


History of the use of sextants in Astronomy: A Literature and Development Review

Dimas Ardana^{1*}, Nadia Rahma Ardilla²

^{1,2}Universitas Muhammadiyah Sumatera Utara, Indonesia

Email: dimasardana338@gmail.com , nadiarahmaardilla@gmail.com

Article Info	ABSTRACT
<p>Article History Received 02-01-2025 Revision 04-02-2025 Accepted 11-06-2025</p> <p>Keywords: History Sextant Astronomy Development</p>	<p>This research aims to trace the history of the use of the sextant as a navigational and astronomical tool, focusing on a review of the literature as well as its technological development over time. The sextant, as one of the most significant optical instruments in the history of astronomy, has played an important role in the measurement of the positions of celestial bodies. This research uses the literature review method by analyzing primary and secondary sources, including historical manuscripts, travel records, and technical manuals. The results show that the sextant was first developed in the 18th century and was widely used by seafarers for maritime navigation. The use of sextants in astronomy developed along with advances in optical and mechanical technology, which allowed for more precise angle measurements. This study also discusses the sextant's contribution to sky mapping, the development of navigation tables, and its diminishing role after the advent of modern tools such as GPS and electronic telescopes. The study highlights the importance of the sextant as a symbol of scientific and technological progress in the history of navigation and astronomy.</p> 

I. Introduction

One of the most important astronomical tools in the history of measuring the positions of celestial bodies is the sextant. It is used to measure the angle between a celestial body and the horizon, which allows scientists and sailors to get accurate data on the position of celestial bodies. It is essential for various disciplines, such as astronomy,

navigation, and astrology. The basic concept of angle measurement existed long before, but the tool was first invented in the 18th century by English astronomer John Hadley. At the time, sextants significantly impacted the development of science, especially astronomy and navigation, as they were created to fulfil the practical need to measure angles over vast oceans.

In the beginning, sextants were used to measure the latitude and longitude of uncharted seas; this was crucial for the safety of shipping and ocean exploration. Before this, ocean navigation relied heavily on approximate methods, which were often wrong and had high risks. The use of sextants in marine navigation opened a new era in world exploration, where sailors could explore and map previously unknown oceans and continents [1]. Using a sextant, sailors can measure the angle between the sun and horizon at any given time, allowing them to determine their geographical position at sea more precisely.

Over time, sextants began to be used in astronomy and were not only used for navigation. At first, sailors used sextants to measure the angle between the sun or other celestial bodies and the horizon to determine their geographical position while sailing across vast oceans. However, as awareness of the importance of measuring the positions of celestial bodies in a scientific context grew, the sextant became an important tool used by astronomers to make more accurate observations of the positions of stars, planets and other celestial bodies [2]. Many astronomers began utilizing sextants to make astronomical measurements with greater precision in the 17th and 18th centuries as the scientific revolution began to take hold. Astronomers such as Johannes Kepler and Galileo Galilei developed the heliocentric theory proposed by Copernicus. They continued by Galileo and Kepler, using constants to help develop new astronomical theories that changed how we understand the universe [3].

Previously, astronomers relied heavily on simpler equipment, such as astrolabes and quadrants, which had limitations in angle measurement accuracy. However, by using sextants, which can measure angles with very high precision, astronomers can make more precise and accurate observations. The constant allows astronomers to measure angles between stars and other celestial objects more precisely than before. It therefore, allowed astronomers to calculate the trajectories of the planets more precisely. This was crucial to forming the laws of planetary motion discovered by Kepler. Using the data collected from Tycho Brahe's observations, Kepler formulated three laws of planetary motion that describe the movement of the planets around the sun in elliptical orbits.

In astronomy, the use of constants significantly impacts the mapping of celestial constellations. Astronomers could draw more precise and detailed maps of the sky using more accurate measurements of the positions of celestial bodies. More accurate constellation mapping laid the foundation for advancing modern astrology and astronomy. These mappings were useful for practical needs in timing and navigation, but also allowed astronomers to study the movements of stars and planets more systematically and identify astronomical phenomena that were previously not well observed.

In addition, using constants in celestial observations allowed astronomers to develop more efficient observation methods. The use of constants introduces the concept of sidereal time, which is the time used to measure the position of celestial bodies concerning fixed stars, which is essential for measuring planetary motion. Astronomers can obtain more consistent data by observing the positions of celestial bodies at the right time and at the right angle.

In the context of astronomy, using constants allows scientists to measure the positions of celestial bodies in the sky with very high precision. This was crucial to the development of astrology, which focuses on observing and calculating the positions of celestial bodies' positions and determining celestial time and coordinates. The constant also played an important role in formulating basic concepts in astronomy, such as sidereal time, which is used to measure the movement of stars and planets in the sky, and in creating more accurate sky maps.

Sekstant helped scientists during a period of significant astronomical discovery to get more accurate information about the positions of celestial bodies. This allowed them to perform more complex experiments and create new theories. For example, astronomers used sextants to measure the positions of stars with great accuracy, which allowed them to make more precise calculations about the distances between stars and planets and to study the motions of celestial bodies in the context of the laws of physics discovered by Isaac Newton. In addition, sextants are also used to calculate the motions of other celestial bodies, such as the sun, moon and planets, deepening our understanding of the structure of nature [4]. Innovations in the design of the sekstant in the early 19th century increased the precision of its measurements. Angle measurements became more accurate with magnifying glasses, finer scales, and lighter, more durable materials. With these advancements, the sextant became an increasingly valuable tool in astronomy, geodesy and world mapmaking. For example, sextants measure the length of Earth's degrees. This is very important for determining geographical positions and for global mapping [5].

In addition, sextants have a significant history, especially in educational and scientific terms. In many educational institutions, sextants are still used to teach the basic concepts of astronomy and astrology, such as angle measurement, celestial coordinates, and image-taking techniques, even though many of the functions of sextants needed to view objects in the sky have been replaced by modern technology such as digital telescopes and advanced optical instruments. In addition, sextants play an important role in science and astronomy history education. They connect us to centuries-old traditions of sky-gazing, giving us an idea of how scientists of the past conducted observations and experiments to understand the universe. In this sense, sextants symbolize the progress of science, especially in the development of scientific methods used to understand the physical world and celestial bodies. Therefore, studying sextants provides insight into

the past observation technology of the sky and helps us appreciate the scientific progress that has been achieved through centuries of research and experimentation.

As science has evolved, many contemporary instruments have been used instead of constants for more sophisticated astronomical observations. Thanks to digital telescope technology and other observing devices, astronomers can now observe celestial objects with more precision and in various wavelengths. Nonetheless, sextants are still an important component of the history of astronomy and navigation and are still used in astronomy education and research. A review of the literature on sextants increases our understanding of the development of these instruments and their role in supporting astronomical discoveries and scientific advancements.

II. Method

This research employs a qualitative approach through document study and primary source analysis to comprehensively understand the sextant from historical, technical, and practical perspectives. The document study involves collecting secondary sources such as academic books, scientific journals, popular articles, and historical documents discussing the sextant. These sources provide information on the origin and development of the sextant, its optical design and working principles, and its applications in various fields, particularly in navigation and astronomy. To complement the data, this research also analyzes primary sources, including visual documentation and technical drawings of antique sextants from museum collections, instruction manuals written by historical manufacturers or navigators, and field notes from expeditions that utilized the sextant for navigation. Through this approach, the study examines theoretical aspects and traces the practical use of the sextant in its historical context. In addition, a comparative evaluation between classical and modern sextant models is conducted to understand the evolution of its design and function in line with technological advancements.

III. Results and Discussion

This research employs a qualitative approach through document study and primary source analysis to comprehensively understand the sextant from historical, technical, and practical perspectives. The document study involves collecting secondary sources such as academic books, scientific journals, popular articles, and historical documents discussing the sextant. These sources provide information on the origin and development of the sextant, its optical design and working principles, and its applications in various fields, particularly in navigation and astronomy [6]. Compared to previous instruments such as the astrolabe and quadrant, the sextant allows astronomers to observe the positions of celestial bodies with a much higher degree of precision. A sextant measures the angle between a celestial body and the horizon. Through more accurate measurements of the positions of stars, planets and other celestial bodies, the invention and use of the sextant helped progress in astronomy [7].



Figure 1. The sextant used by John Hadley

The sextant was first introduced and used by British astronomer and mathematician John Hadley in the early 18th century, marking a significant breakthrough in navigational science. One of its primary functions was to measure latitude and longitude, particularly in the vast and often uncharted expanses of the world's oceans (Figure 1). Before the sextant, sailors relied on earlier tools like the astrolabe or cross-staff, which were less accurate and more difficult to use in unstable conditions aboard a moving ship. As a result, navigation was often based on rough estimations that increased the risk of error, shipwreck, or becoming lost at sea.

The sextant dramatically changed this by enabling navigators to determine their geographical position more precisely. It measures the angle between a celestial object—such as the sun, moon, or a star—and the visible horizon. By recording this angle at a specific time of day, and using astronomical tables, sailors could accurately calculate their latitude and, with the aid of a precise timekeeping device, even their longitude. This capability greatly enhanced the accuracy of sea travel, allowing ships to cross oceans more safely and efficiently.

In this context, the sextant became indispensable to maritime exploration, playing a vital role in the discovery age and expanding global trade routes. It contributed to the safety and reliability of seafaring and scientific voyages that mapped the globe and charted previously unknown territories. Thus, the sextant stands as a landmark invention bridging the gap between observational astronomy and practical navigation, solidifying its place in scientific history and maritime heritage. [8].

With the advancement of science in astronomy, astronomers also began to use constants in the 17th and 18th centuries to measure the positions of celestial bodies. At this time, constants helped support the heliocentric theory developed by Copernicus and expanded upon by astronomers such as Galileo Galilei and Johannes Kepler. This allowed astronomers to make more accurate observations of the positions of stars and planets, which allowed them to observe stars and planets more accurately [9].

Astronomers began using sextants in the 17th and 18th centuries to obtain more accurate measurements of the positions of celestial bodies. This allowed them to measure

angles between stars and other celestial objects with a previously unattainable precision using simpler astronomical tools such as astrolabes or quadrants. One example is Johannes Kepler's measurement of planetary trajectories, which helped develop the laws of planetary motion [10]. Using observational data made by astronomer Tycho Brahe using a sextant, Kepler formulated three laws of planetary motion, which underlie our understanding of the movement of planets around the sun. The accuracy of the measurements that the sextant was able to make allowed astronomers to develop more accurate theories about the movements of planets and other celestial bodies [11]. The mapping of celestial constellations, which is essential for timing and navigation and for systematically studying the movements of stars and planets, began with constants. Astronomers could draw more detailed maps of the sky by measuring the positions of celestial bodies more accurately. This facilitated the observation of previously poorly observed astronomical phenomena.

During the 19th century, the design and accuracy of sextants changed. Using magnifying glass to increase precision, finer scales, and lighter, more durable materials improved the accuracy of the sextant. With these advancements, the sextant became a more useful tool in various disciplines, including geodesy, astronomy, and world mapmaking. Using sextant in geodesy and world mapping strengthens its function as an important scientific tool, providing the basis for more precise world mapping [12]. Sextant is used in astronomical observations to determine the positions of celestial bodies and to measure the degree of length of the Earth, which is very important for geographical mapping and determining geographical positions more accurately.

In addition, sextants play an important role in astronomy education and the history of science. In educational institutions, sextants are still used to teach the basic concepts of astronomy. This is so even though many of the functions of sextants are now performed by modern technology such as digital telescopes and advanced optical instruments. A sextant can be used as a teaching tool to teach concepts such as angle measurement, celestial coordinates and how to take pictures of the sky. This allows students to understand the basics of astronomy more practically, giving them an understanding of how scientists in the past conducted observations and experiments to understand the universe [13].

Overall, sextants play an important role in advancing various fields of science, especially in navigation and astronomy. The sextant helped astronomers better understand the universe's structure, calculate distances between stars and planets, and study the laws of planetary motion - on which modern theories of physics are based - with its ability to measure the positions of celestial bodies with high precision. Although many of the functions of the sextant required for astronomical observations have been replaced by modern technology, the sextant remains a representation of the scientific progress achieved over the centuries [14].

Astronomers could perform more complex experiments and develop new theories, such as the theory of universal gravitation proposed by Isaac Newton, thanks to the existence of sextants. Concepts such as sidereal time, which is used to measure the

motion of celestial bodies, is one of the basic concepts of astronomy that was greatly influenced by it. Therefore, sextants have played an important role in the history of science and astronomy education, even though more advanced technologies have replaced them.

From the above discussion, it can be concluded that sextants played a crucial role in advancing navigation and astronomy. As a groundbreaking instrument of its time, the sextant enabled far more accurate observations of celestial bodies, which in turn supported the development and validation of key astronomical theories—such as the heliocentric model proposed by Copernicus and later refined by Kepler's laws of planetary motion. The ability to precisely measure angles between celestial objects and the horizon allowed astronomers and navigators alike to understand the heavens' movements better and apply this knowledge to real-world contexts, such as mapping, exploration, and timekeeping.

Furthermore, as innovations in sextant design emerged over the centuries—such as improved optics, graduated arcs, and materials—the precision and reliability of measurements also increased. This enhanced accuracy improved celestial navigation during long sea voyages. It contributed to more detailed mapping of the Earth and observing the night sky, laying the groundwork for modern observational astronomy.

Although modern digital tools such as GPS and satellite-based systems have largely replaced the sextant in contemporary navigation, its historical significance remains enduring. The sextant represents a pivotal stage in the evolution of the scientific method, demonstrating how empirical observation and technological innovation were combined to understand the physical world and the cosmos. Studying the literature on the sextant, therefore, offers valuable insights into the development of scientific instrumentation and methodology. It also highlights this tool's profound impact on shaping centuries of exploration, discovery, and scientific advancement in astronomy.

IV. Conclusion

Sextants played a very important role in the advancement of navigation and astronomy. Important theories of astronomy, such as the heliocentric theory and Kepler's laws of planetary motion, were supported by more accurate measurements of the positions of celestial bodies using sextants. With innovations in the design of sextants, the precision of the measurements also increased, making it an essential tool for observation and mapping of the world. Even though contemporary technology has replaced this piece, the sextant is still an important part of scientific history as it shows the development of the scientific approach used to understand the physical world and celestial bodies. Therefore, researching the literature on sextants provides an essential understanding of the long history of this tool in supporting the discovery and advancement of science in astronomy.

References

- [1] T. D. and M. Raharto, "Perkembangan Alat Ukur Astronomi di Indonesia," *J. Astron. Indones.*, vol. 8, no, 2019.
- [2] D. McGee, "From Craftsmanship to Science: The Hawkins Papers and the Study of the Sextant in the Eighteenth Century," *Hist. Sci.*, vol. 37, n, 1999.
- [3] B. Hidayat, "Sejarah Astronomi Islam dan Instrumentasinya," *Al-Marshad J. Astron. Islam dan Ilmu-Ilmu Berkaitan*, vol. 4, no, 2018.
- [4] M. A. Hoskin, "The Cambridge Illustrated History of Astronomy," *Cambridge Cambridge Univ. Press*, 1999.
- [5] H. Selin, *Encyclopaedia of the History of Science, Technology, and Medicine in Non-Western Cultures*. Berlin: Springer,. 2008.
- [6] S. Mohammad, "The Development of Astronomical Instruments in Islamic World," *J. Islam. Stud.*, vol. 12, n, 2016.
- [7] H. Turner, *Sains Islam yang Mengagumkan: Sebuah Catatan Terhadap Abad Pertengahan*. 2024.
- [8] M. Kusaeri, *Alat-alat Astronomi dalam Sejarah Islam*. 2019.
- [9] A. B. Dermawan and E. Apriaskar, "Lampu Penerangan Jalan Otomatis Berdasarkan Intensitas Cahaya Dan Keberadaan Kabut Atau Asap," *J. Pendidik. Tek. Elektro Undiksha*, vol. 9, no. 1, pp. 56-63, 2020.
- [10] D. Herdiwijaya, "Instrumentasi Astronomi: Dari Klasik hingga Modern," *J. Pendidik. Sains*, vol. 5, no, 2017.
- [11] S. S. and M. Raharto, "Instrumen Astronomi Tradisional dan Modern dalam Kajian Ilmu Falak," *J. Ilmu Falak dan Astron.*, vol. 4, no, 2019.
- [12] J. A. Bennett, "The Divided Circle: A History of Instruments for Astronomy," *Navig. Surv.*, 1987.
- [13] T. Djamaluddin, "Astronomi Islam dalam Perkembangan Sains Modern," *J. Al-Hisab*, vol. 2, no, 2020.
- [14] A. A. and T. Hidayat, "Sejarah Pengukuran Astronomi di Nusantara," *J. Astron. Indones.*, vol. 7, no, 2018.