

## Felix Klein: Visions for Mathematics, Applications, and Education



**Renate Tobies**

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MAA REVIEW

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[Reviewed by Benjamin Linowitz, on 01/29/2023]

Robert Fricke once compared Felix Klein to a triptych whose central panel concerns Klein's mathematical research, and whose flanking panels concern his interests in education and his organizational skills. As Tobies explains in her preface, "the goal of this book is to put this triptych into words and enrich it with a human dimension".

Mathematically, Klein is perhaps most well known for accomplishments that recognize and enhance the connections between disparate fields. His incredibly influential *Erlangen Program* famously synthesized geometry by focusing on the study of properties that are invariant under a certain group of transformations. Similarly, Klein's book on the icosahedron tied together the seemingly disparate fields of geometry and the theory of algebraic equations by showing how the icosahedral group could be used in order to solve the general equation of fifth degree.

Although Klein never abandoned pure mathematics altogether, over time the focus of much of his scholarly work transitioned towards applied mathematics. In 1896 he wrote (in a letter to Hurwitz) that while he had no interest in his colleague Hilbert's abstract approach to number theory, he was very enthusiastic about his project on the motion of a spinning top. This project culminated in a four volume monograph, written with Sommerfeld, *Die Theorie des Kreisels*. In this work, it is shown that the motion of any point of a symmetrical top can be given in terms of formulae involving multiplicative elliptic functions. When Klein gave the lecture *The stability of the sleeping top* on the work at Princeton University that October, the lecture notes immediately gained international recognition and were soon translated into French.

Throughout his life, and especially after his arrival in Göttingen, Klein was interested in secondary school education. In 1892, for instance, he organized the first mathematical teacher continuing education course. This course, which would be held every two years, would bring new findings into the schools and would focus on only those topics which were of direct importance to secondary school teachers yet lied outside of the scope of their school lessons. Topics would include the motion of the spinning top, the transcendence of pi, and the three classical Greek impossible construction problems. When Klein was invited to give a plenary address at the conference of the Association for the Promotion of Mathematical and Natural-Scientific Instruction he prepared a 66 page commemorative text *Vorträge über ausgewählte Fragen der Elementargeometrie (Famous Problems of Elementary Geometry)*. Later, in 1905, Klein played an important role in the decision to include differential and integral calculus in the secondary school curriculum.

Two of the distinguishing features of Klein's professional life were his leadership qualities and his collaborative approach to mathematics. Tobies identifies all of Klein's important collaborators during the various scientific periods of his career (most notably, Sophus Lie) and discusses the many collaborative projects that he spearheaded (e.g., his *Encyklopädie der mathematischen Wissenschaften*). To appreciate how successful Klein's leadership was, consider that under his management the journal *Mathematische Annalen* became one of the world's leading mathematical journals, while his initiatives at Göttingen were largely responsible for its development into a top research facility.

Renate Tobies' *Felix Klein* is meticulously researched. The biography contains thousands of footnotes, a thirty-page bibliography, and a five-page survey of the scholarly literature surrounding Klein's life and works. The text includes dozens of tables that give the questions that 16 year old Klein was asked on his *Abitur* examination, the names of the participants in Klein's research seminars, the titles and content of all of the courses that Klein taught during the last ten years of his life, and more. Additionally, Tobies goes to great lengths to use primary historical sources (many of which were previously only infrequently analyzed) in order to allow Klein to speak for himself. Most notable is her use of the extensive correspondence documented in Klein's comprehensive Nachlass in Göttingen.

Renate Tobies has written an authoritative biography of Felix Klein. It is informative, detailed, and marks an important addition to the scholarly literature. I recommend it enthusiastically.

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