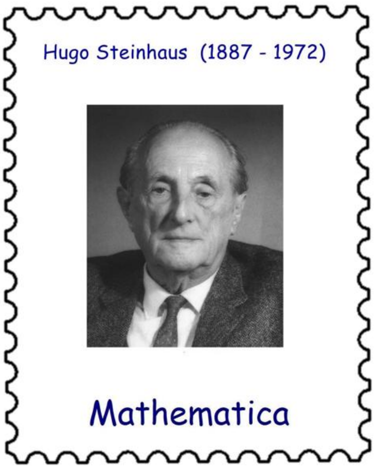
Hugo Steinhaus (January 14, 1887 – February 25, 1972)

by Heinz Klaus Strick , Germany



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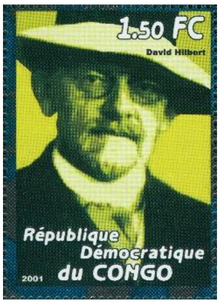
Wydział Matematyki

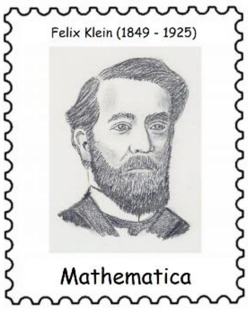
When Hugo Dyonizy Steinhaus was born in 1887, his birthplace Jasło belonged to the province of Galicia of the Austro-Hungarian Empire (the Polish town lies between Krakow/Krakóv and Lemberg/Lwów/Lviv).

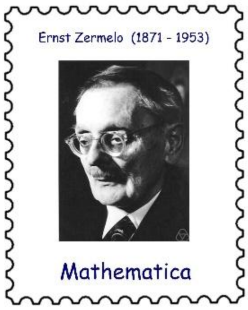
Hugo 's father, Bogusław, was a wealthy merchant who could provide his wife and four children with a comfortable life; later, he also traded in building materials. After successfully completing primary school and the local secondary school, Hugo was faced with the decision of what profession to pursue. Initially, he considered a career in the army, but his pacifist grandfather dissuaded him. The family would have liked him to become an engineer, but for Hugo, *pure mathematics*, rather than *applied* mathematics, was more appealing, as he had already studied lecture notes on analysis during his school years.

In his first year of studies, he moved into an apartment in Lwów, together with a cousin who was studying law at the same university. In the spring of 1906, Hugo Steinhaus happened to meet a professor from the *Technical University of Charlottenburg* (now: TU Berlin) who was visiting Lwów. When the professor heard that Steinhaus was studying mathematics, he issued him an ultimatum: "*Young man, pack your things and go to Göttingen*!"

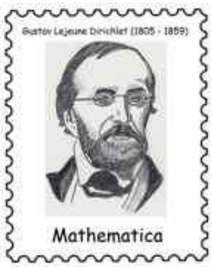
Hugo's father was not enthusiastic about the idea, but let him go. Steinhaus thus continued his studies in Göttingen, where mathematicians such as David Hilbert, Felix Klein, Constantin Carathéodory, and Ernst Zermelo taught.







As a minor subject, he chose *Applied Mathematics* (Mechanics, Analytical Geometry, Numerical Analysis and Geodesy – with practical exercises on the theodolite).

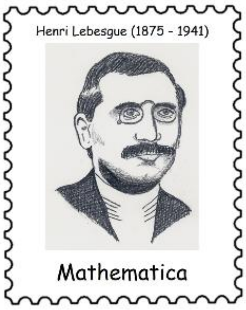


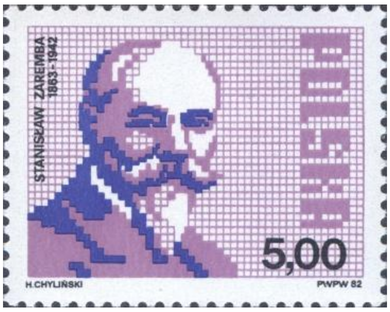
In 1911 he received his doctorate under David Hilbert with a dissertation on the topic of *New Applications of Dirichlet's Principle* (a method from the field of the calculus of variations).

After receiving his doctorate, Steinhaus returned to his homeland, commuted between Jasło and Krakow, published articles as *a private scholar* (as he called himself) and undertook trips to Italy and France.

With the outbreak of the First World War, the family moved from the front-line city of Jasło to Vienna. Hugo Steinhaus initially joined the *Polish Legion* of Józef Piłsudski (the future head of state of Poland). In 1916, he took on duties in the Ministry of the Interior of the soon-to-be-re-established Polish state in Kraków and prepared to assume a position at the newly founded *Jan Kazimierz University* in Lwów. In his free time, he continued working on his habilitation thesis.

Such a work typically expands upon a research question from the preceding doctoral dissertation; this was not the case with Steinhaus – rather, he had spent the last few years intensively studying Henri Lebesgue's integration theory.



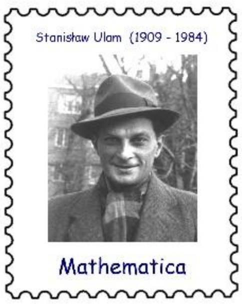


During an evening stroll in Krakow's Botanical Garden, he overheard a conversation between two young men in which the term "Lebesgue measure" came up. The two men were mathematics students Stefan Banach and Otto Nikodym, with whom Steinhaus began meeting regularly.

Steinhaus told them about a problem that was currently occupying his mind and for which he had not yet found a solution. A few days later, Banach presented him with a solution, and together they wrote an article about it (*Sur la convergence en moyenne de séries de Fourier*) for a scientific journal edited by Stanisław Zaremba, one of Krakow's mathematics professors. It was accepted for publication, but due to the war, the article did not appear until 1918; in the meantime, however, Banach wrote one article after another.

When Steinhaus was later asked about his own most important contribution to mathematics, he answered without hesitation: "My discovery of Stefan Banach."

After the war, Steinhaus and Zaremba founded the *Kraków Mathematical Society*, which in 1920 was renamed the *Polish Mathematical Society*; Zaremba assumed the chairmanship. Steinhaus became an assistant professor in 1920 and a full professor at the University of Lwów in 1923; he persuaded Banach to also come to Lwów. Together they founded the *Lwów School of Mathematics*, and from 1927 they published the journal *Studia Mathematica,* which continues to this day. Primarily contributions will be published for functional analysis.



The Lwów mathematicians met regularly at the *Scottish Café*; there they discussed for hours on end mathematical problems that had arisen in their research. If, even after lengthy discussion, a complete solution to a problem could not be found, they recorded the question and the latest state of the discussion in a notebook (*Scottish Book, Księga Szkocka)* – a total of 193 entries*. The last entry*, from 1941, was made by Steinhaus; the book was saved by Stefan Banach's wife, Łucja. In 1955, Steinhaus made a copy of it and sent it to Stanisław Ulam , who then published the collection.

Steinhaus became co-editor of a series of textbooks (*Mathematical Monographs*) in collaboration with Wacław Sierpiński and Kazimierz Kuratowski at the University of Warsaw. He served for a time as Dean of the Faculty of Mathematics and Natural Sciences.

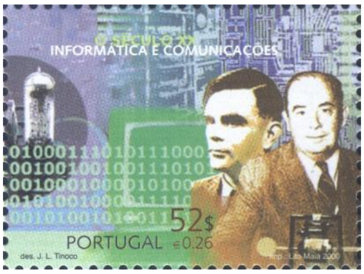
He retained his professorship even after the occupation of Lwów by Soviet troops (1939-1941, following the partition of Poland under the Hitler-Stalin Pact).

Immediately after the German invasion of the Soviet Union on June 22, 1941, Steinhaus went into hiding (together with his wife Stefania, whom he had married in 1918) – partly because he feared reprisals due to his Jewish ancestry (he himself was a self-proclaimed atheist) – just in time, as on the very first day of the German occupation, 22 professors from the university were systematically arrested and shot by the SS. Using forged documents, including a Greek Orthodox baptismal certificate, the couple managed to survive. Despite the danger, Hugo Steinhaus secretly taught at underground schools.

At the Tehran Conference in October 1943, the Allied powers established Poland's eastern border according to the so-called Curzon Line; Lviv was now definitively to become part of Soviet territory. After the liberation of Poland, the surviving members of the University of Lviv transferred to the newly founded University of Wrocław, including Steinhaus, who there dedicated himself to establishing the Faculty of Mathematics and Natural Sciences and, more generally, to rebuilding scientific institutions in Poland. He taught at the University of Wrocław until his death. For his outstanding contributions, he received numerous honours.

Steinhaus authored 170 scientific papers, initially focusing on functional analysis (including the fundamental *Banach - Steinhaus theorem* from 1927). His "counterexamples" to mathematical theorems, which helped to formulate the prerequisites for these theorems more precisely, caused a stir in the scientific community.

Later, Steinhaus shifted the focus of his research to topics in probability and game theory (even before Kolmogorov and von Neumann, respectively), as well as to methods of applied statistics, such as investigations into the generation of random numbers or the probability of paternity in paternity suits.

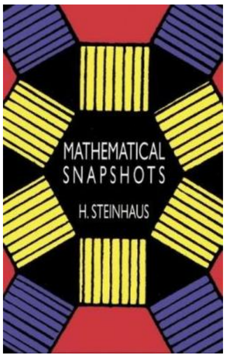


It was of particular importance to him to show the interested public that mathematics is contained in everything around us. His 1938 book, *Kalejdoskop matematyczny*, became famous; it was translated into many languages and reprinted several times (*Kaleidoskop der Mathematik*, *Mathematical Snapshots*). He wanted neither to "instruct" nor to "entertain" his readers.

As he writes in the preface, the idea for this book arose from a typical conversation with a layperson in mathematics:

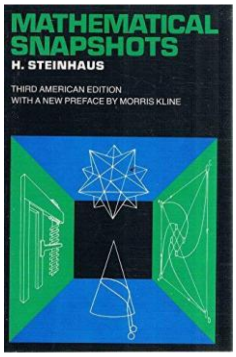
"*You claim to be a mathematician; well, what does one do all day when one is a mathematician*?" *My conversation partner and I were sitting in a park, and I was trying to explain some geometric problems to him, solved and unsolved, by drawing a Jordan curve or a Peano curve on the gravel path with a stick ...*

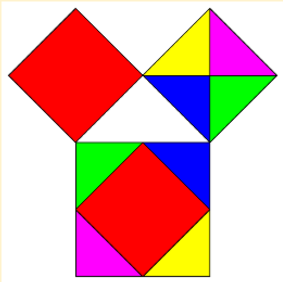
This is how the idea for this book came about, in which sketches, diagrams, and photographs offer a direct language and proofs can be avoided or at least reduced to a minimum.



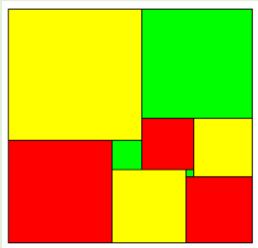
The thirteen richly illustrated chapters cover a diverse range of topics. The individual headings offer little indication of the actual content of each chapter.

Chapter 1 (“Triangles, Squares, Games”), for example, does indeed deal with the aforementioned geometric figures, but also addresses problems that go far beyond this scope:

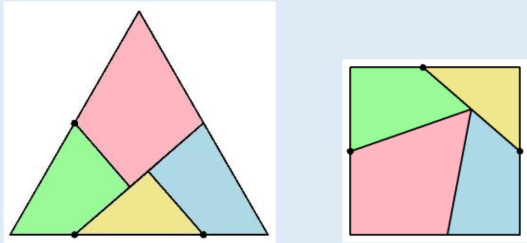




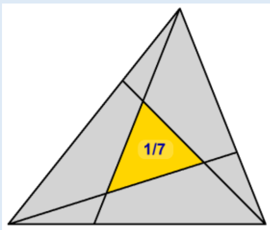
A construction that can divide a square into two squares of equal size.



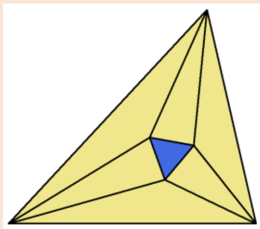
Squares with side lengths 1, 4, 7, 8, 9, 10, 14, 15, 18 can be combined to form a rectangle.



A triangle is divided into four puzzle pieces that can also be assembled to form a square. (If hinges are placed at the marked corners, each piece can be rotated into the other.)



If you divide the sides of a triangle in the ratio 1:2 and connect the points of the division to the opposite vertex, then the area inside will always be one seventh of the area of the entire triangle.



If you divide the angles of a triangle into thirds, you will always create an equilateral triangle in the middle of the triangle.

1	2	3	4
5	6	7	8
9	10	11	12
13	14	15	

1	2	3	4
5	6	7	8
9	10	11	12
13	15	14	

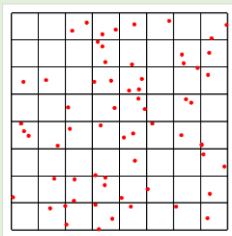
In the so-called 14-15 puzzle, the 15 numbered pieces can be moved horizontally or vertically due to the existing gap. However, the two configurations shown here cannot be transformed into each other by sliding.

	I	II	III
I	1	3	2
II	2	3	1
III	3	1	4

Two players (red, blue) make 1, 2, or 3 marks – without being observed by the other. After revealing their scores, the table shows which of the two players receives 1, 2, 3, or 4 coins. Which strategy is advantageous?

A	B	C	D	E
C	D	E	A	B
E	A	B	C	D
B	C	D	E	A
D	E	A	B	C

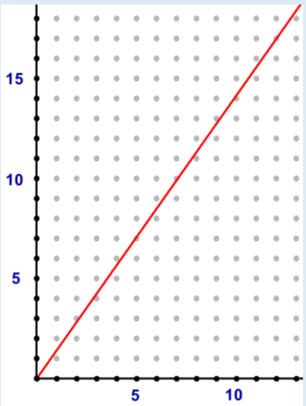
Each of the five colours and each of the five letters appears in every row and every column of the table. This solution to EULER's officer problem can be used to compare cultivation methods based on the crop yields of individual experimental plots, using mean square deviations.



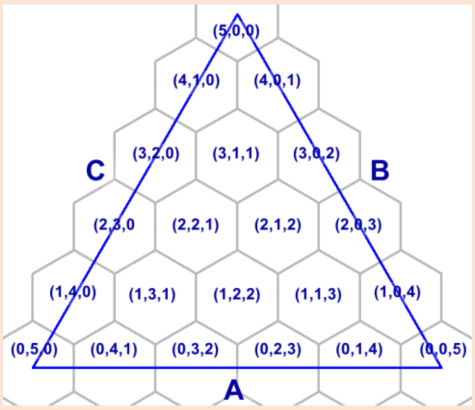
Sixty-four grains are distributed across the 64 squares of a chessboard. If this is a random experiment, then on average, 23 squares are expected to remain empty, 24 squares to contain one grain, 12 squares to contain two grains, 4 squares to contain three grains, and 1 square to contain more than three grains – randomness can be verified using the sum of squared deviations.

The transitions between the individual topics are breathtaking: From the solution of special positions in a chess game, STEINHAUS moves on to the so-called *Knight's Problem*; from the history of the invention of chess to MERSENNE's prime numbers; he compares the probability distribution of a random scattering on a chessboard with the distribution of the 64 largest cities on the map of Poland, and he ends with a comparison of the chances of a high win depending on the numbers chosen in the lottery game '5 *out of* 90'.

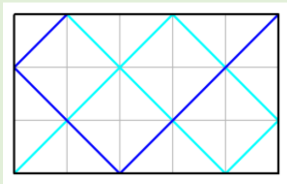
The remaining twelve chapters also contain numerous problems for which STEINHAUS refrains from providing explicit solutions, instead using illustrations to lead to clear, intuitive and playful insights – here are three further examples:



$m = \sqrt{2}$ m is an irrational number: If you draw a straight line with slope m in a grid of points, then approximate values can be read off, e.g. $\frac{3}{2}, \frac{7}{5}, \frac{17}{12}, \ldots$, as can also be seen from the continued fraction expansion of m.



Scheme for the allocation of five parliamentary seats in an election with three parties: Paradoxically, slight changes in the shares of two parties can cost the third party a seat, even though its share has remained the same.



If a ball on a rectangular billiard table, whose side lengths are in the ratio $p : q$, is struck from a corner at an angle of 45°, then the path after $p + q - 2$ reflections ends again in a corner.

Numerous questions arise from practical applications, such as fair division — be it for a single cake or a substantial inheritance consisting of various objects. STEINHAUS considers it unfair to designate the losing team in the final of a knockout tournament as the runner-up; in fact, all teams that lost to the winning team during the tournament should determine separately who deserves second place. The book contains numerous illustrations (391 in total, including many photographs of three-dimensional objects) used to examine mathematically interesting phenomena: tessellations, roll and thread curves, surface colourings, shortest paths, topological questions (circular paths, knots, MÖBIUS strip), polyhedra, the use of nomograms, and more.

Even decades after its publication, the book has lost none of its appeal, and it amazes not only mathematical laypeople, perhaps also due to STEINHAUS's work – for example the famous *Ham sandwich theorem*, which can generally be formulated as follows: *It is always possible to divide three arbitrarily arranged bodies using a plane cut such that each of these bodies is halved* (plane variant: *For three arbitrarily arranged flat pieces, a circle can always be found that bisects each of these three flat pieces*).

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https://mathematik-ist-schoen.jimdoweb.com/

Translated by John O'Connor, University of St Andrews

Here is an important hint for philatelists who also like individual (not officially issued) stamps.