## FERDINAND VON LINDEMANN (April 12, 1852 – March 6, 1939)

by HEINZ KLAUS STRICK, Germany

At the age of 30, he had a brilliant idea that brought him world fame. JAMES JOSEPH SYLVESTER called him the *conqueror of* π – which was, in his eyes, *a prouder title than if he had been the victor of Solferino or Sadowa*.
(Solferino was a 1859 decisive battle between Austria and Sardinia, and France for the independence of Italy; Sadowa near Königgrätz was a 1866 battle between Austria and Saxony, and Prussia about the "German problem".)
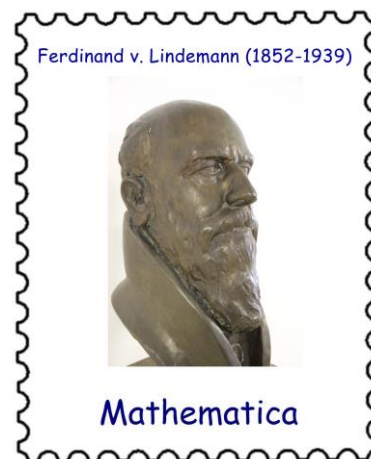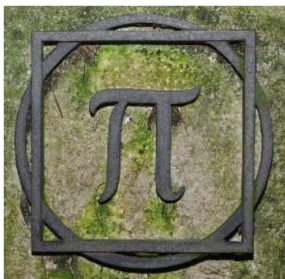
We are talking about CARL LOUIS FERDINAND VON LINDEMANN, who proved in 1882 that the circle number π cannot be the solution to an *algebraic* equation, and is therefore a *transcendental* number.

One conclusion from this is that the so-called *squaring of the circle* is not possible – a given circle cannot be converted into a square with the same area by construction with compass and ruler alone.

(picture on the left: Illustration of the problem posed on Lindemann's gravestone, Photo: Georg Schierscher, Liechtenstein)

FERDINAND LINDEMANN was born in Hanover in 1852. His father (also named FERDINAND) was a teacher of modern foreign languages at the local high school and his mother EMILIE was a daughter of CHRISTIAN CRUSIUS, a teacher of ancient foreign languages at the gymnasium and famous as the editor of a HOMER dictionary.

In 1854, one of the father's brothers had built a gasworks in Schwerin with the help of English engineers, for which he urgently needed the support of a responsible person who was fluent in English – so it came about that FERDINAND LINDEMANN (the elder) moved with his family to Mecklenburg and took on a managerial position in his brother's gasworks.

Since the father was not satisfied with the standard of instruction in elementary school, he took over his son's school education himself – with the result that by the age of eight, his son, who was obviously gifted in mathematics, had already mastered not only the rule of three but also elementary algebraic transformations with variables and basic constructions with ruler and compass.

FERDINAND passed his *Abitur* exam at Schwerin High School as the best in his class and his father tried to persuade his son to study classical philology. However, he also agreed with his decision to study mathematics and astronomy. FERDINAND enrolled at the University of Göttingen in the winter semester of 1870/71. Due to health problems, he was not called up for military service (the Franco-Prussian War was going on) and was therefore able to begin his studies.

In geometry, LINDEMANN attended the lectures given by ALFRED CLEBSCH, who died unexpectedly in November 1872 at the age of only 39 after contracting diphtheria. The lecturer who was commissioned to continue the lecture, was relieved that LINDEMANN was able to provide him with an exemplary version of his notes. As chairman of the *Mathematical Society*, an association that competed with the fraternities, LINDEMANN organised the student body's wake at the coffin of the deceased professor.

LINDEMANN had already caught the attention of FELIX KLEIN, a private lecturer from Göttingen who was only three years older and had completed his habilitation under CLEBSCH IN 1871.

When KLEIN was asked to compile CLEBSCH'S geometry lectures and publish them as a book, he accepted the job, but immediately passed it on: he thought that LINDEMANN was the only person he could consider for this demanding task. The work, with updated additions, was published in 1876; the volume, generally referred to as *Clebsch-Lindemann,* remained standard reading for mathematics students for several decades.
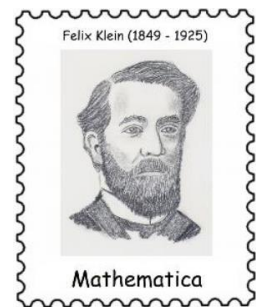
KLEIN had accepted a professorship in Erlangen in 1872, and LINDEMANN had followed him, as he wanted to do his doctorate under KLEIN while working on the book. In the summer semester of 1873, LINDEMANN submitted his dissertation on the motion of a rigid body in a non-Euclidean geometry (*On infinitely small movements and force systems with general projective measurement*) – less than three years after beginning his studies.

LINDEMANN followed KLEIN after he moved to the *Polytechnic School* in Munich (today: the *TUM*) to complete his *habilitation* there. However, at that time this was only possible at universities. The Bavarian Minister of Culture found a solution to the problem: LINDEMANN first received a scholarship for a study trip to England and France, then – on the basis of the geometry book that had been published in the meantime – he completed his *habilitation* at the University of Würzburg. The private lecturer LINDEMANN did not stay there for long – in 1877 he accepted an offer of an extraordinary professorship (then later a full professorship from 1879) in Freiburg.

During his study stay in Paris, LINDEMANN also had close contact with CHARLES HERMITE, who in 1873 had succeeded in proving that EULER'S number *e* is a transcendental number. HERMITE had tried in vain to apply the method of his impossibility proof to the number π, and LINDEMANN had also constantly thought about it after his meeting with HERMITE.
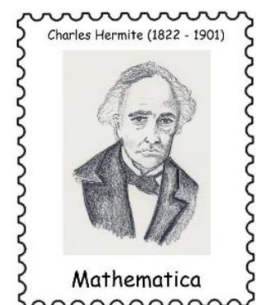
On April 12, 1882, on his 30th birthday, the time had come. During a long, lonely walk, LINDEMANN had the longed-for idea of how HERMITE'S approach could also be applied to the proof of the transcendence of π.

LINDEMANN put his idea on paper and sent it to KLEIN for publication in the *Mathematische Annalen*. KLEIN found no errors but remained suspicious. PAUL GORDAN in Erlangen and GEORG CANTOR in Halle were also unsure whether the proof might not be incomplete. KARL WEIERSTRASS in Berlin, however, confirmed that LINDEMANN had indeed succeeded in proving it and – after consulting with LINDEMANN – arranged for the paper to be distributed immediately.
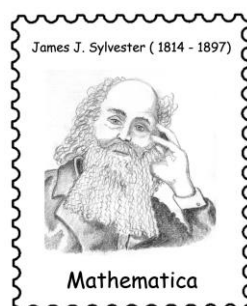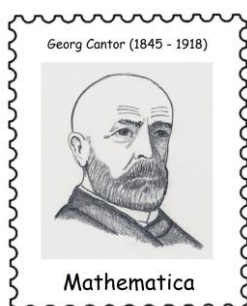
International recognition followed immediately, including from HERMITE and SYLVESTER (see above), but the rumour quickly spread that the proof had not been complete and that WEIERSTRASS had completed it. In his paper, LINDEMANN had hinted at the possibility of a generalisation, but had not gone into detail. In fact, WEIERSTRASS succeeded in doing this immediately afterwards, and was later able to simplify LINDEMANN's original proof.

LINDEMANN's sudden fame led to a generous offer of a professorship in Königsberg. In his negotiations for the position, he managed to get ADOLF HURWITZ, another of KLEIN's doctoral students, to receive an extraordinary professorship at the prestigious East Prussian university at the same time. (Because of his Jewish origins, HURWITZ – despite his extraordinary professional competence – had problems finding a suitable position.) During the ten years he worked in Königsberg, LINDEMANN supervised numerous doctoral students, including HERMANN MINKOWSKI, DAVID HILBERT and ARNOLD SOMMERFELD.

During his time in Königsberg he married LISBETH KÜSSNER, a successful actress who later helped him to translate works by HENRI POINCARÉ into German.

In 1893, LINDEMANN accepted a position at the *Ludwig Maximilian University* in Munich, where he worked extremely successfully from his retirement (1923) until the end of his life (1939). In 1894, he was admitted to the *Bavarian Academy of Sciences* and after various honours from the Bavarian king, he was knighted in 1918. As head of the university's administrative committee (1908-1932), he helped to maintain university operations even in turbulent times of the short-lived Bavarian Soviet Republic.

At the celebration of his 70th birthday in 1922, his former student OSKAR PERRON noted that LINDEMANN, a university professor who was greatly admired by his students, had supervised a total of over 60 doctoral students.

During his time in Munich, LINDEMANN wrote a number of papers though none of them were as significant as his paper on the number π, which led jealous colleagues to maliciously claim that LINDEMANN had simply been lucky with his discovery. This in turn increased the pressure on him to produce another spectacular paper. His attempts to prove FERMAT's Last Theorem failed, which in turn strengthened his opponents' opinions. Derogatory remarks from colleagues contributed to LINDEMANN staying away from German mathematicians' meetings, but on the other hand, he was honoured for his services to *international* scientific relations with an honorary doctorate from St Andrews University.

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