Computer Assisted Calculations to Help Determine the Beginning of Islamic Months

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Abstract

Rapid technological advancement, exploration of space, a better understanding of the solar system, and man's ability to make accurate measurements of planetary movements and their relationship to the earth may be of particular interest to Muslims in the context of the Islamic Calendar. The accuracy with which the movement of the earth, the moon and the sun are tracked today may afford Muslims the opportunity to precisely determine the start of Islamic months within the framework of Islamic laws. This may prove helpful in preventing unnecessary conflicts in Islamic communities, and may provide for more brotherhood among Muslims. This manuscript presents a method that will help determine the beginnings of the Islamic months by using a computer to assess the available scientific data and their interpretation in accordance with the guidelines set forth by Qur'an and Sunnah. Also the manuscript will introduce a computer program developed as a part of the Stonehenge project of the University of Missouri at Rolla.

Introduction

While Arabs and other civilizations used a lunar calendar before Islam, 'Umar Ibn al Khattab formally proclaimed the lunar calendar as the Islamic calendar.[1] This aroused a Muslim interest in lunar cycles, resulting in many

1. William Benton, "A Society of Gentlemen in Scotland," *Encyclopaedia Britannica* (Encyclopaedia Britannica, 1971), p. 626.

considerable strides made by early Muslims in the area of Astronomy.[2] However, for the sake of simplicity and practical considerations, and because of inappropriate equipment to precisely determine the movement of the moon, its occurrance—which heralded the beginning of an Islamic month—was left to actual sighting.[3] This is clear from the following hadith:

> Fast upon sighting the new moon and stop your fasting upon seeing the new moon of the next month. (Sahih Al-Bukhari [6])[4]

The beginning of Islamic months have special significance for Muslims because of religious and social activities that follow the appearance of the new moon. Therefore, considerable attention is paid to the determination of the new Islamic month by Muslims all over the world. Laws were designed to prevent confusion and promote harmony in order to establish the beginning of the month. However, despite attempts to unify Islamic communities, confusion often prevails. At the beginning of the months of Ramadan and Shawal, for example, differences in the interpretation of Islamic laws occasionally lead to raging controversies within a community leading to division both locally and regionally. This paper proposes a method to accurately determine the beginning of the lunar month by taking advantage of available scientific data and by developing a computer program.

HISTORICAL PERSPECTIVE

During the Prophet Muhammad's time, people reported the sighting of the moon to him or whoever was in the position of authority. Then, based on the credibility of the witness(es), appropriate decisions were made which were acceptable to the masses. This system worked satisfactorily when communities were small and distances between them long. Each community decided independently when a given Islamic month started. However, with rapid transportation available today, distances have been reduced and advances in telecommunication have virtually linked distant

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2. 'Abd al-Halim 'Uways, "Al-Taqwim al-Qamari wa Mushkilatahu," *Asharq al-Awsat*, December 26: 13 (1984).

3. 'Ali al-Jundi, *Qurratu al-'Ayn fi Ramadan wa al-'Idayn* (Matābi' al-Ahram al-Tijariyah, 1969), pp. 49–58.

4. Muhammad Ibn Isma'il Al-Bukhari, *Saḥīḥ Al-Bukhari*, #1722 (Cairo Al-Jumhuriyah al-Arabiyah al-Muttahidah: Al-Majlis al-A'la li al-Shu'wn al-Islamiyah, Lijnat Ihya' Kutub al-Sunnah, 1971).

communities. This may have aroused the desire of Muslims around the world to unify. As a result, the validity of the conventional method of determining the beginning of the month—actually sighting the new moon—fell into question. Confusion in determining the regional boundaries and how far the boundaries should extend in the event a new moon is sighted in one locality, occasionally leads to divisions among neighboring Muslim communities, particularly at the beginning of Ramadan, and the day of *'Id al Fiṭr*. The conflicts become more serious when reports of sighting contradict logic and scientific fact. This has necessitated a closer scrutiny of the problems and triggered discussions as to how to take advantage of the scientific facts known today and how to adapt them to suit the needs of Muslims in the light of Islamic guidelines. Islamic teachings strongly emphasize the power of logic and the use of the mind to solve worldly problems. The challenge to the Muslims now is to prove that they are capable of comprehending the new technology and using it for their advancement.

Early Muslims had recognized the possibility of computing the different stages of the moon and decisions based on calculations received preference over that by sighting, if the credibility of the Muslim scholars were well established.[5] However, for the sake of simplicity early Muslim schools of thought did not force such a policy and left the final decision to an appointed regional authority.

Movement of the Sun and the Moon

The movement of the sun and the moon has been tracked for a long time but accurate measurement traditionally required a great deal of calculation. With the introduction of computers, it has become possible to integrate a number of equations into one problem. This paper will neither discuss the technical part of the equations nor the methods used to solve them, instead it will introduce a computer program written in FORTRAN to solve the equations,[6] and it will discuss the possibilities of using such programming to find a solution for the problem of determining the beginning of the lunar (Islamic) months.

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5. 'Ali al-Jundi, *Qurratu al-'Ayn fi Ramadan wa al-'Idayn;* and Hamid Al-Jawhari, "Al-Taqwim al-Hijri; Matali' Hilal Flamadan," Majallat al-Hidayah (1986): 20–26.

6. Sun Rise, Sun Set, Moon Rise, Moon Set, computer program distributed by the Muslim Student Association at the University of Missouri Rolla, 1985.

Table 1.

INPUT DATA

RAH	RAM	RASEC	DD	DM	DSEC	PMA	PMD	PARX	IEPH	FYR	FMO	FDY	FHR	FMN	FSC	DT	FINC	NOINC	FJD
0.	0.	.000	0.	0.	.000	0000	.000	.0000	1980	1999.	1.	1.	0.	0.	0	54.20	1.	30	.0000

2451179.50000 = BEGINNING JD. JMP= 4, IDT= 0, IET= 0, ISKIP= 0 PRAYER TIMING & MOON SIGHTING VER 1

LATITUDE AND LONGITUDE OF STATION FOR SUNRISE-SET & OPTIONAL STD TIME

LATITUDE D M S	LONGITUDE D M S	TIME ZONE H	TWILIGHT ANGLE D	ALT D
21. 27 .00 N	-39 45. .00 W	3.0	-18.	-.8333

DAY	FAJR H M	SUN RISE H M	ZUHR H M S	ASER H M	MAGHRIB H M	ISHA H M	SR AZ °	SS AZ °	NOON ALT DEG.
1999 JANUARY									
1 FRI	5 39.5	6 58.8	12 24 20.5	15 28.9	17 50.0	19 9.2	114 30.4	245 31.9	45.55
2 SAT	5 39.9	6 59.1	12 24 48.6	15 29.5	17 50.6	19 9.8	114 25.1	245 37.5	45.63
3 SUN	5 40.3	6 59.4	12 25 16.4	15 30.1	17 51.2	19 10.4	114 19.2	245 43.6	45.72
4 MON	5 40.6	6 59.7	12 25 43.9	15 30.7	17 51.9	19 10.9	114 12.8	245 50.2	45.82
5 TUE	5 40.9	6 59.9	12 26 10.9	15 31.3	17 52.5	19 11.5	114 6.0	245 57.3	45.93
6 WED	5 41.2	7 .2	12 26 37.5	15 31.9	17 53.2	19 12.1	113 58.6	246 4.9	46.04
7 THU	5 41.5	7 .4	12 27 3.7	15 32.5	17 53.9	19 12.7	113 50.8	246 12.9	46.16
8 FRI	5 41.8	7 .6	12 27 29.4	15 33.1	17 54.5	19 13.3	113 42.5	246 21.4	46.29
9 SAT	5 42.0	7 .8	12 27 54.7	15 33.8	17 55.2	19 13.9	113 33.7	246 30.4	46.43
10 SUN	5 42.3	7 .9	12 28 19.4	15 34.4	17 55.9	19 14.5	113 24.5	246 39.9	46.57
11 MON	5 42.5	7 1.0	12 28 43.5	15 35.0	17 56.5	19 15.1	113 14.8	246 49.8	46.72
12 TUE	5 42.7	7 1.2	12 29 7.2	15 35.6	17 57.2	19 15.7	113 4.6	247 .2	46.88
13 WED	5 42.9	7 1.2	12 29 30.2	15 36.2	17 57.9	19 16.3	112 54.0	247 11.0	47.05
14 THU	5 43.0	7 1.3	12 29 52.6	15 36.9	17 58.6	19 16.9	112 42.9	247 22.3	47.22
15 FRI	5 43.2	7 1.4	12 30 14.4	15 37.5	17 59.3	19 17.5	112 31.4	247 34.1	47.40
16 SAT	5 43.3	7 1.4	12 30 35.5	15 38.1	17 60.0	19 18.1	112 19.4	247 46.2	47.58
17 SUN	5 43.4	7 1.4	12 30 56.0	15 38.7	18 .6	19 18.6	112 7.0	247 58.8	47.77
18 MON	5 43.4	7 1.4	12 31 15.7	15 39.3	18 1.3	19 19.2	111 54.2	248 11.9	47.97
19 TUE	5 43.5	7 1.3	12 31 34.7	15 39.9	18 2.0	19 19.8	111 40.9	248 25.3	48.18
20 WED	5 43.5	7 1.3	12 31 53.0	15 40.5	18 2.7	19 20.4	111 27.3	248 39.2	48.39
21 THU	5 43.6	7 1.2	12 32 10.5	15 41.1	18 3.4	19 21.0	111 13.2	248 53.4	48.61
22 FRI	5 43.6	7 1.1	12 32 27.3	15 41.6	18 4.0	19 21.5	110 58.7	249 8.1	48.83
23 SAT	5 43.5	7 .9	12 32 43.3	15 42.2	18 4.7	19 22.1	110 43.9	249 23.1	49.06
24 SUN	5 43.5	7 .8	12 32 58.5	15 42.8	18 5.4	19 22.6	110 28.6	249 38.6	49.30
25 MON	5 43.4	7 .6	12 33 12.8	15 43.3	18 6.0	19 23.2	110 13.0	249 54.4	49.54
26 TUE	5 43.3	7 .4	12 33 26.4	15 43.9	18 6.7	19 23.8	109 57.0	250 10.6	49.79
27 WED	5 43.2	7 .2	12 33 39.1	15 44.4	18 7.4	19 24.3	109 40.6	250 27.1	50.04
28 THU	5 43.1	6 59.9	12 33 51.0	15 44.9	18 8.0	19 24.8	109 23.8	250 44.1	50.30
29 FRI	5 42.9	6 59.6	12 34 2.1	15 45.4	18 8.6	19 25.4	109 6.7	251 1.3	50.56
30 SAT	5 42.7	6 59.4	12 34 12.4	15 45.9	18 9.3	19 25.9	108 49.3	251 18.9	50.83
27 WED	5 43.2	7 .2	12 33 39.1	15 44.4	18 7.4	19 24.3	109 40.6	250 27.1	50.04
28 THU	5 43.1	6 59.9	12 33 51.0	15 44.9	18 8.0	19 24.8	109 23.8	250 44.1	50.30
29 FRI	5 42.9	6 59.6	12 34 2.1	15 45.4	18 8.6	19 25.4	109 6.7	251 1.3	50.56
30 SAT	5 42.7	6 59.4	12 34 12.4	15 45.9	18 9.3	19 25.9	108 49.3	251 18.9	50.83
31 SUN	5 42.5	6 59.0	12 34 21.9	15 46.4	18 9.9	19 26.4	108 31.5	251 36.9	51.11

*** INDICATES NO PHENOMENON

The computer program provides information in two sets. One of them is for the calculation of the movements of the sun (see Table 1) and the other for the calculation of the movements of the moon (see Table 2). The user

Table 2.

INPUT DATA:

RAH RAM RASEC DD DM DSEC PMA PMD PARX IEPH FYR FMO FDY FHR FMN FSC DT FINC NOINC FJD
0. 0. .000 0. 0. .000 .0000 .000 .0000 1980 1999. 1. 1. 0. 0. .0 54.20 1. 30 .0000
2451179.50000 = BEGINNING JD. JMP= 4, IDT= 0, IET= 0, ISKIP= 0 PRAYER TIMING & MOON SIGHTING VER 1
LATITUDE AND LONGITUDE OF STATION FOR SUNRISE-SET & OPTIONAL STD. TIME

LATITUDE D M S LONGITUDE D M S TIME ZONE H
21. 27. .00 N -39. 45. .00 W 3.0

	DAY	MOON RISE H M	MOON SET H M	LENGTH SHINE H M	MOON SOUTH H M S	MOON AZIMUTH RISE 0 '	MOON AZIMUTH SET 0 '	MERD. ALT DEG.	---THE MOON AGES--- AT RIS DAYS	AT MER DAYS	AT SET DAYS
1999 JANUARY											
F	1 FRI	17 22.3	5 56.7	13 32.2	** 0 .0	69 3.6	290 32.6	******	13.65	****	13.18
	2 SAT	18 22.1	6 57.4	13 35.1	0 10 2.5	69 18.2	290 59.7	88.08	14.69	13.9	14.22
	3 SUN	19 22.2	7 54.2	13 32.1	1 9 11.8	70 57.6	289 57.8	87.48	15.74	15.0	15.26
	4 MON	20 21.0	8 46.1	13 23.9	2 5 47.0	73 46.5	287 39.4	85.60	16.78	16.0	16.29
	5 TUE	21 17.6	9 33.2	13 12.1	2 58 60.0	77 25.6	284 22.7	82.72	17.82	17.1	17.33
	6 WED	22 11.6	10 15.9	12 58.4	3 48 45.6	81 36.5	280 26.6	79.13	18.85	18.1	18.36
	7 THU	23 3.4	10 55.5	12 43.9	4 35 30.5	86 3.1	276 8.3	75.12	19.89	19.1	19.38
	8 FRI	23 53.6	11 32.9	12 29.5	5 19 58.9	90 33.5	271 40.8	70.91	20.92	20.2	20.41
	9 SAT	***	.0	12 9.1	12 15.6	6 3 1.8	267 14.8	66.69	20.93	21.2	21.43
	10 SUN	0 42.7	12 45.2	12 2.5	6 45 30.6	94 57.6	262 58.9	62.60	21.96	22.2	22.46
	11 MON	1 31.6	13 22.0	11 50.4	7 28 13.6	99 7.2	259 1.2	58.77	22.99	23.2	23.49
A	12 TUE	2 20.8	14 0.4	11 39.6	8 11 53.7	102 54.0	255 29.8	55.33	24.03	24.3	24.51
	13 WED	3 10.8	14 41.3	11 30.5	8 57 5.3	106 9.3	252 33.8	52.43	25.06	25.3	25.54
	14 THU	4 1.6	15 25.2	11 23.6	9 44 9.7	108 43.1	250 23.1	50.21	26.10	26.3	26.57
	15 FRI	4 53.1	16 12.5	11 19.3	10 33 10.4	110 25.4	249 7.8	48.82	27.13	27.4	27.60
	16 SAT	5 44.7	17 3.1	11 18.4	11 23 50.4	111 6.8	248 56.5	48.41	28.17	28.4	28.64
	17 SUN	6 35.6	17 56.6	11 21.0	12 15 35.2	110 40.7	249 54.5	49.06	29.20	29.4	29.68
N	18 MON	7 25.1	18 52.2	11 27.1	13 7 42.1	109 5.1	252 1.7	50.79	.53	.8	1.01
	19 TUE	8 12.6	19 49.1	11 36.5	13 59 32.7	106 23.6	255 12.6	53.54	1.56	1.8	2.05
	20 WED	8 58.2	20 46.5	11 48.4	14 50 44.8	102 44.7	259 16.5	57.16	2.59	2.8	3.09
	21 THU	9 42.0	21 44.2	12 2.2	15 41 17.2	98 21.0	263 59.4	61.46	3.62	3.9	4.13
	22 FRI	10 24.7	22 42.1	12 17.4	16 31 29.2	93 27.1	269 5.4	66.18	4.65	4.9	5.17
	23 SAT	11 7.3	23 40.5	12 33.2	17 21 54.6	88 19.2	274 17.1	71.07	5.68	5.9	6.21
	24 SUN	11 50.6	***	***	18 13 14.7	83 14.5	***	75.84	6.71	7.0	7.25
	25 MON	12 35.7	0 39.6	12 49.0	19 6 7.5	78 30.7	279 16.3	80.19	7.74	8.0	7.25
	26 TUE	13 23.5	1 40.0	13 4.3	20 0 56.8	74 26.7	283 44.1	83.82	8.78	9.1	8.29
P	27 WED	14 14.7	2 41.3	13 17.7	20 57 39.6	71 20.9	287 21.1	86.45	9.81	10.1	9.33
	28 THU	15 9.3	3 42.6	13 27.9	21 55 38.6	69 29.4	289 49.5	87.85	10.85	11.1	10.37
	29 FRI	16 6.6	4 42.7	13 33.5	22 53 45.9	69 2.1	290 56.3	87.91	11.89	12.2	11.42
	30 SAT	17 5.6	5 40.2	13 33.5	23 50 41.7	70 .1	290 36.7	86.66	12.93	13.2	12.46
F	31 SUN	18 4.6	6 33.7	13 28.1	**	72 14.9	288 55.9	******	13.97	****	13.49

*** INDICATES NO PHENOMENON, N = NEW MOON, F = FULL, P = MOON NEAR PERIGEE, A = NEAR APOGEE, B = MOON BELOW HORIZON NEW MOON OCCURS ON DAY 17 AT 18.7 HOURS

has to select the appropriate table in order to make the best use of the provided information.

Table 3.
Exact Location of Sun and Moon and the Difference in Their Setting Time on January 17, 18, and 19, 1999

Date of Observation	January 17	January 18	January 19
Location from North			
Location of Sunset*	247 58.8	248 11.9	248 25.3'
Location of Moonset*	249 54.5	252 1.7	255 12.6'
The Difference	1 55.3	3 49.8	6 47.3
Time of Sunset**	18 0.6	18 1.3	18 2.0
Time of Moonset**	17 56.6	18 52.2	19 49.1
The Different	-0 4.0	0 50.9	1 47.1
Moon's Age at Set (in Days)	29.68	1.01	2.05

* Locations are given in degrees and minutes starting from true North.
** Time is given in hours and minutes for local time (Makkah, Saudi Arabia).

THE SUN AND MOON TABLES

The results shown in Table 1 provide basic information about the movement of the sun. This table can be used for calculating prayer times as well as for calculating the location of the sun at sunrise, noon, and sunset for a given location on earth. Makkah has been chosen as the example in Table 1. The results shown in Table 2 provide similar information for the moon.

For most locations on earth the best place to locate the new moon is near where the sun sets; and the best time to sight the new moon is at sunset. Therefore, information about the location of the sun and the difference between its location and that of the moon's can provide the observer with the best predicted location for sighting of the new moon. The difference between the time of the sunset and the time of the moonset can give the observer an idea about the time available for sighting the moon. The program also gives the day when the new moon starts so that one does not have to look through all the days; such attempts could be limited to only one day before or after the expected appearance of new moon. The example given in Table 3 is for the days of January 17, 18, and 19, 1999.

In order to make use of the results of Table 3, it should be realized that if the moon sets before the sun, the new moon cannot be sighted because the light of the sun will make sighting impossible. Therefore, the new moon of Shawwal cannot be sighted on January 17 because on this day the moon sets 5 minutes before the sun. On January 18, the moon sets 51 minutes

after the sun, thus making it probable to sight the moon. From this example, the first day of Shawwal will be January 19, 1999. In addition to this information, the program also gives an idea about the age of the moon at the time of observation. This information is given for three times of the day.

Proposed General Solution

If simplicity and science are acceptable, the following two general solutions could be proposed by employing the previous information:

The first solution is, taking Makkah as a reference point, calculate the beginning of the Islamic month astronomically in advance and let all Muslims follow that, regardless of location or political system. This approach is more logical for the pilgrimage to Makkah, for Hajj is an international Islamic event even though appearance of the moon may be considered a regional matter.

The second solution responds to the insistence of local sighting of the moon. The program offers valuable and precise information about the time of the new moon, regardless of the observer's location. In the example above, the new moon began on January 17 at 16.3 Hr. (Table 2). If the scientific solution is accepted as the basis for decision making, then the new moon is decided with relevance to the astronomical new moon, regardless of the observer's location. This means that once the time of the new moon is decided astronomically, each country will start the month of Ramadan according to their time zone or that of the community's political center. For example, if the sun sets at 6 o'clock for a given observer in a given time zone, while the new moon started before six for that observer, then Shawwal is the next day regardless of whether the observer saw the new moon or not. If the new moon started after six then Shawwal begins the day after. With such a system the time and location of the astronomical new moon can be announced in advance, benefiting Muslims all over the world.

Conclusion

To continue ignoring the scientific facts is in no way Islamic. Scientific facts should be accepted and adapted within the Islamic context. In the Qur'an Allah says:

> If ye realize this not, ask of those who possess the message. (*al Nahl*:43)

Also, when the Prophet Muhammad was asked about a method of polinating the date palms to increase their yield, he responded by saying: "You know better about your worldly problems."[7]

The general meaning of the *ayah* and the *hadith* is that in worldly issues, it is up to Muslims to evaluate their circumstances and make decisions. Decisions on the new moon should be given to Muslim scientists who possess the knowledge and wisdom to help answer the question. It is time for Muslim scholars and governments to recognize the fact that such decisions are worldly issues and can be solved scientifically, keeping in mind the guidelines set forth by the Qur'an and Sunnah.

Computer programs that calculate the movement of the sun and moon have been made by several Muslim and non-Muslim scientists and can be purchased [or downloaded from the Internet, Ed., 1998].

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7. Muhammad Ibn Yazid Ibn Majah, *Sunan al-Hajiz Abi 'Abd Allah Muhammad ibn Yazid al-Qazwini ibn Majah, 15 Kitab Al-Ruhun*, #2471, edited by Muhammad Fu'ad 'Abd al-Baqi (Dar Ihya' al-Turath al-'Arabi, 1975), p. 825.