DOI: 10.21276/sjpms.2017.4.1.2

Scholars Journal of Physics, Mathematics and Statistics **ISSN 2393-8056 (Print)**
Sch. J. Phys. Math. Stat. 2017; 4(1):10-16 **ISSN 2393-8064 (Online)**

(An International Publisher for Academic and Scientific Resources)

Calculation of the Dates of New Moon and Full Moon of All Months of the Upcoming Five Years (2017-2021)

Md. Towhiduzzaman[1*], A. Z. M Asaduzzaman[2]

[1]Lecturer in Mathematics, Department of Electrical & Electronic Engineering, Uttara University (UU), Dhaka-1230, Bangladesh

[2]Lecturer, Department of Information & Communication Technology (ICT), Khoksa College, Khoksa, Kushtia-7020, Bangladesh

***Corresponding Author:**
Md. Towhiduzzaman
Email: towhid.math.iu@gmail.com

Abstract: In this paper we have investigated some aspects of astronomical phenomenon of Moon. We have discussed about Moon's phases and different phenomena of Moon's phases. We have calculated the dates of new moon and full moon of all months of the five years (2017-2021) with respect to the Bangladesh time. Actually these calculations need to find the date of lunar and solar eclipses.
Keywords: Astronomy, moon's orbit, moon's phases, moon visibility, new moon, full moon, harvest moon

INTRODUCTION

Every night, the moon shows its different phases in the night sky. On some nights we can see its entire face, sometimes it's partial, and on others it isn't visible at all. These phases of the Moon aren't random; they change throughout the month in a regular and predictable way. As the Moon travels in its 29.53 day orbit, its position changes daily. Sometimes it's between the Earth and the Sun and sometimes it's behind us. So a different section of the Moon's face is lit up by the Sun, causing it to show different phases. Over the billions of years of the Moon's existence, it has moved farther away from the Earth, and its rate of rotation has also slowed. The Moon is tidally locked with the Earth, which means that the Earth's gravity drags the Moon to rotate on its axis. This is why the Moon rotates only once per month and why the same side of the moon always faces the Earth [1-2].

The moon rises and sets every day, appearing on the horizon just like the sun. The time depends on the phase of the Moon. It rises about 30 to 70 minutes later each day than the previous day, so the Moon is out during daytime as often is it's out at night. At the time of the new Moon, the moon raises at about the same time the sun rises, and it sets at about the same time the sun sets. As the days go by the Moon rises during daytime, rising later each day, and it sets at night time, setting later and later each night. At the full Moon, the times of moonrise and moonset have advanced so that the Moon raises about the same time the Sun sets, and the Moon sets at about the same time the Sun rises. As the moon wanes, the moon rises during the night, after sunset, rising later each night. It then sets in the daytime, after the sun rises. Eventually, the moon rises so late at night that it's actually rising around sunrise, and it's setting around sunset. That's when it's a new Moon once again [3-4].

The revolution of the Moon around the Earth makes the Moon appear as if it is changing shape in the sky. This is caused by the different angles from which we see the bright part of the Moon's surface. These are called phases of the Moon.

The Moon doesn't generate any light itself; it just reflects the light of the Sun. The Moon passes through four major shapes during a cycle that repeats itself every 29.53 days. The phases always follow one another in the same order.

There are four major phases of Moon. The four major moon phases are new, first quarter, full and last or 3rd quarter. These phases have to do with the relative positions of the Sun, the Moon and the Earth in the Moon's 29 day monthly orbit of the Earth. Although this cycle is a continuous process, there are eight distinct, traditionally recognized stages, called phases. The phases designate both the degree to which the Moon is illuminated and the geometric appearance of the illuminated part [5-6]. These phases of the Moon, in the sequence of their occurrence which are listed below in the Fig. 1.

Fig-1: The Phases of the Moon, from bobthealien.co.uk

MATERIALS AND METHOD

When the Moon is roughly in the same direction as the Sun, its illuminated half is facing away from the Earth, and therefore the part that faces us is all dark, we have the new moon. When in this phase, the Moon and the Sun rise and set at about the same time.

Two weeks after the new moon, the moon is now halfway through its revolution, and now the illuminated half coincides with the one facing the Earth, so that we can see a full disk and we have a full moon. As mentioned above, at this time the Moon rises at the time the Sun sets, and it sets when the Sun rises. If the Moon happens to align exactly with the Earth and Sun, then we get a lunar eclipse. The Moon's illuminated side is facing the Earth [7-8].

The Moon appears to be completely illuminated by direct sunlight. The lighter side of the Moon faces the Earth. This means that the Earth, Sun, and Moon are nearly in a straight line, with the Earth in the middle. The Moon that we see is very bright from the sunlight reflecting off it.

Relative to the sun, the moon moves from west to east through 360^0 every 29.53 days and in this period the moon crosses meridian 28.5 times. The interval between two successive upper transits is $\frac{29.53}{28.5}\times 24$ hours or about 24 hours and 50 minutes of mean solar time. Thus the Moon crosses the celestial meridian about 50 minutes later from day to day. The daily retardation of moonrise also averages about 50 minutes but it is not uniform; in high latitudes it is sometimes as great as 1 hour 26 minutes and sometimes as small as 17 minutes [9-10].

Metonic cycle

Meton first discovered (in 433 B.C.) that 19 years expressed in days is an almost exact multiple of a lunation (29.5305881 days).

$$One\ \ tropical\ year = 365.2422\ days$$

$$19\ years = 365.2422\times 19 = 6939.6018\ days$$

$$29.5305881\times 235 = 6939.6882\ days$$

Thus in every 19 years there are almost exactly 235 lunation. Hence at the end of every 19 years, the sun and the moon return to the same positions with respect to the fixed stars so that all the phases of the moon occur again in the same days of the month as for the preceding 19 years, only that they will occur about 0.0864 days or 2 hours 4 minutes later [1]. This is called Metonic cycle [11].

Moon visibility

The table following gives a summary of approximately when the Moon is visible and where to look (the crescent and gibbous phases are in between the table values). There are times during the moon's monthly cycle that the Moon is sometimes visible in broad daylight.

Table 1: The crescent and gibbous phases

Phase	Ahead or Behind the Sun	Rise Time in East	Mid-Point In Sky	Set Time In West
New	Within few minutes	Sunrise	Noon	Sunset
1st Qtr.	6 hrs behind	Noon	Sunset	Midnight
Full	12 hrs behind	Sunset	Midnight	Sunrise
3rd Qtr.	6 hrs *ahead*	Midnight	Sunrise	Noon

Why does the Moon have phases?

The Moon has phases because it orbits Earth, which causes the portion we see illuminated to change. The Moon takes 27.32 days to orbit Earth, but the lunar phase cycle is 29.5 days. The Moon spends the extra 2.2 days catching up because Earth travels about 45 million miles around the Sun during the time the Moon completes one orbit around Earth.

At the new Moon phase, the Moon is so close to the Sun in the sky that none of the side facing Earth is illuminated. In other words, the Moon is between Earth and Sun. At first quarter, the half-lit Moon is highest in the sky at sunset, then sets about six hours later. At full Moon, the Moon is behind Earth in space with respect to the Sun. As the Sun sets, the Moon rises with the side that faces Earth fully exposed to sunlight.

We can create a mockup of the relationship between Sun, Earth, and Moon using a bright lamp, a basketball, and a baseball. Mark a spot on the basketball, which represents us as an observer on Earth, then play with various alignments of Earth and Moon in the light of our imaginary Sun [12].

Why do we always see the same side of the Moon from Earth?

The Moon always shows us the same face because Earth's gravity has slowed down the Moon's rotational speed. The Moon takes as much time to rotate once on its axis as it takes to complete one orbit of Earth. Both are about 27.32 Earth days. In other words, the Moon rotates enough each day to compensate for the angle it sweeps out in its orbit around Earth.

Gravitational forces between Earth and the Moon drain the pair of their rotational energy. We see the effect of the Moon in the ocean tides. Likewise, Earth's gravity creates a detectable bulge 60 foot land tide on the Moon. Eons from now, the same sides of Earth and Moon may forever face each other, as if dancing hand in hand, though the Sun may balloon into a red giant, destroying Earth and the Moon, before this happens [13].

When does the young Moon first become visible in the evening sky?

There is no real formula for determining the visibility of the young Moon. It depends on several factors, the angle of the ecliptic with respect to the horizon, the clarity of the sky, and even the keenness of the observer's eyesight.

The young Moon becomes visible to the unaided eye much earlier at times when the ecliptic is perpendicular to the horizon, and the Moon pops straight up into the sky. In these cases, it may be possible to see the Moon as little as 24 hours after it was new, although every hour beyond that greatly increases the chances of spotting it. When the ecliptic is at a low angle to the horizon, and the Moon moves almost parallel to the horizon as it rises, the Moon probably doesn't become visible until at least 36 hours past new.

The record for the earliest claimed sighting of the young crescent Moon is around 19 hours, although most experts are suspicious of any claims of times less than about 24 hours [14-15].

Mathematical formula for Calculating of Moon's phases

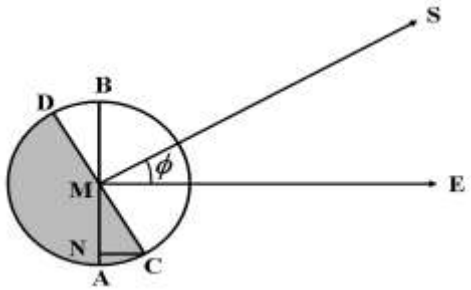

Fig-2: Position of the Sun, Earth and Moon

Let M be the centre of the moon and MS, ME be the direction of the sun and the earth. Also let r be the radius of the moon. ACBD is the section of the moon by the plane through MS and ME which has been shown in the Fig. 2. Then CBD is the illuminated half of which CB is the portion presented towards the earth. From C we draw CN perpendicular to the diameter AB, which are the right angles to the direction of the earth [16-17]**.**

$$Let,\quad \angle SME = \phi, \text{ then } MN = r\cos CMN = r\cos(90^0 - CME)$$

and phase

$$= r\cos\{(90^0 - (90^0 - SME)\} = r\cos\phi$$

$$= \frac{BN}{AB} = \frac{r + MN}{2r} = \frac{r + r\cos\phi}{2r} = \frac{1+\cos\phi}{2} \qquad (1)$$

where ϕ is the angle subtended at the moon by the earth and the sun**.**

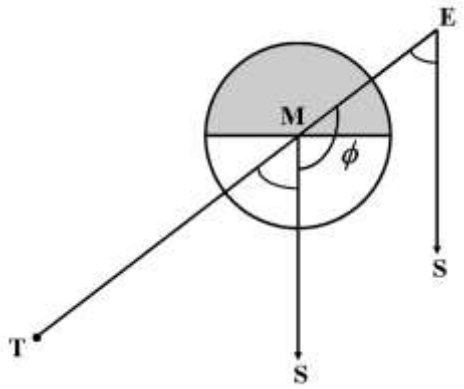

Fig-3: Position of the Sun, Earth and Moon

Now, the sun being very far away from the earth in comparison with the distance of the moon from the earth, MS and ES may be regarded parallel which has been shown in the Fig.3. so that, if we take $\angle MES = \angle TMS = E,\ then\ \phi = 180^0 - E$

$$\text{and phase } = \frac{1+\cos\phi}{2} = \frac{1+\cos(180^0 - E)}{2} = \frac{1-\cos E}{2} \qquad (2)$$

Now if we consider 8 phases of the moon, then using by the following Fig.4 and using equation (2), we wet,

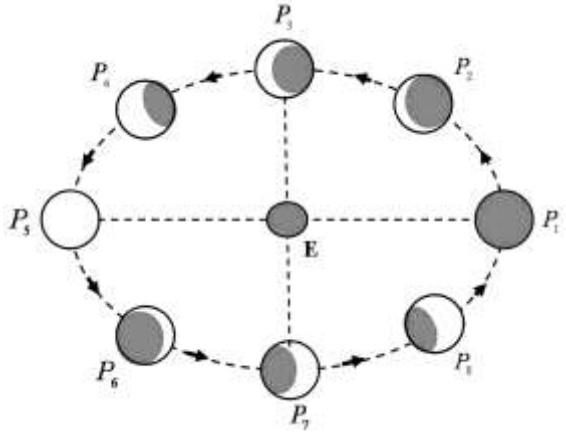

Fig-4: Orbital positions of the Moon around the Earth

(i) when the moon is at the position P_1, then $E = 0$

$$\therefore Phase\ of\ moon = \frac{1-1}{2} = 0\text{, then new moon.}$$

(ii) when the moon is at the position P_2, then E is actual angle

$\therefore$ Phases is less than $\frac{1}{2}$, then waxing crescent moon.

(iii) when the moon is at the position P_3, then $E = 90^0$

$\therefore Phase\ of\ moon = \frac{1-0}{2} = \frac{1}{2}$, then first quarter moon.

(iv) when the moon is at the position P_4, then E is obtuse

$\therefore$ Phases is greater than $\frac{1}{2}$, then waxing gibbous moon.

(v) when the moon is at the position P_5, then $E = 180^0$

$\therefore Phase\ of\ moon = \frac{1-(-1)}{2} = 1$, then full moon.

RESULTS AND DISCUSSION

At this point, we attempted to give a brief account on the measurements by calculating the dates of new moon and full moon of all months of the five years (2017-2021).

Table 2: New Moon and Full Moon 2017

Month	New Moon		Full Moon	
	Day	Time	Day	Time
January	4	3 pm	20	3 am
February	3	8 am	18	3 pm
March	5	3 am	20	12 am
April	3	9 pm	18	9 am
May	3	1 pm	17	5 pm
June	2	3 am	16	2 am
July	1	10 pm	15	12 pm
July	31	12 am		
August	29	9 am	14	1 am
September	27	5 pm	12	3 pm
October	27	2 am	12	8 am
November	25	12 pm	10	3 am
December	25	12 am	10	9 pm

Table 3: New Moon and Full Moon 2018

Month	New Moon		Full Moon	
	Day	Time	Day	Time
January	23	1 pm	9	2 pm
February	22	4 am	8	4 am
March	22	9 pm	8	4 pm
April	21	2 pm	7	2 am
May	21	6 am	6	10 am
June	19	9 am	4	5 pm
July	19	10 am	4	1 am
August	17	10 pm	2	9 am
August			31	8 am
September	16	8 am	30	9 am
October	15	6 pm	30	2 am
November	14	4 am	28	9 pm
December	13	3 pm	28	4 pm

Table 4: New Moon and Full Moon 2019

Month	New Moon		Full Moon	
	Day	Time	Day	Time
January	12	1 am	27	11 am
February	10	1 pm	26	3 am
March	12	2 am	27	4 pm
April	10	4 pm	26	2 am
May	10	6 am	25	10 am
June	8	10 pm	23	5 pm
July	8	1 pm	23	12 am
August	7	4 am	21	8 am
September	5	6 pm	19	5 pm
October	5	7 am	19	6 am
November	3	7 pm	17	9 pm
December	3	6 am	17	3 pm

Table 5: New Moon and Full Moon 2020

Month	New Moon		Full Moon	
	Day	Time	Day	Time
January	1	5 pm	16	11 am
January	31	4 am		
February			15	6 am
March	31	1 am	17	12 am
April	29	12 pm	15	2 pm
May	29	12 am	15	1 am
June	27	2 pm	13	10 am
July	27	5 am	12	5 pm
August	25	8 pm	11	12 am
September	24	12 pm	9	8 am
October	24	4 am	8	5 pm
November	22	7 pm	7	4 am
December	22	8 am	6	6 pm

Table 6: New Moon and Full Moon 2021

Month	New Moon		Full Moon	
	Day	Time	Day	Time
January	20	8 pm	5	11 am
February	19	6 am	4	5 am
March	20	4 pm	6	12 am
April	19	1 am	4	6 pm
May	18	10 am	4	10 am
June	16	8 pm	2	10 pm
July	16	7 am	2	8 am
July			31	5 pm
August	14	9 pm	30	1 am
September	13	1 pm	28	9 am
October	13	6 am	27	6 pm
November	12	12 am	26	4 am
December	11	5 pm	25	5 pm

CONCLUSION

Here, we have presented the phases of Moon and different aspects of Moon's phases. We have computed the dates of new moon and full moon of all months of the next five years (2017-2021) of Bangladesh time. Basically these enumerations need to find the date of lunar and solar eclipses. We think this paper will be useful for those who are interested to know the dates of new moon and full moon of all months of the upcoming five years.

REFERENCES

1. Bailey JM, Slater TF. A Review of Astronomy Education Research, the Association of Universities for Research in Astronomy, Inc. 2004;2(2):20-45.
2. Barnett M, Morran J. Addressing Children's Alternative Frameworks of the Moon's Phases and Eclipses. International Journal of Science Education. 2002;24(8):859-879.
3. Dunlop J. How Children Observe the Universe. Publications of the Astronomical Society of Australia. 2000;17(2):194-206.
4. Hemenway MK, Straits W, Wilke RR, Hufnagel B. Educational Research in an Introductory Astronomy Course. Innovative Higher Education. 2002;26(4):271-280.
5. Parker J, Heywood D. The Earth and Beyond: Developing Primary Teachers' Understanding of Basic Astronomical Events. International Journal of Science Education. 1998;20(5):503-520.
6. Sadler PM. Choosing Between Teaching Helioseismology and Phases of the Moon. The Physics Teacher. 2001;39(December):554-555.
7. Brickhouse NW, Dagher ZR, Shipman HL, Letts WJ. Evidence and Warrants for Belief in a College Astronomy Course, Science and Education. 2002;11(6):573-588.
8. Skam K. Determining Misconceptions about Astronomy. Australian Science Teachers Journal. 1994; 40(3):63-67.
9. Abell S, George M, Martini M. The Moon Investigation: Instructional Strategies for Strategies for Elementary Science Methods. Journal of Science Teacher Education. 2002;13(2):85-100.
10. Prather EE, Slater TF, Offerdahl EG. Hints of a Fundamental Misconception in Cosmology. Astronomy Education Review. 2002;1(2):28-34.
11. Slater TF, Adams JP. Mathematical Reasoning over Arithmetic in Introductory Astronomy. The Physics Teacher. 2002;40(5):268-271.
12. Trundle KC, Atwood RK, Christopher JE. Preservice Elementary Teachers' Conceptions of Moon Phases before and After Instruction. Journal of Research in Science Teaching. 2002;39(7):633-658.
13. Gislén L, Eade CJ. Burmese shadow calculations. Journal of Astronomical History and Heritage. 2014;17(3):258–266.
14. Hufnagel B. Development of the Astronomy Diagnostic Test. Astronomy Education Review. 2002;1(1):47-51.
15. Adams JP, Slater TF. Astronomy in the National Science Education Standards. Journal of Geoscience Education. 2000;48(1):39-45.
16. Marzouk BA, Abdel-Rahman HI, Bendary R, Elsayed AA. Statistical Investigation of the Solar Eclipses During Four Centuries (1601-2000). International Journal of Advanced Research. 2016;4(2):221-226.
17. Abell S, Martini M, George M. That's what Scientists have to do': Preservice Elementary Teachers' Conceptions of the Nature of Science during a Moon Investigation. International Journal of Science Education. 2001;23(11):1095-1109.