

In mathematics and computer science, an algorithm (/ˈælɡərɪd̩əm/ (listen)) is a finite sequence of rigorous instructions, typically used to solve a class of specific problems or to perform a computation.[1] Algorithms are used as specifications for performing calculations and data processing. More advanced algorithms can use conditionals to divert the code execution through various routes (referred to as automated decision-making) and deduce valid inferences (referred to as automated reasoning), achieving automation eventually. Using human characteristics as descriptors of machines in metaphorical ways was already practiced by Alan Turing with terms such as "memory", "search" and "stimulus".[2] In contrast, a heuristic is an approach to problem solving that may not be fully specified or may not guarantee correct or optimal results, especially in problem domains where there is no well-defined correct or optimal result.[3] As an effective method, an algorithm can be expressed within a finite amount of space and time,[4] and in a well-defined formal language[5] for calculating a function.[6] Starting from an initial state and initial input (perhaps empty),[7] the instructions describe a computation that, when executed, proceeds through a finite[8] number of well-defined successive states, eventually producing "output"[9] and terminating at a final ending state. The transition from one state to the next is not necessarily deterministic; some algorithms, known as randomized algorithms, incorporate random input.[10]

#### Ancient algorithms

Since antiquity, step-by-step procedures for solving mathematical problems have been attested. This includes Babylonian mathematics (around 2500 BC),[11] Egyptian mathematics (around 1550 BC),[11] Indian mathematics (around 800 BC and later; e.g. Shulba Sutras, Kerala School, and Brāhmasphuṭasiddhānta),[12][13] Greek mathematics (around 240 BC, e.g. sieve of Eratosthenes and Euclidean algorithm),[14] and Arabic mathematics (9th century, e.g. cryptographic algorithms for code-breaking based on frequency analysis).[15]

#### Al-khwarizmi and the term algorithm

Around 825, Muhammad ibn Musa al-Khwarizmi wrote *kitāb al-ḥisāb al-hindī* ("Book of Indian computation") and *kitab al-jam' wa'l-tafriq al-ḥisāb al-hindī* ("Addition and subtraction in Indian arithmetic"). Both of these texts are lost in the original Arabic at this time. (However, his other book on algebra remains.)[16]

In the early 12th century, Latin translations of said al-Khwarizmi texts involving the Hindu–Arabic numeral system and arithmetic appeared: *Liber Alghoarismi de practica arismetrice* (attributed to John of Seville) and *Liber Algorismi de numero Indorum* (attributed to Adelard of Bath).[17] Hereby, *alghoarismi* or *algorismi* is the Latinization of Al-Khwarizmi's name; the text starts with the phrase *Dixit Algorismi* ("Thus spoke Al-Khwarizmi").[18]

In 1240, Alexander of Villedieu writes a Latin text titled *Carmen de Algorismo*. It begins with:

Haec algorismus ars praesens dicitur, in qua / Talibus Indorum fruimur bis quinque figuris.

which translates to:

Algorism is the art by which at present we use those Indian figures, which number two times five.

The poem is a few hundred lines long and summarizes the art of calculating with the new styled Indian dice (Tali Indorum), or Hindu numerals.[19]

English evolution of the word

Around 1230, the English word algorism is attested and then by Chaucer in 1391. English adopted the French term.[20][21]

In the 15th century, under the influence of the Greek word ἀριθμός (arithmos, "number"; cf. "arithmetic"), the Latin word was altered to algorithmus.

In 1656, in the English dictionary Glossographia, it says:[22]

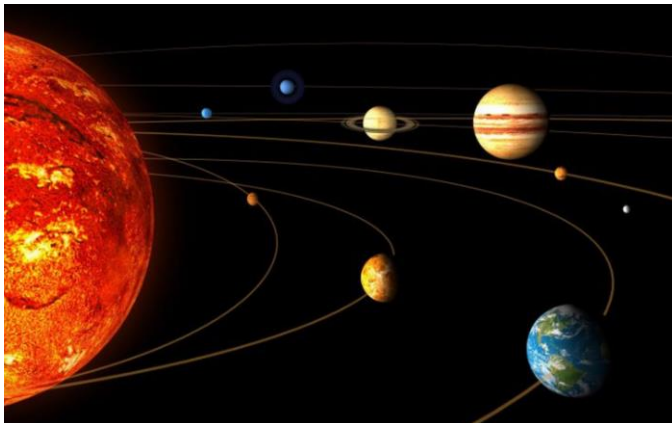
Algorism ([Latin] algorismus) the Art or use of Cyphers, or of numbering by Cyphers; skill in accounting.

Augrime ([Latin] algorithmus) skil in accounting or numbring.

In 1658, in the first edition of The New World of English Words, it says:[23]

Algorithm, (a word compounded of Arabick and Spanish,) the art of reckoning by Cyphers.

In 1706, in the sixth edition of The New World of English Words, it says:[24]



Algorithm, the Art of computing or reckoning by numbers, which contains the five principle Rules of Arithmetick, viz. Numeration, Addition, Subtraction, Multiplication and Division; to which may be added Extraction of Roots: It is also call'd Logistica Numeralis.

Algorism, the practical Operation in the several Parts of Specious Arithmetick or Algebra; sometimes it is taken for the Practice of Common Arithmetick by the ten Numeral Figures.

In 1751, in the Young Algebraist's Companion, Daniel Fenning contrasts the terms algorism and algorithm as follows:[25]

Algorithm signifies the first Principles, and Algorism the practical Part, or knowing how to put the Algorithm in Practice.

Since at least 1811, the term algorithm is attested to mean a "step-by-step procedure" in English.[26][27]