

Paper 1: Seki Takakazu [関孝和]

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## I. Biography

Seki Shinsuke Takakazu (1642–1708) was a Japanese mathematician in Edo-period Japan who was known for his many contributions in early Japanese mathematics. Independent from the influence of western mathematics, Takakazu's researched topics entails linear algebra, calculus, and algebraic equations. Seki's mathematical research was known to be similar to European mathematics, such as works seen from



Newton and Leibniz, despite no direct contact with western mathematicians due to Japan being, at the time, an isolationist country. Takakazu is known as the Isaac Newton of Japan and, to this day, remains a notable figure in Japanese history.

Takakazu was originally born as the second son in a samurai family known as the Uchiyama family. While in his youth, he was adopted by the Seki family, also of the samurai class. The birth place and year of Seki Takakazu remain historically ambiguous, as there is no concrete evidence of such details. However, Takakazu's biological father, Uchiyama Shichibei Nagaajira, served as an imperial guard in the main tower of Edo Castle—a role that began in 1640. It therefore follows that

Takakazu's birth year is estimated to be between 1640 and 1645. The Uchiyama family tree records Nagaajira living in Fujioka until moving to Edo (modern-day Tokyo) in order to begin his guard duties. Takakazu's birthplace is, therefore, likely Edo, but there is a possibility that Fujioka is the true birthplace. According to the family records, Takakazu's biological father, Nagaajira, died in 1646. Where the eldest son of Nagaajira inherited the Uchiyama family, a chain of sudden events in Takakazu's early life likely led to Takakazu's adoption into the Seki family.

The Seki family crest features a Seki-phoenix in the shape of a circle, as if its wings are in full stretch. Most other historical records of the Seki family are limited due to Takakazu's adopted son, Seki Shinshichirou, being sentenced to Ju-tsuiho, known as



the most severe form of exile. Takakazu took an interest in mathematics from a young age, which he taught himself through Chinese research and texts. As Seki Takakazu was raised as a samurai, destined to serve in the shogunate's administration, he was entitled to the proper education and resources to pursue mathematics.

Takakazu eventually got married in the late 17th century and had two daughters, both who unfortunately died young. Due to the reasons previously mentioned, not much is known about Takakazu's wife and the deaths of their daughters, apart from their existence. Heirless for some interval of time, Takakazu and his wife adopted two sons from his brother: Shinshichirou, who was mentioned earlier, and Heizou. Takakazu lived in front of a Buddhist temple in Ushigome, an area within Shinjuku, and was likely forced to relocate with the temple to Yotsuya due to a fire.

In his early sixties, Seki Takakazu died on the modern-equivalent date of December 5, 1705. His burial location is the temple cemetery of Jorin-ji, in Ushigome, Edo (Tokyo). Twenty-two years later, the Seki family bloodline would go on to be declared extinct by the Edo-period government over the Ju-tsuiho of Seki Shinshichirou, and all preceding family records artificially ceased to exist. The difference in price Ju-tsuiho held compared to other forms of exile was the loss of money, possessions, and banishment from the country, whereas lighter exile sentences were restricted to areas contained domestically. While the cause of the exile is unknown, Seki Takakazu's mathematic research survived the purge of Seki family records.

## **II. Mathematical Contributions**

Seki Takakazu was known for a large handful of major contributions to Edo-period Japanese mathematics, and this section will cover the most significant of his research. Taking concrete examples from traditional Japanese mathematics and translating them into the modern system is a challenging task, since all pre-Meiji period mathematics was practiced on a system called Wasan. Takakazu explored other formats to improve mathematical computation by creating an algebraic model called Tengen Jutsu, using the influence of Chinese mathematics. A number of fundamental improvements were made to the Tengen justsu, such as developing an algebraic notation to allow computations on paper, a better alternative than using the traditional methods practiced in Wasan. A compendium of definitions, proofs, and propositions was also developed by Takakazu to improve the algebra system at the time. The

strongest impact of the development on the Tengen jutsu took Japanese mathematics beyond the realm of Chinese mathematics.

An area of mathematics that Seki Takakazu was the first in history to study, set up, and work with determinants. While he was searching to find efficient solving methods for the three-by-three and four-by-four matrices, Takakazu wrote a manuscript called *Kaifukudai no ho (Methods of Solving Concealed Problems)* and was able to discover the proper computation. He established the concept of the resultant and developed a method to represent a resultant, that method being known today as a determinant.

Takakazu was aware about and studying the length of curves and their area underneath. Wasan had a concept called the Wasan Circle Theory algorithm, in which involved the computation of arc length. In this part of calculus, Seki Takakazu is credited with being the first person to make innovations on arc length, including the rule of finding differences.

### **III. Relation to Other Mathematicians Works**

The only published book by Takakazu was called *Mathematical Methods without Secrets (1674)*, where he demonstrated the first solutions to fifteen unsolved problems in a book by Sawaguchi Kazuyuki, another mathematician. In Sawaguchi's book, *Mathematical Methods, Old and New (1670)*, Takakazu solved all of the remaining open unsolved problems within the text. The mathematical contributions of Takakazu not only reshaped Japanese mathematics, but also inadvertently predicted future discoveries of concepts in math.

The discovery of determinants was a result of Takakazu's dissatisfaction with a rivaling mathematician's research, Tanaka Yoshizane, and his published text, *Clearly Explained Methods of Mathematics* (1679). In Tanaka's text, he solves a set of problems from Sawaguchi Kazuyuki while avoiding the techniques of Takakazu. Tanaka snubbing Takakazu's research eventually led to Takakazu finding more efficient solving methods by publishing his manuscript a few years later, in which he formally introduced the concept of resultants and determinants. It was in the same year, with respect to the western knowledge of mathematics, that Leibnitz also discovered determinants. However, Leibnitz's initial research on determinants, as far as the solving process of determinants, was found to not be as efficient compared to Takakazu's work.

Calculus was a western concept brought into Japan at the beginning of the Meiji Restoration period, but Seki Takakazu was close to being the first person to discover both differential and integral calculus. Isaac Newton and Gottfried Leibniz beat Takakazu to the introduction of calculus, both sides without being aware of each other's existence.

## **IV. Citations**

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