Dynamics of Changes from the *Abajadun* Numbers to the *Ghubari* System

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Abstract: *The numbering system has undergone significant evolution along with the development of human civilization. One form of a numerical system with historical and symbolic value is the Abajadun numerals that associate Arabic letters with certain numerical values. However, along with the increasing need for efficiency in scientific calculations and documentation, especially in astronomy and mathematics, there was a transition to the Ghubari numeral system. This paper attempts to trace the history of the shift in using Abajadun numerals to modern numerals. In addition, this study examines the influence of Middle Eastern culture on the use of Abajadun numerals in various contexts, especially in astronomy and astrology. This study uses a qualitative approach with historical methods to examine the transition from the Abajadun numeral system to the Ghubari system. The results show that Abajadun numerals were used in various fields such as astronomy, astrology, administration, and mathematics before being replaced by more practical Indian numerals. The process of transmitting knowledge and trade in the Persian region during the reign of Khosru Nusirwan played an important role in the spread of the Ghubari numerals. In conclusion, this study reveals that the Abjadun numbering system does not merely function as a counting tool but reflects a cosmology of numbers that is integrated with the classical Arab-Islamic intellectual tradition. The transition from the Abjadun to the Ghubari system marks a crucial point in the history of number epistemology, where efficiency, clarity of notation, and compatibility with the development of arithmetic and astronomy became urgent needs.*
Keywords: *Abajadun, Ghubar, Arab.*

Abstrak: *Sistem penomoran telah mengalami evolusi signifikan seiring perkembangan peradaban manusia. Salah satu bentuk sistem numerik yang memiliki nilai historis dan simbolik adalah angka Abajadun yang mengaitkan huruf-huruf Arab dengan nilai angka tertentu. Namun seiring meningkatnya kebutuhan akan efisiensi dalam kalkulasi dan dokumentasi ilmiah, terutama dalam bidang astronomi dan matematika, terjadi transisi menuju sistem angka Ghubari. Tulisan ini mencoba meruntut sejarah pergeseran penggunaan angka Abajadun ke angka modern. Selain itu, penelitian ini mengkaji pengaruh budaya Timur Tengah terhadap penggunaan angka Abajadun dalam berbagai konteks, terutama dalam astronomi dan astrologi. Penelitian ini menggunakan pendekatan kualitatif dengan metode historis untuk mengkaji transisi dari sistem angka Abajadun ke sistem Ghubari. Hasil penelitian menunjukkan bahwa angka Abajadun digunakan dalam berbagai bidang seperti astronomi, astrologi, administrasi, dan matematika, sebelum digantikan oleh angka India yang lebih praktis. Proses transmisi ilmu pengetahuan dan perdagangan di wilayah Persia pada masa pemerintahan Khosru Nusirwan memainkan peran penting dalam penyebaran angka Ghubari. Kesimpulannya penelitian ini mengungkap bahwa sistem penomoran Abjadun tidak sekadar berfungsi sebagai alat bantu hitung, tetapi mencerminkan suatu kosmologi angka yang menyatu dengan tradisi intelektual Arab-Islam klasik. Peralihan dari sistem Abjadun ke Ghubari menandai titik krusial dalam sejarah epistemologi angka, di mana efisiensi, kejelasan notasi, dan kompatibilitas dengan perkembangan ilmu hisab dan astronomi menjadi kebutuhan mendesak.*
Kata Kunci: *Abajadun, Ghubari, Arab.*

A.   Introduction

The abjad numbering system, originally used in various fields, including mathematics and astronomy, has undergone an interesting transition process towards a more efficient and systematic

modern numbering. In the early days of Islamic civilization, the number system in use was the Abajadun number, which employs hijaiyah letters as number symbols.[1] This system has its roots in the ancient Semitic numeral tradition and developed rapidly during the 8th to 10th centuries AD, particularly in the practices of hisab, astronomy, and astrology.

Over time, the need for a more efficient numbering system in mathematics and astronomy led humans to develop a modern numbering system based on numbers. One of the most important achievements in this transition process was the introduction of the Hindu-Arabic numbering system, which was introduced to the Western world through Arab intermediaries in the Middle Ages. This system used the base numbers 0 through 9 to represent all numbers, and this system became the basis for the modern numbering that we use today. This transition process reflects the development and evolution of human thought in detailing, measuring, and organizing data in the world of science. In the fields of mathematics and astronomy, the alphabetic numbering system has become the foundation for the development of the modern numbering system that we know and use today.[2]

The development of the Abajadun numeral system to the Ghubari system reflects the evolution of numerical recording methods in the classical Islamic tradition. The Abajadun system, which is rooted in the use of hijaiyah letters as symbols for numbers, was widely used in the fields of hisab, astronomy, and numerology in the 8th to 10th centuries AD. However, as the need for a more efficient and universal calculation system increased, the Ghubari system was introduced in the 11th century. This system adopted simpler Arabic numerals that were separate from letters, allowing for increased speed and accuracy in calculations. The discovery of the manuscript of Al-Biruni (973–1048 AD) shows this transition, where early texts still use Abajadun numerals, but later works have switched to Ghubari numerals. This phenomenon reflects the adaptation of Islamic society to the challenges of the times while influencing the development of mathematics in the Western world through the Andalusian route.

Studies on the history of the development of numbers have been widely conducted by researchers. Among them is Woepcke, a French researcher who compiled the book "Empire Sur La Propagation Des Chiffres Indiens," which examines the origins of modern numbers and their distribution by collecting and analyzing manuscripts containing Indian numbers[3]. Smith and Karpinski wrote "The Hindu-Arabic Numerals" by re-analyzing previous studies related to the origins of modern numbers.[4] Then there is Cajori, with his writings on the history of modern numbers by collecting testimonies from scientists from the 8th and 9th centuries.[5]

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[1]Nurliani Manurung, dkk., "Perkembangan Sistem Numerasi Pada Peradaban Manusia Dari Masa Ke Masa" Jurnal Review Pendidikan dan Pengajaran, Volume 7 Nomor 4, 2024.

[2]Joseph, G. G, *The Crest of the Peacock: Non-European Roots of Mathematics,* Princeton University Press, 2011.

[3]Woepcke, P, *Empire Sur La Propagation Des Chiffres Indiens*. Paris: Imprimerie Royale, 1851.

[4]Smith, D. E., & Karpinski, L. C, *The Hindu-Arabic Numerals*. Boston: Ginn & Company, 1911.

[5]Cajori, F, *A History of Mathematical Notations: Volume 1*. Open Court Publishing Company, 1928.

Historians of mathematics agree that the transition from the Abajadun numeral system to the Ghubari system was an important milestone in the development of arithmetic in the Islamic world. According to Sezgin (1984), the Abajadun system that uses hijaiyah letters as a representation of numbers is a legacy of the ancient Semitic numeral tradition, but is less efficient in complex mathematical calculations.[6] Al-Khawarizmi, in one of his treatises, popularized the use of Indian numerals, which later became known as the Ghubari numerals, which, according to Kennedy (1956), had the advantage of a concise symbolic form and compatibility with the decimal system.[7] Quoted from Nasr (1968), this change was driven by the need of Islamic scientists for a more flexible numerical system to support the advancement of astronomy, arithmetic, and trade.[8] In addition, Al-Biruni emphasized the importance of the Ghubari numerals in improving the accuracy of astronomical calculations, as seen in his manuscript on astronomical tables.[9] These expert opinions indicate that the transformation was not only technically based but also a response to the social and intellectual dynamics of the time.

Although much research has been done on the Abajadun and Ghubari numerals separately, comprehensive studies on the transition from one system to the other are still limited. Most studies on the Abajadun numerals focus on their applications in traditional numerology and arithmetic, while research on the Ghubari numerals focuses more on their contributions to modern mathematics. However, there has been no in-depth study of the factors that influenced this change, such as the technical needs of astronomy, the influence of foreign civilizations (India and Greece), and the impact of this transition on the standard number system in the Islamic world. In addition, historical analysis of how the Ghubari system was accepted and adapted by Islamic society is also rare.

Thus, this study aims to bridge the gap in thinking by retracing the history of the emergence of the Abajadun numbers by tracing the transmission and transformation process of ancient numbers in the Middle East. In addition to the transmission process, this paper examines the influence of Middle Eastern culture on the implementation of the Abajadun numbers in life and the representation of astronomical data. Not only astronomical manuscripts, but also other texts need to be explored to strengthen the history and reasons for the importance of this number system at that time.

This paper argues that the transition from the Abajadun number system to the Ghubari system reflects the evolution of human thought in detailing, measuring, and systematically organizing data in the realm of science. This change is one of the important milestones in the development of

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[6]Sezgin, F. *Science and Technology in Islam: Volume 1, Exact and Natural Sciences*. 1984. Institute for the History of Arabic-Islamic Science.

[7]Kennedy, E. S, *A Survey of Islamic Astronomical Tables*. Transactions of the American Philosophical Society, New Series, 1956, Vol. 46, No. 2.

[8]Nasr, S. H, *Science and Civilization in Islam*. Harvard University Press 1968.

[9]Al-Biruni, *Al-Qanun al-Mas'udi*, Manuscript No. 123, fol. 45b.

mathematics and astronomy, which shows the adaptation of society to the need for more efficient calculations.

B.   Methods

This study uses a qualitative approach with historical methods to examine the transition from the Abajadun number system to the Ghubari system. This approach involves four main stages: heuristics, source criticism, interpretation, and historiography. Primary data were collected from classical manuscripts such as Al-Qanun al-Mas'udi by Al-Biruni and other related documents relevant to the development of the number system in the Islamic tradition. Secondary data were obtained from modern literature, including books, journal articles, and previous studies on the history of Islamic mathematics and astronomy. Data analysis was carried out descriptively-analytically to understand the factors that drove the change in the number system and its implications for the development of science. A multidisciplinary approach, including philology and history of science, was used to strengthen the validity of the findings and provide more comprehensive insights.

The data collection technique in this study uses a library research method that is relevant to the nature of historical studies that trace the transition of Abajadun numbers to Ghubari numbers. Data collection is carried out through four main stages of historical research methods, namely heuristics (historical data search), source criticism (verification of the authenticity and credibility of sources), interpretation (meaning of historical data and numerical texts), and historiography (composing logical and chronological scientific narratives). These techniques allow the author to study the development of the number system in the historical trajectory of Islamic astronomy in depth and contextually.

C.   Results and Discussion
1.   History of Alphabet Numbers

The Arabs first appear in the historical records of the Middle East through Assyrian sources. An account of the conflict between the Assyrian King Shalmaneser III and the Syro-Palestinian coalition at Qarqar in 853 BCE.[10] Related to the Arabic alphabet, the An-Namara[11] inscription is the oldest evidence of the introduction of the Nabataean script into the Arabic alphabet. Later inscriptions date from the 6th century and include a trilingual inscription, Greek, Syriac, and Arabic, found in the martyrium at Zebed, southeast of Aleppo. This inscription is dated 512.[12] The

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[10]Bożena Prochwicz-Studnicka, "The Formation and the Development of the Arabic Script from the Earliest Times until Its Standardisation," *The Polish Journal of the Arts and Culture New Series* 9, no. 9 (2019): 53–91, 53.

[11]James A Bellamy, "A New Reading of the Namārah Inscription," *Journal of the American Oriental Society* 105, no. 1 (October 15, 1985): 31–51.

[12]Prochwicz-Studnicka, "The Formation and the Development of the Arabic Script from the Earliest Times until Its Standardisation.", 2.

historical inscription from Jabal Usays[13] dates from 528, southeast of Damascus, and the Greco-Arabic inscription in the martyrium at Harrān at Lejā dates 568, where undated stone inscriptions have been found in the "double church" at Umm al-Jimāl, northeast of Amman, and these inscriptions have been dated.[14]

Further research by Miqdadi, in terms of numbering, the use of Abjad numbers embedded in a word in the chronogram is similar to Greek inscriptions found from various archaeological sites in the 3rd and 4th centuries AD.[15] In The Universal History of Number[16], it is stated that the Arabs and Jews followed the number system used by the Babylonians. They translated it into their alphabet. The Arabs had two alphabet systems, namely the Hebrew and Greek systems. According to Daniel[17], the alphabet is an Arabic letter that, in its tradition, is given a consonant for each letter.[18] As for the order of the Abajadun alphabet, the Arabs followed the order and phonemes of the Hebrew letters. The order is alif, ba ', jim, dal, ha, waw, za, and so on, as many as twenty-two letters. Twenty-two letters from Hebrew were then added, six letters from Greek to reach the number 1000. The six additional letters are *tsa ', kho ', dzal, dlo ', dho, and ghain*.

The alphabetical order studied today is the result of changes after the introduction of the Greek alphabet system for teaching purposes. Gruendler states that in the early Islamic period, with the increasing number of non-Arab converts, the manuscript needed to include more phonetic details.[19] To improve the ability to determine the alphabetical order, the Eastern Arabs developed eight mnemonic methods that must be mastered by each user in order to remember the order of letters according to the applicable arithmetic order. The mnemonics are ابجد (*abajadun*), هوز (*hawazun*), حطيك (*hatayakun*), لمن (*lamanun*), سعفص (*sa'afashun*), قرش (*qarasyun*), تثخذ (*tatsakhadzun*), and ضظغ (*dladhaghun*).

2. Use of Alphabetical Numbers

There are three main classifications of the use of Abjad numbers[20], namely, magic and divination, interpretations related to religious practices, and literary and scientific. The first two classifications are based on the belief in the mystical properties that link a letter to the number it represents. Ibn

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[13]Pierre Larcher, "In Search of a Standard: Dialect Variation and New Arabic Features in the Oldest Arabic Written Documents," *Proceedings of the Seminar for Arabian Studies* 40 (October 15, 2010): 103–12.

[14]Prochwicz-Studnicka, "The Formation and the Development of the Arabic Script from the Earliest Times until Its Standardisation.", 62.

[15]Riham H. Miqdadi, "Abjad Numerals as an Absolute Dating Method: Forts from Al-Ain, UAE," *Mediterranean Archaeology and Archaeometry* 20, no. 3 (2020): 273–89.

[16]"Georges Ifrah - The Universal History of Numbers."

[17]Peter T Daniels, "Fundamentals of Grammatology," *Journal of the American Oriental Society* 110, no. 4 (October 15, 1990): 727–31, 720.

[18]Miqdadi, "Abjad Numerals as an Absolute Dating Method: Forts from Al-Ain, UAE.",277.

[19]Miqdadi., 278.

[20]Miqdadi., 279.

Khaldun gives examples of both in the *Muqaddimah*.[21] He discusses how amulets are made based on the use of astrology and Abjad numbers. The astrological works of Abu Ma'shar al-Balkhi also use *hisab al-jummal* in calculating fate.

The third category relates to the use of Abjad numerals for literary and scientific purposes, namely for page numbering in book introductions and administrative notes.[22] Geography in al-Khwarizmi's book The Image of the Earth, which records latitude and longitude for many locations.[23] In astronomy, all early Islamic astronomical tables (zijes) were written using Abjad numerals. And were also commonly used to mark gradations on astrolabes.[24]

As for its calculation, the writing of the al-jummal hisab numbers has a certain way. The eastern Arabs represented thousands, tens of thousands, and hundreds of thousands by the multiplication method. For this purpose, they connected the letters they wanted to multiply.[25]

3.   Origin of Modern Numbers

The history of modern numbers has been a topic of discussion among researchers, both historians and mathematicians. In 1863, Woepcke wrote the book *Mémoire sur La Propagation des Chiffres Indiens*, which contains research on the origins of modern numbers and their distribution. Woepcke revealed that the numbers commonly used today come from the *Ghubar* numbers. These numbers are widely used in Spain, the Maghreb countries, and Africa.[26] According to him, the *Ghubari* numbers were transmitted by Indians to Arabs.

Woepcke argues that this number was probably brought by Indians through the translation of Indian astronomical tables into Arabic. This translation marked the process of transmitting arithmetic and astronomy from India to Arabia. This happened in 773 AD.[27] At that time, there was an envoy from India who visited the caliph's palace bringing astronomical tables. Then there was testimony from a prominent mathematician during the glory days of Baghdad, namely Muhammad bin Musa from Khawarizm, known as al-Khawarizmi. Al-Khawarizmi stated that this number came from the Hindus. After an astronomical work, *Shindind* was brought to Baghdad, and al-Khawarizmi made a treatise on arithmetic, sundials, astrolabes, chronology, geometry, and algebra.[28] Another testimony came from an Arab scholar, Muhammad bin Ahmad Abu Raihan al-Biruni. Smith also revealed that the first Arab author, al-Kindi (800-870), had written five books on arithmetic and four books on Indian methods of calculation. This evidence convinced Smith that the Ghubar numerals originated in India.

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[21]Bruce B. Lawrence Franz Rosenthal, N. J Davood, *The Muqaddimah – An Introduction to History (F. Rosenthal Trans.)*, 1967.

[22]Stephen Chrisomalis, *The Comparative History of Numerical Notation*, 2003.

[23]Miqdadi, "Abjad Numerals as an Absolute Dating Method: Forts from Al-Ain, UAE."

[24]Chrisomalis, "The Egyptian Origin of the Greek Alphabetic Numerals."

[25]"Georges Ifrah - The Universal History of Numbers.", 246

[26]Woepcke, Par M. F. *Meoire Sur La Propagation Des Chiffres Indiens,* (1863)

[27]Woepcke, Par M. F. *Meoire Sur La Propagation Des Chiffres Indiens*, (1863), 57-58.

[28]Karpinski, 97.

Regarding the spread of *Ghubar* numbers to the Arabs, Smith suspects that the spread of *Ghubar* numbers may have taken place in the pre-Muhammad era around three hundred years before Baghdad's golden age in the field of science.[29] His opinion is supported by the historical fact that the process of transmitting knowledge and trade had developed rapidly in the Persian region during the reign of Khosru Nusirwan.

4.   Process from *Abjadi* Numbers to *Ghubari* Numbers

The use of Abajadun numbers disappeared in the 12th century after surviving for several centuries. Then, 9th-century manuscripts were found containing the use of these numbers. Many of these manuscripts are documents in the fields of astronomy and mathematics. Some are from the fields of media, chemistry, mechanics, and music.

The oldest manuscripts found containing numbers are manuscripts written in 874 and 888 AD.[30] Several other works that contain Abajadun numbers as a representation of a number. The first is the Book of *al-Madkhal al-Kabir fi Ilmi Ahkam al-Nujum*[31] by Abu Ma'shar al-Balkhi, also known as Abu Ma'shar al-Falaki, which was written around the 9th century. Then there is an astrology book entitled *Abu Ma 'shar al-Falaki al-Kabir al-Muhaqiqi al-Mudaqiqi al-Yunani al-Filsuf al-Syuhi*.[32]

Severus Sebokht[33], a Syrian scholar who played a major role in the transmission of Indian numerals to Arabia, showed that by the mid-7th century, the nine Hindu numerals were known in Arabia.[34] In the 8th century CE, the Surya Sidhanta, an astronomical treatise from India, was translated into Arabic, and this had a significant influence on the early development of astronomy in Arabia. Several Sanskrit astronomical terms and methods from India were introduced into Islamic astronomy through this process. For example, the division of the gnomon into 12 parts and the use of the Sanskrit term "*bhukti*" (in Arabic "*buht*") to describe the mean daily motion of a celestial body are illustrative.

Pingree[35] mentioned that in the process of transmitting Hindu numbers in the field of astronomy, Muhammad bin Ibrahim al-Fazari was considered the person most directly related to it. He was assigned by Caliph al-Mansur to translate Indian astronomical works into Arabic. In addition, Caliph al-Mansur also assigned him to create a book that could be used by Arabs as a guide to knowing the movement of stars.

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[29]Karpinski, 91.

[30]Karpinski.

[31]*Kitab Al-Madkhal Al-Kabir Fi 'ilm Ahkam Al-Noudjoum , Traité d'astrologie j.Pdf*, n.d.

[32]"Abu Masyar Al Falaki.Pdf," n.d.

[33]Thomas Hockey et al., "Theon of Alexandria ," 2007, 1044–45.

[34]"The Controversy on the Origin of Our Numerals Author (s): Florian Cajori Source : The Scientific Monthly , Vol . 9 , No . 5 (Nov ., 1919), Pp . 458-464 Published by : American Association for the Advancement of Science Stable URL : Https://Www.Jstor.O" 9, no. 5 (2018): 458–64.

[35]David Pingree, "The Fragments of the Works of Al-Fazā́Rī́," *Journal of Near Eastern Studies* 29, no. 2 (October 11, 1970): 103–23.

D. Conclusion

This study finds that the transition from the Abajadun numerals to the Ghubari system is not simply a chronological phenomenon in the history of Islamic mathematics but rather represents an epistemic paradigm shift in the way classical Islamic societies understood, structured, and transmitted numerical knowledge. The main findings of this study indicate that the Ghubari numerals emerged not only because of practical needs in calculations, but also as a result of cultural and scientific assimilation with Indian and Mediterranean traditions, which were more compatible with advanced mathematical positional systems and operations. This change also reflects a shift from a symbolic-mystical approach (as in the Abajadun numerals associated with cosmology and esotericism) to a rational and functional approach that supported the advancement of the science of arithmetic, astronomy, and economics. Thus, the Ghubari system represents not only a technical innovation but also a modernization of the structure of thought in medieval Islamic science.

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