DANIEL BERNOULLI

The Bernoulli family of Switzerland played a leading part in the development of the calculus and its applications in the seventeenth and eighteenth centuries. Founded by Nicolaus Bernoulli, a shrewd merchant, this dynasty produced in three generations, eight mathematicians, who in turn produced progeny who achieved eminence in law, scholarship, science and literature. Most of the mathematicians worked mainly in applied mathematics and analysis, and among their greatest talents was the ability to stir up an unfortunate rivalry and vigorous quarrels with each other. Today's subject is far the ablest of the younger Bernoullis, **Daniel Bernoulli** (February 8, 1700 – March 17, 1782), the second son of Johann Bernoulli, and nephew of Jacob Bernoulli.

Daniel Bernoulli, who became a pioneer in hydrodynamics and the kinetic theory of gases, was born in Groningen, where his father held the chair of mathematics at the University. At the age of 13 he was sent to Basel to study philosophy and logic. Having learned nothing from his resistance to his own father's desire to have him enter the business profession, Johann was intent on mapping out Daniel's life. Johann pushed his son in the direction of becoming a merchant by trying to place Daniel in an apprenticeship. Daniel resisted and Johann eventually relented. He would not have to become a merchant, but he wasn't allowed to pursue the study of mathematics, because there was no money in mathematics. So Daniel was sent back to Basel to study medicine. Finally it became clear to Johann that his son not only had a passionate interest in mathematics but he also seemed to have inherited the family's talent for it; so he began to tutor Daniel in the methods of calculus and his theories of kinetic energy. In 1720, Daniel completed his doctorate in medicine, writing a dissertation in which he applied mathematical physics to the mechanics of breathing.

By 1723, Daniel was in Padua, Italy. To pass the time while recovering from an illness, he invented a ship's hourglass that accurately measured one hour's time with a flow of sand. The hourglass worked even if it was not perfectly level, as it would be during storms. In 1725, Catherine I appointed Daniel and his brother Nicolaus to positions with the Imperial Academy of St. Petersburg. Nicolaus died of tuberculosis the next year. While in Russia, Daniel investigated a problem now known as the "St. Petersburg Paradox." The St. Petersburg game is played by flipping a fair coin until it shows a head for the first time. If the first occurrence of a head is on the first toss, the player wins $2, if on the second toss, $4, on the third, $8, and so on, the payoff doubling each time. The question is how much should a player be willing to risk playing the game? It turns out that the expected value of the game is infinite. Later investigators of the paradox have concluded that since the expected value of the game is infinity, then for it to be a fair game the price of playing should be infinite.

Finding Russia primitive, Daniel considered returning to Switzerland, but stayed when his father suggested that one of his own students, Leonhard Euler, would make a worthy assistant in his research. The two discovered the relationship between the speed at which blood flows and its pressure. Bernoulli experimented by puncturing the wall of a pipe with a small open ended straw and observed that the height to which the fluid rose in the straw was related to the fluid's pressure in the pipe. In this way he found the law that a moving fluid exchanges its kinetic energy for pressure. This principle, now named for him, is used in designing wings of airplanes in such a way as to create a fast flowing air current above its surface. The pressure of this area of the plane's surface is lower and so the wing is sucked upwards. Bernoulli's principle also has been used to explain how a baseball curves when thrown with spin. It curves because one side of the ball experiences a reduced pressure. The seams and roughness of the baseball are important. If the ball were perfectly smooth, there would not be enough interaction with the air to make it curve.

In the meantime, Johann received much acclaim for his mathematical and scientific work. Unfortunately, unbeknownst to Daniel, both father and son submitted an entry for the Grand Prize of the Paris Academy for 1734. They were declared joint winners, which did not sit well with Johann. When Daniel returned to Basel in 1734, Johann was not ready to admit that his son was at least his equal, and so banned him from his house. It took Daniel three years to complete his work on fluids, *Hydrodynamica.* Apparently in an attempt to mend the rift between himself and his father, he had inscribed on the book's frontispiece "by Daniel Bernoulli, Son of Johann." The ploy didn't work and a year later Johann published his own work called *Hydraulics*, which seemed a blatant plagiarism of his son's work.

After that Daniel Bernoulli lost interest in pure mathematics and, in 1750, he was appointed to the chair of physics at Basel, where he taught for 26 years. He won the Grand Prix of the Paris Academy of Sciences on 10 occasions, for topics ranging from astronomy to nautical matters. He wrote a number of papers on various mechanical questions, including problems connected with vibrating strings. He showed that the movements of strings of musical instruments consist of an infinite number of harmonic vibrations. Bernoulli died in Basel at the age of 82.

Quotation of the Day: "… it would be better for the true physics if there were no mathematicians on earth." – Daniel Bernoulli (perhaps showing his frustration with his mathematician father, Johann)