# THE BATTLE OVER THE ELECTRON

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## Introduction

The history of Physics is replete with controversies. One such controversy occurred in the first quarter of the twentieth century over the value of electronic charge symbolically denoted by *'e'* and the elementariness of electron as a constituent of matter. The main players involved were Robert Andrews Millikan (1868-1953) and Felix Ehrenhaft (1879-1952). The controversy raged for a few years and attracted physics stalwarts to both sides. The dispute ended in favour of Millikan, which catapulted him to the pinnacle of glory, with the Physics Nobel Prize for 1923. At the same time, the fame of Ehrenhaft, considered more gifted than Millikan until then, nosedived. The controversy was dubbed "The Battle over the Electron". We have adopted the same phrase as the title of this article. A comprehensive and investigative analysis of the controversy is available in the book titled *The Scientific Imagination: Case Studies,* where the author, physicist and physics historian Gerald Holton has even reproduced photographs of some pages from Millikan's own laboratory notebook. This write-up is primarily based on Holton's account (Holton, 1978, Chapter 2).

## The electron and its charge

As is well known, electron was discovered in 1897 by J. J. Thomson (1906 Physics Nobel Prize) as the first elementary particle and a constituent of atoms. He established that electron is a negatively charged particle (charge = -e, mass=m). His experiment led to a value of the 'specific charge' or the charge-to-mass ratio (e/m) of the electron but could not determine the values of e and m separately. On the other hand, it became important for various reasons to measure e independently. For instance, from the Faraday's laws of electrolysis, an important equation emerges, which combines the three fundamental constants:

$$F = Ne,$$

where $F$ is the Faraday constant, $N$ is Avogadro's number, and e is the value of the charge carried by an electron. Thus, to get the correct value of $F$ or $N$, e needs to be known correctly.

> Historically, it was Faraday's studies in electrolysis, conducted during 1831-1834, that led some scientists to speculate about the existence of an *elementary unit of electric charge,* which was then named 'electron' by G. J. Stoney in 1891, well before its identification by Thomson. Some details regarding the same are available in the book, *Sourcebook on Atomic Energy* (Glasstone, 1971, pp. 31-32).

Since it was not possible to get hold of a single electron and measure its charge directly, scientists settled for indirect experiments to determine e, which was based upon two assumptions: (i) A neutral body gets positively charged by giving up electrons and negatively charged by acquiring electrons.