

## Constantin Carathéodory

While the names of ancient Greek mathematicians are well known, one might wonder who among those of Greek heritage is considered the greatest modern Greek mathematician. Surely, that honor should go to **Constantin Carathéodory** (September 13, 1873 – December 2, 1950).



He made important contributions to the calculus of variations, the theory of real functions, conformal representations, the theory of point-set measure, thermodynamics and special relativity. He inherited a talent for languages and though Greek and French were his first languages, he also mastered German, English, Italian, and Turkish. The Greek language was exclusively spoken in his home, and although the children attended German schools, a priest tutored them in Greek language and culture.

Carathéodory was quite famous during his lifetime, but a half-century after his death, he has been largely forgotten. He was born in Berlin in 1873, the son of a Turkish diplomatic attaché. The next year his family returned to Constantinople, but in 1875 they were on the move again when his father became the Turkish ambassador to Brussels. Constantin attended school in Brussels before entering a French high school, *Athéné Royal d'Ixelles* in 1886. It was there that he discovered his love of mathematics. After graduation he enrolled at the *École Militaire de Belgique*, a type of military cadet institute. During his four years there, he studied engineering, but augmented this with projective geometry, mechanics and thermodynamics. In 1895 he made his way to Mytilene, the seaport capital of Lesbos, where he assisted his engineer cousin in planning the streets of Samos. Before the project could be completed, it was interrupted by the Greek-Turkish war of 1896-97. Carathéodory first went to London

and then to Egypt where he spent two years as an assistant engineer working on the construction of dams along the Nile. Despite the heavy demands of his work he found time to read mathematics during the evenings. By 1900 he had decided to give up his secure and promising position as an engineer and return to school to study mathematics. His family and friends were horrified by his decision, but the family's motto was "No effort too great" and during his life as a mathematician Carathéodory certainly lived up to it.

entered the University of Berlin in May of 1900 where he attended the lectures of Ferdinand Frobenius, but he was most interested in the work of Hermann Schwarz, who had succeeded Karl Weierstrass. Carathéodory studied with Felix Klein and David Hilbert at Göttingen, receiving his doctorate in 1904 for a thesis "Discontinuous Solutions in the Calculations of Variations" under the direction of Hermann Minkowski. Carathéodory spent five years as a lecturer at Göttingen, followed by positions at Bonn, the Technische Hochschule in Hanover, and the newly founded Technische Hochschule at Breslau. In 1913 he succeeded Klein at Göttingen, remaining there until 1918 when he received an offer to go to Berlin. In 1920 the Greek government wanted to start a university in Smyrna (now Izmir in Turkey) and Carathéodory was given *carte blanche* to structure it as he saw fit. He hoped to unify oriental and occidental thought in a unique university but, after two years, the Turks invaded Smyrna. Carathéodory sent his wife and two children to Samos while he remained in Smyrna during the siege. Despite the threat to his life, he remained cool and was able to transport himself and the university library to safety in Athens.

Carathéodory taught at the University of Athens and the technical school until 1924 when he succeeded Ferdinand Lindemann as professor of mathematics at the University of Munich. Except for a brief period in 1930 when he once again answered the call of the Greek government to help reorganize the universities of Athens and Saloniki, he remained at Munich for the rest of his life. During the reign of

the Nazis in Germany, he became something of a recluse. Due to his contacts all over the world he was able to help some of his “non-Arian” colleagues leave the country for a new beginning in the free world. In December 1949 Carathéodory gave his last talk at the Munich mathematical colloquium. He became seriously ill soon afterwards and died on February 2, 1950. Among his books are *Theory of Functions*, *Algebraic Theory of Measure & Integration*, and *Advances in Convex Analysis & Global Optimization*.

‘s interest in problems in variational calculus, his special love, was stimulated by a lecture of Hans Hahn. ‘s *Calculus of Variations and Partial Differential Equations of the First Order* is a classic in the field. The ancient Egyptians empirically knew that the shortest path between two points is a straight line and that the circle is the geometrical figure with the greatest enclosed area inside a given perimeter. Archimedes later proved the first notion and Zenodoros proved the second. Newton was the first to publish a result in the field of by seeking the shape of a body moving in the air that would meet with minimum resistance. The calculus of variations started as a new branch of mathematics in the 17<sup>th</sup> century when the brothers Bernoulli sought the path that takes the shortest time for a small body moving under the influence of gravity along a given curve from one point to another to transverse it. formulated similar problems as differential equations.

reformulated the second law of thermodynamics in terms of differential forms. The second law of thermodynamics states that in any closed system the *entropy* (a term introduced by Rudolf Clausius) must either increase or remain constant. Roughly speaking, entropy is a measure of disorder, so the second law asserts that disorder is always on the rise. For example, ice, left out in the sun, melts. Ice, at the molecular level, is ordered in a crystalline form; water molecules are amorphous, more disorderly. The same law states that energy (heat) cannot flow “uphill” from a colder substance to a warmer one. So how can an electric refrigerator freeze water into ice? Doesn’t that violate the second law? Not at

all. The refrigerator is not a closed system. It draws on an outside source of energy (the electricity) to “squeeze” heat out of the air inside the refrigerator (via a compressor and heat coils) and then transfer that heat into the cooler ambient air (“downhill only”) and the water transforms into ice. But where does the electrical energy come from? Again, from “outside” – either from a fossil fuel or nuclear reactor, or from hydroelectric energy, some of which energy is lost in the conversion. And that energy, in turn, ultimately comes from an “outside” source, the sun, and much of it is lost in the conversion. And that energy in turn ... but you get the idea; you can’t escape the second law.

**Quotation of the Day:** “The strength of mathematics multiplies, like the giant Antaeus, when it makes contact with reality, the ground upon which it was grown.” – Constantin Carathéodory