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Determination of the Beginning of Prayer Time on the Mount Prau Hiking Trail by Applying Spherical Trigonometry

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Abstract

Determining the beginning of prayer time on the Mount Prau hiking trail is very important for Muslims, especially when performing the five daily prayers. Calculation of the beginning of prayer time is important even though prayers can be performed within a certain time range. This study aims to apply spherical trigonometric calculations and to determine the results of the beginning of prayer time on the Mount Prau hiking trail. This research uses spherical trigonometry hisab method with the required data are latitude of place, longitude of place, solar declination and equation of time. The calculation results show the exact prayer time, such as dawn between 04.24 to 04.29 WIB, zuhur between 11.39 to 11.44 WIB, asar between 15.01 to 15.05 WIB, maghrib between 17.32 to 17.36 WIB and isya between 18.46 to 18.51 WIB. This information is useful for climbers of Mount Prau so that they can carry out worship on time.

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A. Introduction

The five daily prayers are an obligation for Muslims (*Fardhu 'ain*). This worship has a very important value and the time of its implementation itself has been determined in Islamic law. These times are Zuhr, Asr, Maghrib, Isha and Fajr. It is preferable to perform the five daily prayers according to the set times, except in urgent situations and conditions.[1]

At the time of the Prophet Muhammad, prayer timings were based on the cyclical position of the sun.[2] The sun is the nucleus of the solar system which consists of a core and a shell. The sun is also the source of human life, the rays of light from the sun provide life on earth. In addition to providing biological needs, the sun can also be used as a time marker.[3]

Calculating the beginning of prayer time is important even though prayers can be performed within a certain time frame.[4] The prayer times are: Zuhr prayer is performed from the time the sun slips until its shadow is as long as itself; Asr prayer is performed when its shadow is as long as or twice as long as itself; Maghrib prayer is performed after sunset; Isha

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prayer is performed when the sun is below the horizon where its light no longer exists; Fajr prayer is performed when dawn breaks or the red mega from the east begins to dawn.[5]

Prayer timing has evolved over time. This method relates to astronomical calculations (hisab) and direct observation of the new moon (rukyat) in proving the determination of the beginning of prayer time in accordance with religious rules.[6]

Research on the cycle of the sun's position on the hiking trail resulted in the determination of prayer times that are more directed towards the hisab system than the rukyat system.[7] The problem was concluded that the hisab method can be determined by trigonometric theory, while the rukyat method can be determined by using a stick to determine the coordinate points.[4] Hisab rukyat and trigonometric hisab are two different methods in terms of the approach used. Hisab rukyat uses an approach with direct observation by humans, while trigonometric hysab uses a mathematical calculation approach and trigonometric models.[8]

Trigonometric hishab is a calculation method that uses the principles of trigonometry. Determination of prayer time using trigonometric hyssop needs to be done to overcome someone who is on a mountain or forest, because the rukyat method is difficult to do in mountain or forest areas because sunlight is blocked by many towering trees.[9]

Mountains have recently become a favourite place for many people, especially teenagers. One of the activities that can be done on the mountain is climbing.[10] The climbers will usually choose the mountain with the best view. Mount Prau is one of the mountains that has a very high attraction for climbers and is often the main destination for many climbers. Mount Prau has the best view at sunrise and sunset, besides having the best view, Mount Prau also has a relatively easy hiking trail.[11]

Mount Prau is located in the Dieng plateau, Central Java. Mount Prau is the highest peak in the Dieng area with an altitude of 2,590 metres above sea level (masl). The climb to reach the summit can be completed within 3 to 4 hours depending on the ability of each climber. Mount Prau is located at latitude -7°11'13" and longitude 109°55'20".[12]

The trigonometric hisab method in determining the beginning of prayer time has been the focus of various researchers. Khalija used the spherical triangle formula to calculate the beginning of prayer time by utilising astronomical data.[13] Hermawan achieved accuracy in

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prayer time calculation with trigonometric concepts and practical use in the field.[14] Mutmainnah uses mathematical equation analysis that can be converted into the spherical triangle formula, making it easier to calculate the beginning of prayer time.[15]

Research on trigonometric hisab has great significance because it is the main basis for calculating the beginning of prayer time. However, the understanding of trigonometric hyssab can vary in the field. These variants include differences in the approaches, methods or interpretations applied. Thus, differences in trigonometric hisab can arise according to the understanding and emphasis of each individual.

Based on this description, the author is interested in analysing the calculation of determining the beginning of prayer time using trigonometric hisab. Based on the problems obtained, the author raises the title "Application of Spherical Trigonometry in Determining the Beginning of Prayer Time on the Mount Prau Hiking Trail" which aims to determine the beginning of prayer time on the Mount Prau hiking trail.

B. Theoretical Foundation

a. Declination of the Sun

The solar declination is the distance of the sun from the equator or equatorial circle measured along the circle of time when the sun passes through its centre. The north is marked positive (+) and the south negative (-).[16]

b. Equation of Time

Equation of Time is the difference between the actual (true) solar culmination time and the assumed fixed (mid) solar culmination time. The true solar time is the actual solar circulation time, while the mid-solar time is the assumed fixed circulation time as seen on the clock.[7]

c. Latitude and Longitude

Latitude is the distance from the equator measured to the earth's poles. Northern latitude refers to the area north of the equator and has a positive value, while southern latitude is the opposite. Longitude is the angle between the meridian plane of a place and the prime meridian plane. Longitude is also divided into two namely east longitude and west longitude. Eastern longitude is positive while western longitude is negative.[17]

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d. Sun Height

The height of the sun reflects the position of the sun that can be seen at the beginning or end of the prayer time. Before determining the beginning of the prayer time, it is necessary to calculate the height of the sun at a predetermined time.[3]

C. Method

In this study, the trigonometric hisab method is used to obtain the results of determining the beginning of prayer time on the Mount Prau hiking trail. This method aims to get objective results. The type of quantitative data used in this research is the latitude and longitude of Mount Prau, solar declination, equation of time in June 2023.

The source of data in this study was obtained from the Directorate of Islamic Affairs and Sharia Development, Directorate General of Islamic Public Guidance, Ministry of Religious Affairs of the Republic of Indonesia.[18] The location to be used is the Mount Prau hiking trail with latitude data -7°11'13" and longitude 109°55'20". Solar declination data and time equation can be seen in Table 1.

Table 1. Solar declination and equation of time data samples

Dates	Declination of the Sun	*Equation of Time*
1 June 2023	22°01’04”	0°02’13”
2 June 2023	22°09’07”	0°02’04”
3 June 2023	22°16’47”	0°01’55”
⋮	⋮	⋮
28 June 2023	23°17’21”	0°-03’11”
29 June 2023	23°14’26”	0°-03’23”
30 June 2023	23°11’07”	0°-03’35”

D. Results and Discussion

Research Results

Table 2. Sample results of early prayer times in June 2023 on the Mount Prau hiking trail

Dates	Zuhr	Asr	Maghrib	Isya	Fajr

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1/06	11.39	15.01	17.32	18.46	04.24
2/06	11.39	15.01	17.32	18.46	04.24
3/06	11.39	15.01	17.33	18.46	04.24
⋮	⋮	⋮	⋮	⋮	⋮
28/06	11.44	15.06	17.37	18.51	04.29
29/06	11.44	15.05	17.37	18.51	04.28
30/06	11.44	15.05	17.36	18.51	04.28

From the table of trigonometric hisab results above, there are some prayer times that have the same results. However, the different results are caused by the condition of solar declination and time equation.

Discussion

The data used in this research is the latitude of the place of -7°11'13" and the longitude of the place of 109°55'20". Mount Prau is located in the Dieng Region, Central Java, precisely in Batur Village, Batur District, Banjarnegara Regency, Central Java. Mount Prau can be accessed through three routes, namely Dieng route, Selo route and Cemoro Kandang route.

Determining the beginning of prayer time requires the application of the concept of trigonometric calculations. The data that will be used as a test is data on 1 June 2023. The following is an example of the results of the calculation of the beginning of prayer time:

a. Zuhr time

Determining the beginning of the Zuhr prayer time, there are calculations that are not needed, such as solar altitude, time angle and solar time angle because the calculation is based on solar culmination time.

1. Regional Time Correction Calculation

$$KWD = \frac{Bujur\ Tempat - Bujur\ Daerah}{15}$$
$$= \frac{105° - 109°55'20"}{15}$$
$$= \frac{105° - 109°55'20"}{15}$$

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$$= \frac{-4°55'20"}{15}$$
$$= -0°19'41{,}33"$$

2. Calculation of the Beginning of Prayer Time

$$Waktu\ Zuhur = 12° - e + KWD + i$$
$$= 12° - 0°02'03 + (-0°19'41{,}33") + 0°1'$$
$$= 11°39'5{,}67"$$
$$= 11.39\ WIB$$

The zuhr time obtained was 11.39 WIB where the sun passed its zenith. Zuhr prayer is also commonly referred to as midday prayer and marks the halfway point between sunrise and sunset.

b. Asr time

1. Sun Height Calculation

Determining the beginning of 'Asr time takes into account the height of the sun at culmination and the length of the shadows of objects at that time. The following is the calculation of the height of the sun at 'asr time:

$$\cot h = \tan(\varphi - \delta) + 1$$
$$= \tan(-7°11'13"\text{-}22°01'04") + 1$$
$$= \tan(29°12'17") + 1$$
$$= 1°33'32{,}36"$$
$$h = 32°40'40{,}03"$$

2. Regional Time Correction Calculation

$$KWD = \frac{Bujur\ Tempat - Bujur\ Daerah}{15}$$
$$= \frac{105° - 109°55'20"}{15}$$
$$= \frac{105° - 109°55'20"}{15}$$
$$= \frac{-4°55'20"}{15}$$
$$= -0°19'41{,}33"$$

3. Time Angle Calculation

$$\cos t = -\tan\varphi \tan\delta + \frac{\sin h}{\cos\varphi \cos\delta}$$
$$= -\tan -7°11'13" \tan 22°01'04"$$

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$$+\frac{\sin 32°40'40{,}03"}{\cos -7°11'13" \cos 22°01'04"}$$
$$t = 50°21'27{,}53"$$

4. Sun Time Angle Calculation

$$\frac{t}{15} = \frac{88°09'54{,}7"}{15} = 5°52'39{,}65"$$

5. Calculation of the Beginning of Prayer Time

$$Waktu\ Asar = 12° - e + \frac{t}{15} + KWD + i$$
$$= 12° - 0°02'03 + 3°21'25{,}53" + (-0°19'41{,}33") + 0°1'$$
$$= 15°00'51"$$
$$= 15.01\ WIB$$

The beginning of the asr time obtained is 15:01 WIB, which is the middle of the time until sunset.

c. Maghrib time

1. Sun Height Calculation

At the beginning of Maghrib time, the altitude of the sun is the same as at Shuruq time, which is -1° below the horizon. The position of the sun's disc at that time is above and in contact with the visible horizon line.

2. Regional Time Correction Calculation

$$KWD = \frac{Bujur\ Tempat - Bujur\ Daerah}{15}$$
$$= \frac{105° - 109°55'20"}{15}$$
$$= \frac{105° - 109°55'20"}{15}$$
$$= \frac{-4°55'20"}{15}$$
$$= -0°19'41{,}33"$$

3. Time Angle Calculation

$$\cos t = -\tan \varphi \tan \delta + \frac{\sin h}{\cos \varphi \cos \delta}$$
$$= -\tan -7°11'13" \tan 22°01'04" + \frac{\sin -1°}{\cos -7°11'13" \cos 22°01'04"}$$

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$$t = 88°09'54{,}7"$$

4. Sun Time Angle Calculation

$$\frac{t}{15} = \frac{88°09'54{,}7"}{15} = 5°52'39{,}65"$$

5. Calculation of the Beginning of Prayer Time

$$Waktu\ Magrib = Waktu\ Zuhur + \frac{t}{15}$$
$$= 11°39'5{,}67" + 5°52'39{,}65"$$
$$= 17°31'45{,}32"$$
$$= 17.31\ WIB$$

The maghrib time obtained is 17.31 WIB, which is when the sun sets. Maghrib is said to mark the end of the day and the beginning of night.

d. Isha time

1. Sun Height Calculation

At the beginning of Isha time, the position of the sun has entered the night phase where the darkness is complete. This condition can be observed when the altitude of the sun is -18° below the horizon.

2. Regional Time Correction Calculation

$$KWD = \frac{Bujur\ Tempat - Bujur\ Daerah}{15}$$
$$= \frac{105° - 109°55'20"}{15}$$
$$= \frac{105° - 109°55'20"}{15}$$
$$= \frac{-4°55'20"}{15}$$
$$= -0°19'41{,}33"$$

3. Time Angle Calculation

$$\cos t = -\tan\varphi \tan\delta + \frac{\sin h}{\cos\varphi \cos\delta}$$
$$= -\tan -7°11'13" \tan 22°01'04" + \frac{\sin -18°}{\cos -7°11'13" \cos 22°01'04"}$$
$$t = 106°33'26{,}39"$$

4. Sun Time Angle Calculation

$$\frac{t}{15} = \frac{106°33'26{,}39"}{15} = 7°06'13{,}76"$$

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5. Calculation of the Beginning of Prayer Time

$$Waktu\ Isya = Waktu\ Zuhur + \frac{t}{15}$$
$$= 11°39'5{,}67" + 7°06'13{,}76"$$
$$= 18°45'43"$$
$$= 18.46\ WIB$$

The beginning of the isha time was obtained at 18.46 WIB, just after the disappearance of the red light from the sky. Isha prayer is the last prayer and marks the end of the day which will be replaced by tomorrow.

e. Fajr time

1. Sun Height Calculation

The time of the beginning of dawn begins when dawn breaks on the eastern horizon, at which time the sun's altitude is -20° below the horizon.

2. Regional Time Correction Calculation

$$KWD = \frac{Bujur\ Tempat - Bujur\ Daerah}{15}$$
$$= \frac{105° - 109°55'20"}{15}$$
$$= \frac{105° - 109°55'20"}{15}$$
$$= \frac{-4°55'20"}{15}$$
$$= -0°19'41{,}33"$$

3. Time Angle Calculation

$$\cos t = -\tan\varphi \tan\delta + \frac{\sin h}{\cos\varphi \cos\delta}$$
$$= -\tan -7°11'13" \tan 22°01'04" + \frac{\sin -20°}{\cos -7°11'13" \cos 22°01'04"}$$
$$t = 108°42'52{,}93"$$

4. Sun Time Angle Calculation

$$\frac{t}{15} = \frac{106°33'26{,}39"}{15} = 7°06'13{,}76"$$

5. Calculation of the Beginning of Prayer Time

$$Waktu\ Subuh = 12° - e - \frac{t}{15} + KWD + i$$
$$= 12° - 0°02'03 - 7°14'51{,}53"$$

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$$+(-0°19'41{,}33") + 0°1'$$
$$= 4°24'14{,}14"$$
$$= 04.24\ WIB$$

The obtained time of Fajr prayer is 04.24 WIB before sunrise. Fajr prayer is also the first prayer of the day.

D. Conclusion

This research uses the concept of spherical trigonometry to determine the beginning of prayer time on the Mount Prau hiking trail. With this application, climbers can identify the beginning of prayer time precisely in accordance with established religious rules. This research has limitations in comparing calculation results, such as direct observation of the sun's position. Thus, further research can provide more information about the position of the sun in determining the beginning of prayer time.

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