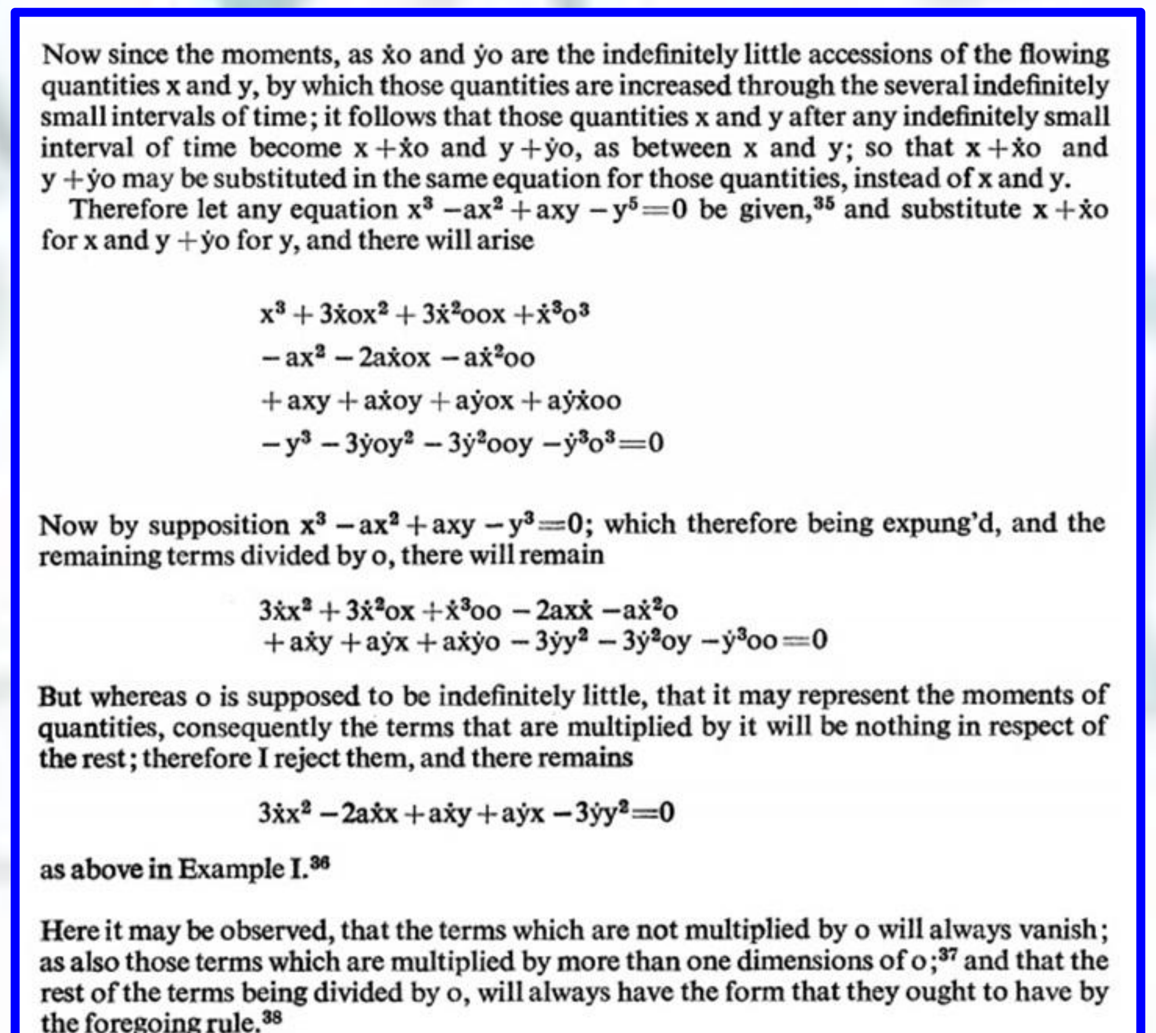
- Greek Mathematicians
  - Method of Exhaustion
    - Leucippus, Democritus, Antiphon, Eudoxus, Archimedes
- Archimedes
  - Volumes and surface areas of 3-D shapes
    - "integration"
- Fermat
  - Max and min for parabola
- Descartes and Hudde
  - Normals to curves
- Barrow
  - Passed on his work – very close to calculus – to his student Newton

Newton's Calculus

***De Method is Serierum et Fluxionum* (1671)**

- ***Fundamental Theorem of Calculus***
- ***Variables changing in relation to time***
- ***Implied the inverse relationship between integration and differentiation***
- ***Geometrical***
- ***Poor notation***
- ***Written for elite mathematicians***
- ***Accepted in England***
- ***Not accepted on the continent***

The following is how Newton took a derivative:



Now since the moments, as $\dot{x}o$ and $\dot{y}o$ are the indefinitely little accessions of the flowing quantities x and y, by which those quantities are increased through the several indefinitely small intervals of time; it follows that those quantities x and y after any indefinitely small interval of time become $x+\dot{x}o$ and $y+\dot{y}o$, as between x and y; so that $x+\dot{x}o$ and $y+\dot{y}o$ may be substituted in the same equation for those quantities, instead of x and y.

Therefore let any equation $x^3-ax^2+axy-y^5=0$ be given,[35] and substitute $x+\dot{x}o$ for x and $y+\dot{y}o$ for y, and there will arise

$$\begin{aligned}&x^3+3\dot{x}ox^2+3\dot{x}^2oox+\dot{x}^3o^3\\&-ax^2-2a\dot{x}ox-a\dot{x}^2oo\\&+axy+a\dot{x}oy+a\dot{y}ox+a\dot{y}\dot{x}oo\\&-y^3-3\dot{y}oy^2-3\dot{y}^2ooy-\dot{y}^3o^3=0\end{aligned}$$

Now by supposition $x^3-ax^2+axy-y^3=0$; which therefore being expung'd, and the remaining terms divided by o, there will remain

$$\begin{aligned}&3\dot{x}x^2+3\dot{x}^2ox+\dot{x}^3oo-2ax\dot{x}-a\dot{x}^2o\\&+a\dot{x}y+a\dot{y}x+a\dot{x}\dot{y}o-3\dot{y}y^2-3\dot{y}^2oy-\dot{y}^3oo=0\end{aligned}$$

But whereas o is supposed to be indefinitely little, that it may represent the moments of quantities, consequently the terms that are multiplied by it will be nothing in respect of the rest; therefore I reject them, and there remains

$$3\dot{x}x^2-2a\dot{x}x+a\dot{x}y+a\dot{y}x-3\dot{y}y^2=0$$

as above in Example I.[36]

Here it may be observed, that the terms which are not multiplied by o will always vanish; as also those terms which are multiplied by more than one dimensions of o;[37] and that the rest of the terms being divided by o, will always have the form that they ought to have by the foregoing rule.[38]

Footnote 35 – the power of y was probably supposed to be to the third instead of to the fifth

Note – today's notation is *x'* instead of "x dot"

Calculus Controversy

- 1666 - Newton informally wrote his calculus (unpublished)
- 1671 – Newton formally wrote his calculus in *De Methodis Serierum et Fluxionum* (unpublished until after his death)
- 1673 – Gottfried Wilhelm von Leibniz elected into Royal Society of which Newton is president
- 1674 – correspondence between Leibniz and Newton began
- 1684 – Leibniz published his own calculus in *Nova Methodus Pro Maximis et Minimis, itemquie Tangentibus*
- 1703 – Newton created biased committee in Royal Society to investigate
  - Reported Newton was first to discover; ambiguous whether Leibniz plagiarized
- 1736 – Newton's calculus was published

- **Looking Back:**
- Newton's and Leibniz's versions were so different, Leibniz most likely created his own separately from Newton
- Newton discovered calculus first

Conclusion

Sir Isaac Newton was a great mathematical mind, and although he was not the only one to discover calculus, he was the first and will always be remembered as such. His achievements stretch beyond calculus to science and astronomy (Burton,), but he will always be known for discovering calculus. It is interesting that a poor farmer's son who seemed not to care about school would become such a great figure in academia. Thankfully, all of the right people stepped in and recognized his potential which led him to develop calculus.

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