

Mathematic and Astronomical Review of the Asr Time on the Shadow Length Criteria

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Article Info	ABSTRACT
<p>Article History Received 23-11-2023. Revision 18-12-2023 Accepted 29-01-2024</p> <hr/> <p>Keywords: Mathematics Asr Prayer Criteria</p>	<p>Asr prayer is one of the prayers that existed before the time of the Prophet Muhammad. The initial criteria for the time of Asr prayer were delivered by the angel Gabriel with two criteria related to the length of the shadow of an object. The initial criterion and the second criterion textually give a different picture. The author researched to find out the similarity of these criteria through a Mathematical and Astronomical review. It was found that in the first criterion (when the shadow of something is the same as it) when the Sun is at the hour angle at about 46-51 degrees the information on the Asr time criterion is conveyed. The height of the Sun will be different and meet the criteria of the length of the shadow produced each day.</p> <p style="text-align: right;">This is an open-access article under the CC-BY-SA license.</p>



I. Introduction

Prayer is a worship to Allah SWT in the form of words and deeds that begin with takbiratul ihram and end with greetings and certain conditions. Prayer is obligatory for Muslims at night when the Prophet performs Isra' mi'raj, which is approximately one year before the Hijra. As for according to the scholars of the Hanafi school, the obligation to pray was set on the night when the Prophet Muhammad (PBUH) performed Isra', which is Friday night on the 10th of Ramadan, which is one and a half years after the Hijra. Ibn Hajar al-Asqalani states that the date is 27 Rajab, one and a half years before Prophet Muhammad (PBUH) migrated to Medina [1].

Many hadiths clarify the prayer times mentioned in the Qur'an, but the author here only takes two hadiths that according to the author clearly describe the time of prayer. As the hadith narrated by Jabir ibn Abdulla (r.a.) has given a clearer picture of the five prayer times with the positions of the sun being the time benchmark [2].

The obligatory prayer has predetermined times, so it is called muwaqqat worship. The times of prayer are contained in the postulates of the Shari'a, namely in the Qur'an and - in more detail - in the hadiths of the Prophet (peace be upon him).

If we consider the prayer time from the source of the law, either from the Qur'an or Hadith, then the prayer time is closely related to the circulation of the Sun. However, it will be hampered if the weather conditions are abnormal or domiciled in an area that has an abnormal day and night cycle. If this is the case, then one needs some other means that can function such as natural phenomena and normal circulation of the Sun.

In each different place the position of the Sun will get a different prayer time, so that science understands that the determination of the implementation of the prayer time is based on the phenomenon of the Sun, which is then translated through the description of the position or position of the Sun at the time of making or realizing conditions that are a sign for the beginning or end of prayer time.

History of Asr prayer

Asr prayer is a prayer performed by Prophet Jonah (as) as many as four rakaat after Allah removed himself from the belly of the fish. Allah took it out just at the time of Asr, when it came out it was like a chick that had no feathers. The four raka'ats of Asr prayer are also a form of gratitude of Prophet Jonah to Allah (swt) for his salvation from the four darkneses, namely: (1) darkness in the entrails of fish; (2) darkness is in the water; (3) darkness at night; and (4) darkness in the belly of the fish itself. Whereas the beginning of the time of 'Asr is the occurrence of the shadow of each thing twice with the length of that thing. The prayer time of 'Asr lasts until before the yellowing of the sun.

Some scholars hold the same opinion in the interpretation of the hadith about the determination of prayer times exemplified by the Prophet of Allah. However, there are also some scholars who differ on the interpretation for determining some prayer times. For example, the opinions of Imam Shafi'i and Imam Hanafi about the beginning of the time of 'Asr prayer and Isha prayer' are different opinions in the interpretation of the hadith of the Prophet SAW.

Hadith of the Prophet (peace be upon him) about the beginning of Asr time

The criteria for prayer times based on the phenomenon of the sun against objects in the earth are mentioned in Sunan An-Nasa'i Hadith No. 510 concerning the Book of Prayer Times:

أَخْبَرَنَا يُوسُفُ بْنُ وَاضِحٍ قَالَ حَدَّثَنَا قُذَامَةُ يَعْنِي ابْنَ شِهَابٍ عَنْ بُرَيْدٍ عَنْ عَطَاءِ بْنِ أَبِي رَبَاحٍ عَنْ جَابِرِ بْنِ عَبْدِ اللَّهِ أَنَّ جِبْرِيلَ أتَى النَّبِيَّ صَلَّى اللَّهُ عَلَيْهِ وَسَلَّمَ يُعَلِّمُهُ مَوَاقِيتَ الصَّلَاةِ فَتَقَدَّمَ جِبْرِيلُ وَرَسُولُ اللَّهِ صَلَّى اللَّهُ عَلَيْهِ وَسَلَّمَ خَلْفَهُ وَالنَّاسُ خَلْفَ رَسُولِ اللَّهِ صَلَّى اللَّهُ عَلَيْهِ وَسَلَّمَ فَصَلَّى الظُّهْرَ حِينَ زَالَتْ الشَّمْسُ وَأَتَاهُ حِينَ كَانَ الظِّلُّ مِثْلَ شَخْصِهِ فَصَنَعَ كَمَا صَنَعَ جِبْرِيلُ وَرَسُولُ اللَّهِ صَلَّى اللَّهُ عَلَيْهِ وَسَلَّمَ خَلْفَهُ وَالنَّاسُ

خَلَفَ رَسُولُ اللَّهِ صَلَّى اللَّهُ عَلَيْهِ وَسَلَّمَ فَصَلَّى الْعَصْرَ ثُمَّ أَتَاهُ حِينَ وَجَبَتْ الشَّمْسُ فَتَقَدَّمَ جِبْرِيلُ وَرَسُولُ اللَّهِ صَلَّى اللَّهُ عَلَيْهِ وَسَلَّمَ خَلْفَهُ وَالنَّاسُ خَلْفَ رَسُولِ اللَّهِ صَلَّى اللَّهُ عَلَيْهِ وَسَلَّمَ فَصَلَّى الْعِشَاءَ ثُمَّ أَتَاهُ حِينَ انْشَقَّ الْفَجْرُ فَتَقَدَّمَ جِبْرِيلُ وَرَسُولُ اللَّهِ صَلَّى اللَّهُ عَلَيْهِ وَسَلَّمَ خَلْفَهُ وَالنَّاسُ خَلْفَ رَسُولِ اللَّهِ صَلَّى اللَّهُ عَلَيْهِ وَسَلَّمَ فَصَلَّى الْغَدَاةَ ثُمَّ أَتَاهُ حِينَ كَانَ ظِلُّ الرَّجُلِ مِثْلَ شَخْصِهِ فَصَنَعَ مِثْلَ مَا صَنَعَ بِالْأَمْسِ فَصَلَّى الظُّهْرَ ثُمَّ أَتَاهُ حِينَ كَانَ ظِلُّ الرَّجُلِ مِثْلَ شَخْصِهِ فَصَنَعَ كَمَا صَنَعَ بِالْأَمْسِ فَصَلَّى الْعِشَاءَ ثُمَّ أَتَاهُ حِينَ وَجَبَتْ الشَّمْسُ فَصَنَعَ كَمَا صَنَعَ بِالْأَمْسِ فَصَلَّى الْمَغْرِبَ فَنِمْنَا ثُمَّ قُمْنَا ثُمَّ نِمْنَا ثُمَّ قُمْنَا فَأَتَاهُ فَصَنَعَ كَمَا صَنَعَ بِالْأَمْسِ فَصَلَّى الْعِشَاءَ ثُمَّ أَتَاهُ حِينَ امْتَدَّ الْفَجْرُ وَأَصْبَحَ وَالنُّجُومُ بَادِيَةً مُشْتَبِكَةً فَصَنَعَ كَمَا صَنَعَ بِالْأَمْسِ فَصَلَّى الْغَدَاةَ ثُمَّ قَالَ مَا بَيْنَ هَاتَيْنِ الصَّلَاتَيْنِ وَقْتُ

Meaning: Having told us Yusuf bin Wadlih he said; It has been told to us Qudamah, namely Ibn Shihab from Burad from Atha bin Abu Rabah from Jabir bin Abdullah, that Jibril came to the Prophet Sallallahu'alaihi wasallam to teach the times of prayer. Jibril came forward and the Prophet Sallallahu'alaihi wasallam behind him, while humans were behind the Prophet Sallallahu'alaihi wasallam. Then Jibril prayed Zhuhur when the sun had slipped, and came back when the shadow was like the original, then did as he did the first time, Jibril came forward and the Prophet Sallallahu'alaihi wasallam behind him, while the man behind the Prophet Sallallahu'alaihi wasallam, then Jibril prayed Maghrib when the red mega was gone, Jibril came again, then Jibril came forward and the Prophet Sallallahu'alaihi wasallam behind him, while the man behind the Prophet Sallallahu'alaihi wasallam, then Jibril immediately prayed Isya. When dawn began to rise, Jibril came again, then Jibril came forward and the Prophet Sallallahu'alaihi wasallam behind him, while the man behind the Prophet Sallallahu'alaihi wasallam, then Jibril prayed Fajr. On the second day, Jibril came when the image of a person was like the original and did as he did yesterday, namely performing the Zhuhur prayer. Then comes again when one's shadow is like the original two times and does as he did yesterday and immediately prays Asr. Then come again at sunset, and do as was done yesterday and Maghrib prayers then we slept. Then woke up, then slept, then woke up again, and came Jibril and did as he did yesterday, and prayed Isya'. The next day, when dawn had reached and it was morning, Gabriel came and the stars were very bright. He immediately acted like yesterday, then he prayed Fajr. Then he said, "The prayer time is between the two prayers."

Asr prayer

Asr prayer time begins when the length of the shadow of an object, equal to the length of the object and ends when it enters Maghreb time [3]. Regarding the end of the Asr prayer time, several scholars have different opinions. First, the length of the shadow of an object is worth twice the length of the object, this is in accordance with the hadith narrated by Jabir that the Prophet prayed Asr on the first day when the shadow of something was the same length, then on the second day when the shadow of an object was twice the length of the object. This opinion is the opinion of Imam Shafii and Imam Malik who state that the time

between the length of the shadow of an object of equal value to twice the length of the object is the best time.

Salat Asar refers to the time of evening until the sun turns red, which signifies the end of daylight [4]. The implementation of Asr Salat must be done when the time of Asar arrives. The difference in the time of Asr prayer from the perspective of jurisprudence is concluded that there are several times. First, fadilah time (when the Sun's shadow is of equal length and ends 45 minutes later). Second, the time of choice or ikhtiari (at the beginning of the time of fadilah or can begin at the time of 45 minutes after the time of fadilah and end when the length of the shadow of the object is twice as long). Third, the time allowed without prohibition or jawaz when karahah (begins when the shadow of the object is twice as long and ends when the sky or the Sun begins to turn yellow). Fourth, the time allowed but makruh or jawaz ma'a karahah (begins when the sky or Sun begins to turn yellow and ends when before sunset) [1].

II. Method

This research is a type of qualitative research supported by primary data and secondary data, where the data in the research is obtained through analysis and relevant previous research then strengthened by literature review with a mathematical model approach. In obtaining research data, researchers collect, analyze, organize, sources from articles, books, previous research on the criteria of asr time. Then the researcher analyzes the textual of these reference sources into mathematical models and languages to see a representative picture of the asr time criterion. Next conclude and present the analysis data for further use and study.

III. Results and Discussion

To find out the criteria for the time of ashar can be analyzed from the fragment of hadith related to the time of ashar above and obtained the following criteria:

.... حِينَ كَانَ الظِّلُّ مِثْلَ شَخْصِيهِ فَصَنَعَ كَمَا صَنَعَ فَتَقَدَّمَ

(...and come back when the shadow is like the original, then do as it was done the first time (zuhur)...)

.... ثُمَّ أَتَاهُ حِينَ كَانَ ظِلُّ الرَّجُلِ مِثْلَ شَخْصِيهِ فَصَنَعَ كَمَا صَنَعَ بِالْأَمْسِ فَصَلَّى الْعَصْرَ

(... Then comes again when one's shadow is like the original two times and does as he did yesterday and immediately prays Asr ...)

The general criterion that the beginning of the time of 'Asr is since the shadow is equal to the height of the actual object, however this still gives rise to some interpretation. In the hadith narrated by Jabir bin Abdullah (r.a), the Prophet (peace be upon him) was invited to pray 'Asr by the angel Gabriel when the length of the shadow was equal to the height of the actual object and the next day the Prophet was invited at the time of the length of the shadow twice the height of the actual object [5].

And in the final determination of the time of prayer 'Asr there is also a difference between the hadith of Imamatu Jibril and the hadith of Abdillah, that is, the first in the hadith of Imamatu Jibril actually the end of the time of 'Asr is when the object is equal to twice its

shadow (opinion of Imam Shafi'i), in the hadith of Abdillah before the yellowing of the sun (opinion of Imam Ahmad bin Hambal), and in the hadith of Abu Hurairah the end of the time of 'Asr before the setting of the sun is approximately one raka'at (opinion of the Experts Dzahir).

Both times of entry of the time of 'Asr are possible because such phenomena cannot be generalized as a result of depending on the seasons or the annual position of the sun. In winter it can be reached in Zhuhur time, maybe even never because the shadow is always longer than the staff.

While opinions that take into account the length of shadows at the time of Zhuhur or take the basis of its addition to twice the length of the stick (in some European countries) are analyzed as solutions intended to overcome the problem of shadow length in winter. For the Indonesian people themselves, the first opinion is used, namely the entry of the time of 'Asr is when the shadow of a person or an object is the same as a person or object.

Jayusman in his book argues that the meaning of the hadith can be understood as the middle time between Zuhr and Maghreb, without taking into account the distance of the zenith of the Sun. This is reinforced by the expression 'mid-salat' in Q.S.al-Baqarah/2:238 which is interpreted by many mufasirs as Asr prayer. If this opinion is used, the Asar prayer time will be about 10 minutes faster than the prayer schedule made by the Ministry of Religious Affairs [6].

In the calculation of Asr time, there are three stages that are often obtained, while the first two stages are calculations to find the height of the Sun shown by equation (1) and the magnitude of the angle of solar time shown by equation (2). While stage 3 is a calculation of time converted into Analog hour values to get the initial value of time shown by equation (3). The equation used is as follows [7] :

$$1). \text{ Sun Height: } \text{Cotan } h^\circ = \tan [\varphi - d] + 1 \dots (1)$$

$$2). \text{ Sun Time Angle: } \text{Cos } t = - \tan \varphi \tan d + \sin h / \cos \varphi / \cos d \dots (2)$$

$$3). \text{ Beginning of Asr time: } 12 - e + (t/15) + \text{kwd} + I \dots (3)$$

To explain the phenomenon in which the length of the shadow is equal to the length of the object at the time of Asr, we can consider astronomical angles and specific dates. This phenomenon occurs when sunlight forms a specific angle with an object so that the length of the shadow of the object is equal to the length of the object itself. This angle can be calculated using trigonometry.

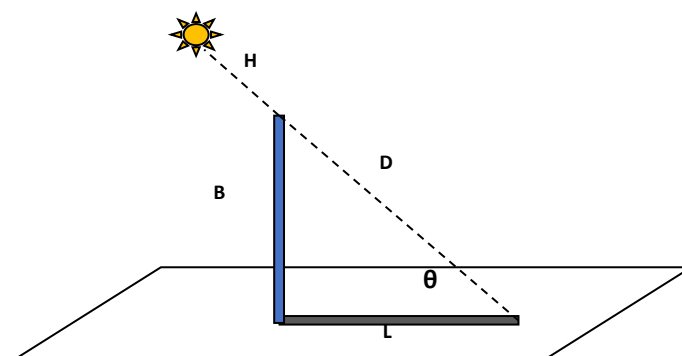


Figure 1. Depiction of Projection of Shadow of Object equal to height of Object

$$\theta = \tan^{-1} (X) \quad \dots(4).$$

The value of $X=1$ in equation (4) become: $\tan^{-1} (1)$ is 45 degrees. This means that the phenomenon in which the length of the shadow equals the length of the object occurs when sunlight forms a 45-degree angle with the object. If the entry of the time of the Asar is based on the opinion that it begins when the shadow of the object has been as long as the object, then the height of the Sun at this time can be formulated with $\text{Cot } h \text{ Asar} = \tan ([\text{latitude of place} - \text{declination of the Sun}] + 1)$. For conditions when the shadow of an object is twice the length of the object, it can be formulated $\text{Cot } h = \tan ([\text{latitude of place} - \text{declination of the Sun}] + 2)$. This formula can be defined with the image as below:

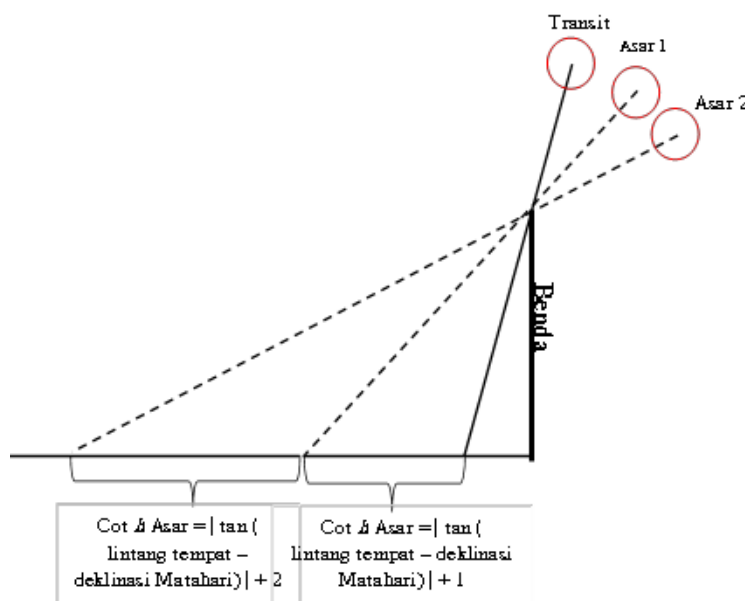


Figure 2. The position of the Sun and the shadow of an object at the moment

The shadow during transit is the shadow when the Sun is at the highest altitude position. At that time the object will cause a shadow, this depends on the value of the Sun's declination and the latitude of the place, if the value of the Sun's latitude and declination are the same then at that latitude location it will not cause a shadow, otherwise it will cause a shadow.

For example, the length of the object is 1 meter and the length of the shadow of the object in transit is 0.5 meters, then the beginning of the Asar time for the concept "when the shadow of the object has been as long as the object" then the beginning of the target time begins when the shadow becomes 1.5 meters while the shadow value is 2.5 meters for the condition "when the shadow of the object is worth twice the length of the object".

The initial time schedule of fadhilah, endeavor, jawaz if karahah has been astronomically studied by other researchers, that is, either when the phenomenon of the shadow of the Sun is equal to the length of the object or is worth twice as long as the length of the object.

To determine the date on which this phenomenon occurred in Mecca, several other dates related to the phenomenon of the sun above the Kaaba, the equinox of the solstice [8] are shown in table 1 as a comparison of the angle of the height of the sun that forms the length of the shadow of an object during the time of Asr.

Table 1. Data on the Sun and Time of Asr in Mecca

Waktu	Deklinasi Matahari	Tinggi Matahari	Sudut Jam
21 Maret	0° 11' 26"	35,76°	51° 12' 33"
28 Mei	21° 26' 41"	44,98°	48° 33' 43"
21 Juni	23° 26' 18"	44,01°	49° 57' 02"
16 Juli	21° 22' 35"	44,97°	48° 33' 47"
23 September	-0° 02' 05"	35,67°	51° 11' 42"
22 Desember	-23° 26' 17"	26,62°	45° 59' 42"

This phenomenon may only occur at certain times, and not always occur every day. In practice, the calculation of prayer times, including Asr time, is based on complex astronomical calculations and is often determined by religious authorities governing the issue of prayer times in a region.

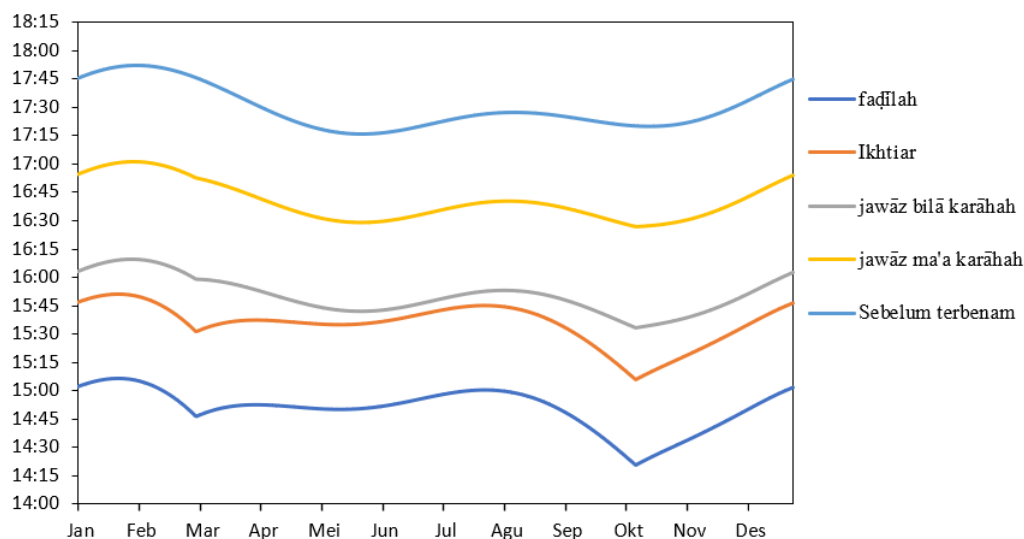


Figure 3. The Effect of Earth's Rotation and Revolution on Time on Earth

One of the factors that causes time changes on this earth, namely the rotation of the earth and the revolution of the earth. The rotation of the earth is the rotation of the earth on its axis from west to east with an average speed of 108 km / h. One full rotation takes about 24 hours, so this motion is called daily motion [9]. The time difference is 1 hour for every 15 degrees longitude, or 4 minutes for every 1 degree longitude. This calculation is obtained from the time required for one full turn (360 degrees) for 24 hours. The circulation of the earth around the elliptical sun is what causes the rotation of the earth on its axis is not necessarily 24 hours, sometimes less and sometimes more [10]. This is the cause of the difference between the true solar time and the average solar time. Actually, the circulation of the sun is not the basis for measuring perfect time. That's because the road isn't exactly flat, meaning sometimes it's a bit fast and sometimes it's a bit slow. Therefore the time between the two times the sun culminates is sometimes not exactly 24 hours long, one day more than 24 hours and the other less than 24 hours.

IV. Conclusion

The division of time in Asr prayer is calculated as it should calculate the time of prayer in general. Astronomically, time fadilah when the phenomenon of the length of the shadow of an object is equal to the length of the object plus the length at culmination can be calculated by the height formula $\cot^{-1}(|\tan(\varphi - \delta)| + 1)$.

The effort time can be calculated by adding up the result of the initial fadilah time by 45 minutes. Jawaz time bila karahah at the time of the phenomenon the length of the shadow of the object is twice as long as the object plus the length at culmination can be calculated by the formula $\cot^{-1}(|\tan(\varphi - \delta)| + 2)$. Then the time of jawaz ma'a karahah can be calculated by dividing 2 between the time of jawaz when karahah and the time before sunset.

It was found that in the first criterion (when the shadow of something is the same as it) when the Sun is at the hour angle at about 46-51 degrees when the information on the asr time criterion is conveyed. The height of the Sun will be different and meet the criteria of the length of the shadow produced each day.

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