

MARY LUCY CARTWRIGHT (December 17, 1900 – April 3, 1998)

by HEINZ KLAUS STRICK, Germany

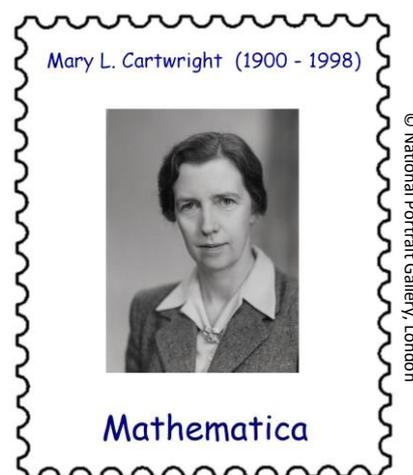
MARY LUCY CARTWRIGHT was born in Aynho (Northamptonshire, about 40 km north of Oxford) as the third of five children of the vicar WILLIAM DEGBY CARTWRIGHT and his wife LUCY. Her two older brothers were killed in action at the front during World War I.

She was taught by a tutor until the age of 11, after which she went to boarding school. Her favourite subject at school was history, but she disliked the cramming of factual knowledge so much that she followed the recommendation of her dedicated mathematics teacher and, after passing the entrance examination and additional examinations in Greek and Latin, was able to enrol in mathematics at *St Hugh's College*, Oxford University, in 1919.

The conditions for studying were particularly difficult at this time. Apart from the fact that only five women in total studied mathematics at the university, they all suffered from the mass influx of young men who were finally – after the end of the World War – able to leave military service. Some days she was unable to get into the lecture halls, so she had to get transcripts from other students.

Despite all her efforts, MARY CARTWRIGHT only achieved a satisfactory grade (*Second Class Honours*) in the mid-term examination after two years, which did not meet her self-imposed performance standards (however, only four graduates in this year achieved a better grade). Temporarily, she even thought about changing to history as a subject, but the memory of cramming facts in her school days stopped her. Later she said with a touch of irony: she continued to choose mathematics because it seemed easier to her ...

Nevertheless, she would maintain her interest in history until the end of her life. After her retirement, she wrote a series of specialist historical treatises and biographies, among others on ABRAHAM DE MOIVRE and on JACQUES HADAMARD.



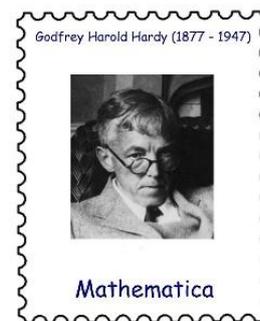
Through a fellow student MARY CARTWRIGHT received the suggestion that she should work through the book *A Course of Modern Analysis* by EDMUND T WHITTAKER and GEORGE N WATSON, which she successfully completed. This "classic" on differential and integral calculus has been reprinted again and again since its publication in 1902 (last edition in 2021).

A second suggestion became decisive for her further life. She attended the evening seminars of GODFREY HAROLD HARDY, which took place every Monday from 8.45 p.m. to 11 p.m.

For this she not only needed his personal permission, but also permission to be out of her college at such a late hour.

HARDY's lectures she later described as captivating and inspiring, and they had an extremely positive effect on her future career. In her final exam, which she took with HARDY in 1923, she achieved the highest grade.

In order to no longer burden her family financially, she subsequently taught at various schools. However, she felt constrained by too many regulations, with the teaching methods, and by administrative duties, so she returned to Oxford in 1928 to do her doctorate with HARDY; she would be the first woman to receive a doctorate at Oxford.



While HARDY was away on a visiting professorship at Princeton, CARTWRIGHT was supervised by EDWARD CHARLES TITCHMARSH, HARDY's former student (and later successor to his chair at Oxford). At the examination of the dissertation on zeros of integral functions (*The Zeros of Integral Functions of Special Types*) the meeting was chaired by HARDY's friend JOHN ENDENSOR LITTLEWOOD of Cambridge University. She met her examiner for the first time in the oral examination.

In 1930 MARY CARTWRIGHT received a scholarship to *Girton College* (a college for women only, affiliated to Cambridge University) to do further research on the topic of her doctoral thesis. It was there that her long and fruitful collaboration with LITTLEWOOD began. Among other things, she succeeded in proving an important theorem about a certain class of complex functions, which today bears her name (*CARTWRIGHT's Theorem*). Her contribution appeared in the world's highest-ranking journal *Mathematische Annalen* in 1935.

Following recommendations from HARDY and LITTLEWOOD, CARTWRIGHT was appointed to give lectures. In 1936 she became *Head of Studies in Mathematics* at *Girton College*.

When the threat of war in Europe loomed in early 1938, CARTWRIGHT learnt of a request from the British government to the *London Mathematical Society* to see if mathematicians could help with a difficult problem arising "in certain electrical apparatus".



What could not be made public was that it concerned the secret research on high-frequency radio waves, which is known today as *radar* (abbreviation for *Radio Detection and Ranging*). The amplifiers developed by the manufacturers were unstable and unreliable and their behaviour was unpredictable when the wavelengths were varied.

However, it was not the "fault of the engineers" who built these devices, but – as CARTWRIGHT found out in collaboration with LITTLEWOOD – it was due to the underlying differential equations, which showed chaotic behaviour at certain parameter values. They were unable to solve the problem before the outbreak of war, but the engineers now knew that certain frequencies should be avoided in the measurements.

For reasons of secrecy, CARTWRIGHT and LITTLEWOOD could not publish their paper *On non-linear differential equations of the second order* until after the war. The behaviour of a so-called VAN-DER-POL oscillator, an oscillatory system with non-linear damping and self-excitation, could be described by a differential equation of the form

$$\frac{d^2x}{dt^2} - \mu \cdot (1 - x^2) \cdot \frac{dx}{dt} + x - A \cdot \sin(\omega t) = 0.$$

The paper remained unnoticed for many years. Today it is regarded as fundamental, since it was a very early treatment of a phenomenon which became popular only in 1972 through EDWARD N LORENZ.



His lecture with the provocative title "Does the flap of a butterfly's wings in Brazil trigger a tornado in Texas?", which is used almost proverbially today, led to intensive research into the chaotic behaviour of physical systems.

MARY CARTWRIGHT was the third woman to be admitted as a *Fellow of the Royal Society* in 1947.

In 1948 women were finally admitted as full members of Cambridge University, and *Girton College* was granted the status of a College of the University. MARY CARTWRIGHT was appointed Mistress of the College – a post she filled with great dedication.

She was always approachable for the female students. Before taking up her new post, she spent a few months as a visiting professor at Stanford, Princeton and the University of California in Los Angeles. Despite the burden of the new post, she continued to lecture, especially on the theory of functions, until her retirement in 1968 and she also supervised eight doctoral students.

Among her many achievements was a great simplification of CHARLES HERMITE's proof that π is an irrational number.



In the years 1961-62 she was – the only woman one so far – President of the *London Mathematical Society*, from which she received the *DE MORGAN Medal* in 1968. Due to her versatile contributions to the analysis of real and complex variables, she was the first woman to receive the *SYLVESTER Medal* of the *Royal Society* in 1964.

When the humorous, self-confident but always modest scientist retired in 1968, Queen ELIZABETH II raised her to the peerage (*Dame MARY CARTWRIGHT, Commander of the Order of the British Empire*) for her services. After her retirement, she continued to hold various visiting professorships and was co-editor of the collected works of HARDY.

First published 2023 by Spektrum der Wissenschaft Verlagsgesellschaft Heidelberg

<https://www.spektrum.de/wissen/mary-cartwright-eine-pionierin-der-mathematik/2121414>

Translated 2023 by John O'Connor, University of St Andrews
