

EMMY NOETHER

French mathematician Siméon-Denis Poisson remarked “Life is good for two things, discovering mathematics and teaching mathematics.” **Emmy Amalie Noether** (March 23, 1882 – April 14, 1935) would seem to have agreed. That she became recognized as probably the greatest woman mathematician of all time, and certainly among the greatest mathematicians of the 20th century, is less remarkable than the fact that she persevered to become so with so many obstacles put in the way of achieving that distinction.



Noether had four strikes against her. She was a woman at a time when the education of women was severely limited. She was a Jew in a country that used Jews as scapegoats for its misfortunes. She was a pacifist in a military nation and although never politically active. She was a liberal when most of the population was conservative. Amazingly she discovered within her the spirit not only to make major contributions to mathematics, but also to share her insights with students and colleagues so that they also made significant strides in their fields. Noether was no early day feminist; she simply loved mathematics, and seemed willing to suffer any indignity and injustice to fulfill her destiny.

Noether was born in Erlangen, Bavaria, Germany, the daughter of Max Noether, a distinguished mathematics professor at Erlangen and Ida Amalie Kaufmann, the daughter of a wealthy Cologne family. Emmy was the oldest of four children. Her three brothers were Alfred, Fritz, and Gustav Robert. Fritz became a quite respected mathematics professor like his father. Some might suspect her mathematical talent was in her genes. Perhaps, but her colleague Edmund Landau accurately observed:

“Max Noether was the father of Emmy Noether. Emmy is the origin of coordinates in the Noether family.”

As a girl, Noether took music lessons, attended parties and was particularly fond of dancing. She was considered clever, friendly, and cheerful. She was rather plain in appearance, nearsighted, short, and would grow to become what has been described as solid and earth-bound. Throughout her life Noether endured many unkind comments about her appearance. In high school, she showed considerable talent for languages, and passed a test that certified her to teach French and English in Bavarian girls' schools. Instead of exercising this career option, she joined her brother Fritz at Erlangen to study mathematics. At the time, women were allowed to study at German universities as auditors only if they received permission to do so from the professors. Noether received the necessary authorization, and, between 1900 and 1902, she was an unofficial mathematics student. Although not allowed to enroll in a university, she was able to take and pass an examination making her a doctoral student. From 1903 to 1904 she was an unofficial student at Göttingen, "the Mecca of Mathematics," attending lectures of such prominent mathematicians as David Hilbert, Felix Klein and Herman Minkowski.

In 1904 Noether was allowed to matriculate at Erlangen, the only female in the class of forty-seven doctoral students. Her advisor was Paul Gordan, known as the "king of invariant theory." Noether's thesis was titled *On complete systems of invariants for ternary biquadratic forms*. In 1907 Noether was granted a doctorate *summa cum laude*. She faced the daunting task of finding a university position, which at the time was unheard of for women. With no prospects she remained at Erlangen and assisted her father. He had been stricken with polio as a child and by this time was no longer able to give his lectures, so she substituted for him. At the end of WWI, Germany changed from a monarchy to a republic. This earned her and other German women the right to vote, but still did not open university posts to them. Noether was allowed to lecture and teach at Erlangen but could not be paid for her services.

In the next few years, still without an official position and no pay, she published her research, resulting in her growing reputation as an important mathematician. Noether's first major work was a 1915 result in theoretical physics, now often referred to as "Noether's Theorem." She proved a relationship between symmetries in physics and conservation principles. The paper became a cornerstone for the theory of general relativity, and that same year Hilbert and Klein invited Noether to join them at Göttingen. They were working on the general theory of relativity and believed that Noether's research and theoretical knowledge would benefit their investigations. They fought to have her offered the Habilitation (permission to lecture); which would mean she was officially a member of the faculty, but many members of the University community forcefully opposed the move. Their objection was summarized in the following statement:

"How can it be allowed that a woman become a Privatdozent? Having become a Privatdozent, she can then become a professor and a member of the University Senate. Is it permitted that women enter the Senate? What will our soldiers think when they return to the university and find they are expected to learn at the foot of a woman?"

Hilbert countered his colleague's objections by saying:

"I do not see that the sex of the candidate is an argument against her admission as Privatdozent. After all, we are a university and the Senate is not a bathing establishment."

Permission was denied. Hilbert found a way around the roadblock by advertising her lectures as his, with Noether serving as his assistant. Finally in 1919 Noether won the dubious distinction of the position of Privatdozent, a very insecure academic post as a non-tenured lecturer, who is paid a pittance and whose academic rights are non-existent. For the rest of her stay at Göttingen her mathematical reputation as a researcher and teacher flourished. Yet she was never offered a mathematics chair, even when vacancies occurred. Her 1921 paper, *Ideal Theory in Rings*, is considered of fundamental

importance in the development of modern algebra. Prior to the 20th century the study of algebra had been primarily concerned with developing techniques for solving equations. Modern algebraists, such as Noether, were concerned with formal properties of algebraic operations. They defined and studied the properties of what are now known as groups, rings and fields.

Noether published only 37 research papers but her influence was far greater and is reflected in the work of her “boys,” most of whom became outstanding mathematicians in their own rights. She taught her pupils how to think for themselves in simple and in general terms. In this way she and her students created a path toward the discovery of new algebraic patterns that had previously been obscure. Noether was generous with her genius, sharing her brilliant ideas with colleagues and students alike. She was not the easiest teacher to follow. Her explanations were “rattled off at top speed.” She feverishly wrote on the blackboard, seeming to invent the mathematics on the spot.

In 1933, the Nazis caused Noether and other Jews to be dismissed from their positions. Her brother Fritz also was dismissed and when offered a post in Siberia, he moved there with his family. After WWII he was never heard from again. Hermann Weyl later described her behavior when she was dismissed.

“Her courage, her frankness, her unconcern about her own fate, her conciliatory spirit, were, in the midst of all the hatred and meanness, despair and sorrow, a moral solace.”

Friends in the U.S.S.R. attempted to secure a position for Noether at the University of Moscow, but before an offer could be made she accepted a position at Bryn Mawr College in the United States. There for the first time in her life she held an actual professorship and had female colleagues and

female students, including her last Ph.D. student, Ruth Stauffer McKee. On April 14, 1935, at the age of 54, Emmy Noether died. Her death was caused by a postoperative infection after the removal of an uterine tumor.

Hearing about remarkable individuals who have overcome great obstacles to make their marks on the world is an inspiration for most people. Greatness is not something that comes with simply being born; it is something that must be earned over. Some people believe that geniuses are those individuals to which things come easily. The truth is that geniuses are those who are capable of working harder than everyone else and who thrive on the work. Can anyone become a genius just by hard work? It seems unlikely, but potential genius can be wasted unless there is hard work. Often someone is called a genius merely because he or she can do something that few others can do. This is only a part of it. To truly deserve the title, one must think about something in a way that no one has ever thought of before. After geniuses think in new ways, often about old ideas, others come along and discover ways of explaining the new idea so that it seems obvious. Then people wonder why it had never been thought of before. Of course, the answer is that it was waiting for a genius to put the idea into the right perspective. Consider the view of Paul Eldridge in *Maxims for a Modern Man*, 1965:

“With the stones we cast at them, geniuses build new roads for us.”

Quotation of the Day: “In the judgment of the most competent living mathematicians, Fräulein Noether was the most significant creative mathematical genius thus far produced since the higher education of women began. In the realm of algebra, in which the most gifted mathematicians have been busy for centuries, she discovered methods which have proved of enormous importance in the development of the present day younger generation of mathematicians.” – Albert Einstein