Leonhard Euler (1707 – 1783)

From Wikipedia, the free encyclopedia,
http://en.wikipedia.org/wiki/Leonhard_Euler

Euler was a pioneering Swiss mathematician and physicist. He made important discoveries in fields as diverse as infinitesimal calculus and graph theory. He also introduced much of the modern mathematical terminology and notation, particularly for mathematical analysis, such as the notion of a mathematical function. He is also renowned for his work in mechanics, fluid dynamics, optics, and astronomy.

Euler spent most of his adult life in St. Petersburg, Russia, and in Berlin, Prussia. He is considered to be the preeminent mathematician of the 18th century, and one of the greatest of all time. He is also one of the most prolific mathematicians ever; his collected works fill 60 -80 quarto volumes. A statement attributed to Pierre-Simon Laplace expresses Euler's influence on mathematics: "Read Euler, read Euler, he is the master of us all."

Euler was born on April 15, 1707, in Basel to Paul Euler, a pastor of the Reformed Church. His mother was Marguerite Brucker, a pastor's daughter. He had two younger sisters named Anna Maria and Maria Magdalena. Soon after the birth of Leonhard, the Eulers moved from Basel to the town of Riehen, where Euler spent most of his childhood. Paul Euler was a friend of the Bernoulli family - Johann Bernoulli, who was then regarded as

Europe's foremost mathematician, would eventually be the most important influence on young Leonhard. Euler's early formal education started in Basel, where he was sent to live with his maternal grandmother. At the age of thirteen he enrolled at the University of Basel, and in 1723, received his Master of Philosophy with a dissertation that compared the philosophies of Descartes and Newton. At this time, he was receiving Saturday afternoon lessons from Johann Bernoulli, who quickly discovered his new pupil's incredible talent for mathematics. Euler was at this point studying theology, Greek, and Hebrew at his father's urging, in order to become a pastor, but Bernoulli convinced Paul Euler that Leonhard was destined to become a great mathematician. In 1726, Euler completed a dissertation on the propagation of sound with the title De Sono. At that time, he was pursuing an (ultimately unsuccessful) attempt to obtain a position at the University of Basel. In 1727, he entered the Paris Academy Prize Problem competition, where the problem that year was to find the best way to place the masts on a ship. He won second place, losing only to Pierre Bouguer -a man now known as "the father of naval architecture". Euler subsequently won this coveted annual prize twelve times in his career.

Around this time Johann Bernoulli's two sons, Daniel and Nicolas, were working at the Imperial Russian Academy of Sciences in St Petersburg. On July 10, 1726, Nicolas died of appendicitis after spending a year in Russia, and when Daniel assumed his brother's position in the mathematics/physics division, he recommended that the post in physiology that he had vacated be filled by his friend Euler. In November 1726 Euler eagerly accepted the offer, but delayed making the trip to St Petersburg while he unsuccessfully applied for a physics professorship at the University of Basel.

Euler arrived in the Russian capital on 17 May 1727. He was promoted from his junior post in the medical department of the academy to a position in the mathematics department. He lodged with Daniel Bernoulli with whom he often worked in close collaboration. Euler mastered Russian and settled into life in St Petersburg. He also took on an additional job as a medic in the Russian Navy.

The Academy at St. Petersburg, established by Peter the Great, was intended to improve education in Russia and to close the scientific gap with Western Europe. As a result, it was made especially attractive to foreign scholars like Euler. The academy possessed ample financial resources and a comprehensive library drawn from the private libraries of Peter himself and of the nobility. Very few students were enrolled in the academy in order to lessen the faculty's teaching burden, and the academy emphasized research and offered to its faculty both the time and the freedom to pursue scientific questions.

The Academy's benefactress, Catherine I, who had continued the progressive policies of her late husband, died on the day of Euler's arrival. The Russian nobility then gained power upon the ascension of the twelve-year-old Peter II. The nobility were suspicious of the academy's foreign scientists, and thus cut funding and caused other difficulties for Euler and his colleagues.

Conditions improved slightly upon the death of Peter II, and Euler swiftly rose through the ranks in the academy and was made professor of physics in 1731. Two years later, Daniel Bernoulli, who was fed up with the censorship and hostility he faced at St. Petersburg, left for Basel. Euler succeeded him as the head of the mathematics department.

On 7 January 1734, he married Katharina Gsell (1707 _1773), a daughter of Georg Gsell, a painter from the Academy Gymnasium. The young couple bought a house by the Neva River. Of their thirteen children, only five survived childhood.

Concerned about the continuing turmoil in Russia, Euler left St. Petersburg on 19 June 1741 to take up a post at the Berlin Academy, which he had been offered by Frederick the Great of Prussia. He lived for twenty-five years in Berlin, where he wrote over 380 articles. In Berlin, he published the two works which he would be most renowned for: the Introductio in analysin infinitorum, a text on functions published in 1748, and the Institutiones calculi differentialis, published in 1755 on differential calculus. In 1755, he was elected a foreign member of the Royal Swedish Academy of Sciences.

In addition, Euler was asked to tutor the Princess of Anhalt-Dessau, Frederick's niece. Euler wrote over 200 letters to her, which were later compiled into a best-selling volume entitled Letters of Euler on different Subjects in Natural Philosophy Addressed to a German Princess. This work contained Euler's exposition on various subjects pertaining to physics and mathematics, as well as offering valuable insights into Euler's personality and religious beliefs. This book became more widely read than any of his mathematical works, and it was published across Europe and in the United States. The popularity of the 'Letters' testifies to Euler's ability to communicate scientific matters effectively to a lay audience, a rare ability for a dedicated research scientist.

Despite Euler's immense contribution to the Academy's prestige, he was eventually forced to leave Berlin. This was partly because of a conflict of personality with Frederick, who came to regard Euler as unsophisticated, especially in comparison to the circle of philosophers the German king brought to the Academy. Voltaire was among those in Frederick's employ, and the Frenchman enjoyed a prominent position in the king's social circle. Euler, a simple religious man and a hard worker, was very conventional in his beliefs and tastes. He was in many ways the direct opposite of Voltaire. Euler had limited training in rhetoric, and tended to debate matters that he knew little about, making him a frequent target of Voltaire's wit. Frederick also expressed disappointment with Euler's practical engineering abilities:

"I wanted to have a water jet in my garden: Euler calculated the force of the wheels necessary to raise the water to a reservoir, from where it should fall back through channels, finally spurting out in Sanssouci. My mill was carried out geometrically and could not raise a mouthful of water closer than fifty paces to the reservoir. Vanity of vanities! Vanity of geometry!"

Euler's eyesight worsened throughout his mathematical career. Three years after suffering a near-fatal fever in 1735 he became nearly blind in his right eye, but Euler rather blamed his condition on the painstaking work on cartography he performed for the St. Petersburg Academy. Euler's sight in that eye worsened throughout his stay in Germany, so much so that Frederick referred to him as "Cyclops". Euler later suffered a cataract in his good left eye, rendering him almost totally blind a few weeks after its discovery in 1766. Even so, his condition appeared to have little effect on his productivity, as he compensated for it with his mental calculation skills and photographic memory. For example, Euler could repeat the Aeneid of Virgil from beginning to end without hesitation, and for every page in the edition he could indicate which line was the first and which the last. With the aid of his scribes, Euler's productivity on many areas of study actually increased. He produced on average one mathematical paper every week in the year 1775.

The situation in Russia had improved greatly since the accession to the throne of Catherine the Great, and in 1766 Euler accepted an invitation to return to the St. Petersburg Academy and spent the rest of his life in Russia. His second stay in the country was marred by tragedy. A fire in St. Petersburg in 1771 cost him his home, and almost his life. In 1773, he lost his wife Katharina after 40 years of marriage. Three years after his wife's death Euler married her half sister, Salome Abigail Gsell (1723 _1794). This marriage lasted until his

death.

In St Petersburg on 18 September 1783, after a lunch with his family, during a conversation with a fellow academician Anders Johan Lexell about the newly-discovered Uranus and its orbit, Euler suffered a brain hemorrhage and died a few hours later. A short obituary for the Russian Academy of Sciences was written by Jacob von Shtelin and a more detailed eulogy was written and delivered at a memorial meeting by Russian mathematician Nicolas Fuss, one of the Euler's disciples. In the eulogy written for the French Academy by the French mathematician and philosopher Marquis de Condorcet, he commented,

> "...il cessa de calculer et de vivre _... he ceased to calculate and to live."

He was buried next to Katharina at the Smolensk Lutheran Cemetery on Vasilievsky Island. In 1785, the Russian Academy of Sciences put a marble bust of Leonhard Euler on a pedestal next to the Director's seat and, in 1837, placed a headstone on Euler's grave. To commemorate the 250th anniversary of Euler's birth, the headstone was moved in 1956, together with his remains, to the 18th-century necropolis at the Alexander Nevsky Monastery.

Euler worked in almost all areas of mathematics: geometry, infinitesimal calculus, trigonometry, algebra, and number theory, as well as continuum physics, lunar theory and other areas of physics. He is a seminal figure in the history of mathematics; if printed, his works, many of which are of fundamental interest, would occupy between 60 and 80 quarto volumes. Euler's name is associated with a large number of topics.

Euler introduced and popularized several notational conventions through his numerous and widely circulated textbooks. Most notably, he introduced the concept of a function and was the first to write f(x) to denote the function f applied to the argument x. He also introduced the modern notation for the trigonometric functions, the letter e for the base of the natural logarithm (now also known as Euler's number), the Greek letter $\sum$ for summations and the letter i to denote the imaginary unit. The use of the Greek letter π to denote the ratio of a circle's circumference to its diameter was also popularized by Euler, although it did not originate with him.

The development of infinitesimal calculus was at the forefront of 18th Century mathematical research, and the Bernoullis -family friends of Euler- were responsible for much of the early progress in the field. Thanks to their influence, studying calculus became the major focus of Euler's work. While some of Euler's proofs are not acceptable by modern standards of mathematical rigour (in particular his reliance on the principle of the generality of algebra), his ideas led to many great advances. Euler is well known in analysis for his frequent use and development of power series, the expression of functions as sums of infinitely many terms.

Euler introduced the use of the exponential function and logarithms in analytic proofs. He discovered ways to express various logarithmic functions using power series, and he successfully defined logarithms for negative and complex numbers, thus greatly expanding the scope of mathematical applications of logarithms. He also defined the exponential function for complex numbers, and discovered its relation to the trigonometric functions.

In addition, Euler elaborated the theory of higher transcendental functions by introducing the gamma function and introduced a new method for solving quartic equations. He also found a way to calculate integrals with complex limits, foreshadowing the development of modern complex analysis. He also invented the calculus of variations including its best-known result, the Euler-Lagrange equation.

Euler also pioneered the use of analytic methods to solve number theory problems. In doing so, he united two disparate branches of mathematics and introduced a new field of study, analytic number theory. In breaking ground for this new field, Euler created the theory of hypergeometric series, q-series, hyperbolic trigonometric functions and the analytic theory of continued fractions. For example, he proved the infinitude of primes using the divergence of the harmonic series, and he used analytic methods to gain some understanding of the way prime numbers are distributed. Euler's work in this area led to the development of the prime number theorem.

Some of Euler's greatest successes were in solving real-world problems analytically, and in describing numerous applications of the Bernoulli numbers, Fourier series, Venn diagrams, Euler numbers, the constants e and π, continued fractions and integrals. He integrated Leibniz's differential calculus with Newton's Method of Fluxions, and developed tools that made it easier to apply calculus to physical problems. He made great strides in improving the numerical approximation of integrals, inventing what are now known as the Euler approximations. The most notable of these approximations are Euler's method and the Euler-Maclaurin formula.

Euler helped develop the Euler-Bernoulli beam equation, which became a cornerstone of engineering. Aside from successfully applying his analytic tools to problems in classical mechanics, Euler also applied these techniques to celestial problems. His work in astronomy was recognized by a number of Paris Academy Prizes over the course of his career. His accomplishments include determining with great accuracy the orbits of comets and other celestial bodies, understanding the nature of comets, and calculating the parallax of the sun. His calculations also contributed to the development of accurate longitude tables.

In addition, Euler made important contributions in optics. He disagreed with Newton's corpuscular theory of light in the Opticks, which was then the prevailing theory. His 1740s papers on optics helped ensure that the wave theory of light proposed by Christian Huygens would become the dominant mode of thought, at least until the development of the quantum theory of light.

In 1757 he published an important set of equations for inviscid flow, that are now known as the Euler equations.

Euler has an extensive bibliography. His best known books include:

Elements of Algebra. This elementary algebra text starts with a discussion of the nature of numbers and gives a comprehensive introduction to algebra, including formulae for solutions of polynomial equations.

Introductio in analysin infinitorum (1748). English translation Introduction to Analysis of the Infinite by John Blanton (Book I, ISBN 0-387-96824-5, Springer-Verlag 1988; Book II, ISBN 0-387-97132-7, Springer-Verlag 1989).

Two influential textbooks on calculus: Institutiones calculi differentialis (1755) and Institutionum calculi integralis (1768 _1770).

Lettres à une Princesse d'Allemagne (Letters to a German Princess) (1768 -1772). Available online (in French). English translation, with notes, and a life of Euler, available online from Google Books: Volume 1, Volume 2

Methodus inveniendi lineas curvas maximi minimive proprietate gaudentes, sive solutio problematis isoperimetrici latissimo sensu accepti (1744). The Latin title translates as a method for finding curved lines enjoying properties of maximum or minimum, or solution of isoperimetric problems in the broadest accepted sense.

A definitive collection of Euler's works, entitled Opera Omnia, has been published since 1911 by the Euler Commission of the Swiss Academy of Sciences.