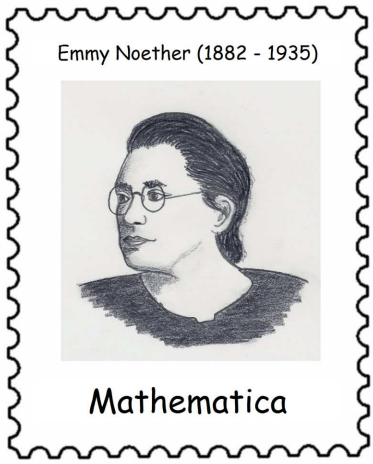
EMMY NOETHER (March 23, 1882-April 14, 1935)

by HEINZ KLAUS STRICK, Germany

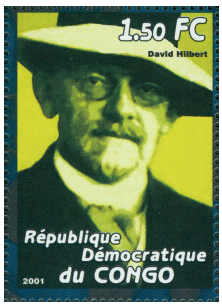


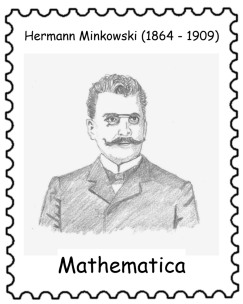
If one looks her up in the *Lexikon bedeutender Mathematiker* (Encyclopaedia of Important Mathematicians), then the Erlangen native AMALIE EMMY NOETHER was the "most significant woman mathematician to date". In the traveling exhibition *Jewish Mathematicians in German-Speaking Academic Culture*, her outstanding contributions to mathematics were given their full due. However among the 39 postage stamps in the series *Woman in German History* (released between 1986 and 2003 by the German Postal Service), one will look for her portrait in vain.

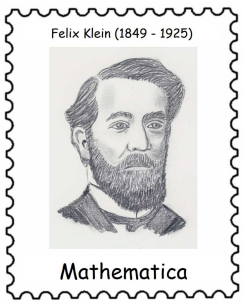
In Erlangen, EMMY NOETHER attended the City High School for Girls, a precursor of girls' gymnasia that was the usual educational path for daughters of middle-class families. At first, she showed little interest in mathematics, and besides, the curriculum contained little more in the way of mathematics than might be found at the lowest levels of the boys' gymnasia. She was much more interested in improving her knowledge of English and French. At the age of 18, she passed a language examination that certified her to pursue the profession of a teacher in "educational and instructional institutions for girls in Bavaria". However, as a Jew, she was unable to obtain a position, since the schools were organized on religious principles, for the schools were oriented toward Catholicism or Lutheranism.

In the meantime, the focus of her interests shifted. One may suppose that her father, MAX NOETHER, a professor of mathematics at the University of Erlangen, played a significant role in this. In any case, she decided to study mathematics. The directory of students enrolled at the University of Erlangen for the winter semester of 1900/1901 contains just under one thousand names. Of these, only two are of women, one of whom was EMMY NOETHER. These two had the status of auditors; that is, if the instructors gave them explicit permission, they were allowed to *be present* at lectures. In order to be admitted to a regular course of study, EMMY NOETHER had to present the credential of having passed an examination equivalent to the high-school graduation exam (A-levels). While she was preparing for such an external examination, which she took in 1903 in Nuremberg, she continued to attend lectures.

Beginning in 1903, women were permitted to study at Bavarian universities. But EMMY NOETHER was drawn to the centre of German mathematics, to Göttingen, to attend the lectures of DAVID HILBERT, FELIX KLEIN, HERMANN MINKOWSKI, and KARL SCHWARZSCHILD.







In Göttingen, however, women were not yet allowed to study, and here, too, her status was that of an auditor. In Göttingen, she became ill and returned to Erlangen, where she enrolled in the university as a regular student. She completed her doctorate in 1907 with a dissertation on the theory of invariants. Later, she called her thesis, which had been awarded *summa cum laude*, "mere calculation" and a "tangle of formulas".

Indeed, her dissertation reflected the style of her thesis advisor, PAUL GORDAN, who had made a few small advances in the theory of invariants, in contrast to HILBERT, who after a short acquaintance with that branch of mathematics had presented fundamentally new results, about which GORDAN had only this to say: “That is not mathematics, but theology”.

She spent the following eight years teaching and doing research at the university, but only unofficially, even when she took over for her advisor, who had taken ill. Following sensational publications on various topics in algebra, she was accepted into the *Deutsche Mathematiker Vereinigung* (DMV), the German Mathematical Society. In 1909, she became the first woman to present a lecture at the DMV’s annual conference.

In 1915, she was invited by KLEIN and HILBERT to continue her mathematical researches in Göttingen, but the regulations governing habilitation at Prussian universities did not allow women as instructors, and so her lectures could be given only with the following disclaimer:
Theory of Invariants: Prof. Hilbert with the Support of Fräulein Dr. Noether.

In 1918, she published a theorem in which geometric properties of space were considered in connection with the conservation laws of physics. This theorem, now known in her honour as *NOETHER’s theorem*, proved in the years to come to be one of the most important foundations of theoretical physics.

Petitions by HILBERT and KLEIN to make an exception in the case of EMMY NOETHER and give her permission to teach were processed only grudgingly by the relevant ministry and were eventually turned down. Even the intervention of ALBERT EINSTEIN, who expressed his enthusiasm about NOETHER as a mathematician, was unsuccessful.

The main argument against accepting these petitions was typical of the time: no one had any experience to be able to tell whether over time, a woman would be able to withstand the pressures of university teaching, and for that reason, it was impossible to give them permission to teach. HILBERT is believed to have said in this regard, “The candidate’s gender can surely be no argument against granting permission. After all, we are talking about a university, not a bathhouse.”

As part of the political reforms following the November Revolution of 1918, the laws governing the universities were changed; in June 1919, EMMY NOETHER finally obtained the *venia legendi*—the right to teach at a university. Although she now was able to lecture under her own name, and from 1922 on had the title of *Außerordentlicher Professor* (associate professor), she received no salary and depended on family for financial support.

It was not until 1923, that is, when she was 41 years old, that EMMY NOETHER began to be paid for giving lectures, which is to say that she was paid only during the semester properly. On account of her continued financial straits, she increasingly neglected her appearance, putting little value on her dress. She did not maintain a healthy diet, making puddings, because of their low cost, her primary source of sustenance, which did her no good.

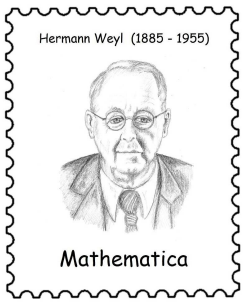
EMMY NOETHER’S publications had in the meanwhile achieved international recognition. But while her students and doctoral advisees would go on to tenured professorships, she had to make do with her meagre remuneration.

Beginning in 1920, she devoted her research efforts primarily to questions of abstract algebra. The publication of *Idealtheorie in Ringbereichen* (theory of ideals in ring domains) from the year 1921 represents the beginning of a series of researches into increasingly abstract structures. (The term *ring* was introduced by HILBERT for sets on which two binary operations are defined such that certain additional properties are satisfied. Ideals are certain subsets of rings that are closed under the two operations.)

One of EMMY NOETHER'S most famous students was BARTEL LEENDERT VAN DER WAERDEN, who arrived in Göttingen in 1924 and attended her lectures. In 1931, he published his epochal work *Modern Algebra*. He expressed his gratitude to EMMY NOETHER, who had given him important ideas for the second volume of that work.

In 1928, EMMY NOETHER accepted a visiting professorship in Moscow. In 1932, she was awarded the prestigious ACKERMANN-TEUBNER Memorial Award (together with EMIL ARTIN). In the same year, she became the first woman to present one of the plenary lectures at the *International Congress of Mathematicians*, in Zurich.

Following the rise to power of the National Socialists, EMMY NOETHER was dismissed on "racial grounds" under the new *Law for the Restoration of the Professional Civil Service* (Gesetz zur Wiederherstellung des Berufsbeamtentums). There were also political grounds for her dismissal: her sporadic membership in the *Social Democratic Party of Germany*, her pacifistic attitudes, and her guest professorship in Moscow together with contacts with Soviet mathematicians caused the new rulers and their minions to suspect that she might be disseminating "Jewish–Marxist mathematics".



When finally, in September 1933, her licence to teach was revoked, she accepted an invitation to lecture at Oxford, eventually ending up on the faculty of *Bryn Mawr College*, in Pennsylvania. Every week, she gave a lecture at the *Institute for Advanced Study* in nearby Princeton, New Jersey, where ALBERT EINSTEIN and HERMANN WEYL (until 1933 HILBERT's successor in Göttingen) had meanwhile taken up residence. However, she never obtained real access to the male bastion of Princeton. In 1934, she briefly returned to Germany, where she dissolved her household and took leave of her brother Fritz, who had accepted a professorship of mathematics in Tomsk, in Siberia.

The following year, she had to undergo a routine operation on a tumour. Unanticipated complications arose, and three days later she was dead. In an obituary, VAN DER WAERDEN emphasized her modest, selfless, and benevolent manner as well as her keen intellect. WEYL remarked that the worldwide renown of Göttingen as a centre of mathematical research in the years around 1930 was due primarily to EMMY NOETHER.

First published 2012 by Spektrum der Wissenschaft Verlagsgesellschaft Heidelberg

https://www.spektrum.de/wissen/amalie-emmy-noether-1882-1935/1141528

Translated by David Kramer

English version first published by the *European Mathematical Society* 2013

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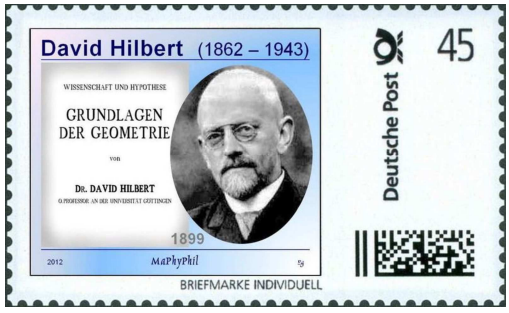

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