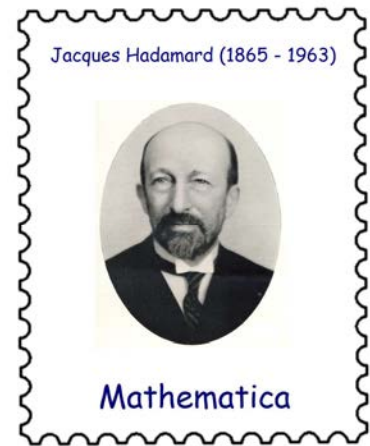


JACQUES HADAMARD (December 8, 1865 – October 17, 1963)

by HEINZ KLAUS STRICK, Germany

Mathematicians who deal intensively with prime numbers live long ...

You could agree with this rather light-hearted saying when you consider the ages of CHARLES DE LA VALLÉE POUSSIN and JACQUES SALOMON HADAMARD – the former lived to be 95 years old, the latter 97 years. These two mathematicians shared a very special accomplishment: independently in 1896, they proved the so-called *prime number theorem*.



This states that the quotient $\frac{\pi(x)}{x/\ln(x)}$ converges to one, where $\pi(x)$ denotes the number of prime numbers which are at most equal to x .

JACQUES SALOMON HADAMARD was the first child of AMÉDÉE HADAMARD and CLAIRE MARIE JEANNE PICARD. The father taught history, grammar and classical literature at the *Lycée Imperial* in Versailles; the mother gave private piano lessons at home. In 1869 the young family moved to Paris, where AMÉDÉE HADAMARD took a job at the *Lycée Charlemagne* – just a few months before the outbreak of the *Franco-Prussian war*. As the Prussian troops were about to lay siege to Paris, the newly-born second child of the HADAMARDS (a daughter) died. A great famine broke out in the capital. After the armistice in January 1871, a humiliating peace treaty followed in May. In Paris, civil war-like conditions occurred, in which the HADAMARD family's house was destroyed. A second daughter also died; she was not even three years old.

From 1874, JACQUES attended the Lycée, where his father worked as a teacher, with excellent performances – except in arithmetic. In 1875 AMÉDÉE HADAMARD was transferred to the Lycée *Louis-le-Grand* and JACQUES also changed to this school. In 1882 he graduated from school with the *Baccalauréat des Sciences*. At the national student competition of 1883 (*Concours Général*) JACQUES won first prize in algebra as well as in mechanics.

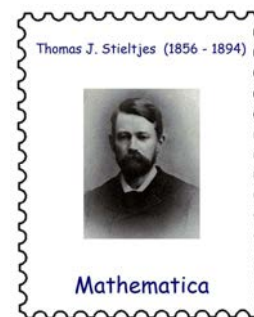


In 1884, JACQUES HADAMARD passed the entrance exams at the two elite universities in Paris, the *École Polytechnique* and the *École Normale Supérieure*, each as the top student. He decided to study mathematics at the second faculty, where he attended lectures by CHARLES HERMITE and ÉMILE PICARD among others. He finished his studies in 1888. While researching for his doctoral thesis, he taught at various schools, but with little success. He had difficulty adjusting to the understanding of his students. An exception was MAURICE RENÉ FRÉCHET, whom he was able to support as a school student and later as a university student as far as a doctorate.

The year 1892 became a special year for HADAMARD. He was awarded a doctorate (by PICARD) for a thesis on complex TAYLOR series and, surprisingly, he was awarded the *Grand Prix des Sciences Mathématiques* for his research on the prime number theorem.

The mathematician THOMAS JEAN STIELTJES had actually been nominated for the prize, as he had announced that he had found a proof for the *RIEMANN conjecture*, but there were gaps in his proof.

1892 was also the year in which HADAMARD married his childhood sweetheart LOUISE-ANNA TRÉNEL. The two moved to Bordeaux, where HADAMARD received a teaching position at the university. In the following four years he wrote 29 papers, including his famous proof of the prime theorem and a treatise on trajectories (orbital curves), for which he received the *Bordin Prize* of the *Académie des Sciences*. In 1896 his position in Bordeaux was changed to a professorship of astronomy and mechanics.



The time in Bordeaux also included an event that strongly influenced HADAMARD's life:

ALFRED DREYFUS, who was married to a cousin of HADAMARD, was accused in 1894 of the alleged betrayal of military secrets to the *German Reich*. DREYFUS was the first officer of the Jewish faith in the French army, which, from the outset, aroused the distrust of most members of the high command, and he came from Alsace, which had been annexed by the *German Reich* in 1871. Against this background, worthless expert opinions and alleged testimonies were sufficient for the court martial, which did not meet in public, to sentence DREYFUS to life imprisonment.

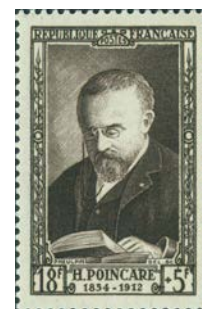
The way in which the innocently convicted man was degraded in front of a cheering crowd of spectators, as well as the conditions of his imprisonment on *Devil's Island* off French Guyana, led to initial reactions in the press that called the entire trial into question. The family, including HADAMARD, did everything in its power to ensure that the trial was reopened – at first in vain.

When the real traitor was acquitted in a trial because the military refused to admit the mistake made earlier, the poet ÉMILE ZOLA made a public appeal (*J'accuse ...*) to the president to intervene. ZOLA was convicted of slandering the military and was forced to leave the country to avoid punishment, but his appeal finally got the matter moving again. And despite all the anti-Semitic propaganda in the press and in Parliament, the retrial was allowed in 1899.

In the new trial, DREYFUS was found guilty again, but was pardoned immediately afterwards. It was not until 1906 that ALFRED DREYFUS was finally fully rehabilitated, after the left had won a majority in a parliamentary election.

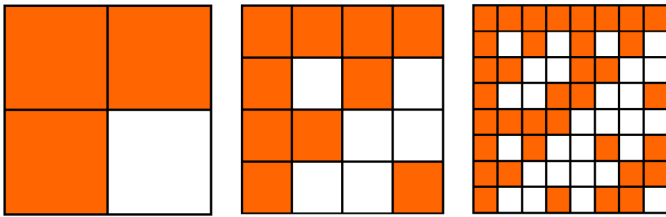
Despite his involvement in the DREYFUS affair, JACQUES HADAMARD was able to continue his professional career. In 1897 he moved from Bordeaux to Paris (*Sorbonne, Collège de France*) and successively published two volumes on *plane and solid geometry*, which had a great impact on mathematics teaching in France. In 1898 he was awarded the *Prix Poncelet* for his scientific achievements over the past ten years. The members of the *Société mathématique de France* elected him president of the association in 1906. In 1909 he was appointed to the chair of mechanics at the *Collège de France*. In 1912 he was appointed professor of analysis at the *École Polytechnique*.

When HENRI POINCARÉ died in the same year, HADAMARD was given the difficult task of sifting through his legacy – he seemed to be the only one able to do so. The *Académie des Sciences* elected HADAMARD to succeed POINCARÉ as a member.



With the outbreak of the First World War, HADAMARD's happy family life ended. His two elder sons died in the battle for Verdun. He suppressed his grief with even more intensive work. He also took on a chair at the *École Centrale*. Lecture tours took him to various European and American countries. He received numerous honours. And he constantly wrote books and scientific articles – there were a total of 300 contributions to various areas of mathematics and theoretical physics.

The so-called *Hadamard matrices* of the form $H_{2n} = \begin{pmatrix} H_n & H_n \\ H_n & -H_n \end{pmatrix}$ with $H_1 = (1)$ play a special role in error-correcting codes.



In 1940 he fled to the United States with his wife to escape the approaching German troops. Apart from a visiting professorship at *Yale University*, however, he was unable to find another job. He therefore worked on a paper that appeared in Princeton in 1945: *An Essay on the Psychology of Invention in the Mathematical Field*, in which he examined the mathematical thought process. He came to similar results to POINCARÉ in 1906: conscious thinking, unconscious thinking (incubation), spontaneous enlightenment and reviewing the thought.

In 1944 he received news of another death: his third son died as a soldier in the French army in Libya. He waited in England until he could return to Paris. After the war, HADAMARD took part in the anti-war demonstrations of the socialist parties, and this almost prevented him from attending the *International Congress of Mathematicians* in Cambridge, Massachusetts. However, despite the authorities, the conference participants elected him as honorary president.

In 1962, the still mentally active scientist received a gold medal as a special honour – in memory of his admission to the *Académie des Sciences* 50 years earlier. However, when one of his grandchildren had a fatal climbing accident in the same year, he lost his will to live and withdrew completely – as if he were just waiting for his death.



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<https://www.spektrum.de/wissen/jacques-hadamard-mathematiker-und-pazifist/1674158>

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