# How to Determine the Day of the Next Conjunction, Easily

(Edition 1.0 10.10.2006)



The modern Islamic and formerly the ancient Jewish community have attempted to estimate the time when a first crescent moon can be seen. With the ancient lists of approved witnesses it proved difficult to predict the day in question and made publishing a Lunar Calendar impossible. Even with modern equipment and available quick computations, regularly knowing the time when a first crescent moon can be seen has proved to be impossible. The conjunction cannot be seen. However, by obtaining the number of centimeters separating the Sun and Moon at sunrise and multiplying this number times two, anyone can easily determine the time and the day of the next conjunction.

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## The Natural Astronomical Cycle

All of Humanity must worship the One True God, our Father, Eloah, on the days that are set apart by the natural astronomical cycle.

The twenty-four hour day, or one solar rotational day, is from dark, or the end of evening nautical twilight, to dark in our local time (Ge. 1:5; Ps. 104:20). (See the paper Start of the Day).

The New Moons occur at the conjunction of the sun, moon and earth. These days are Sabbaths. The first day of the first month establishes, or sets the three annual Feasts with the attendant Sanctified Days, as annually set apart for a specific purpose or made holy, for worship.

The year begins in the northern hemisphere spring (Ex. 12:2), with the first day of the first month being established, or set apart from the conjunction, during Jerusalem time (Isa. 2:3).

The month which is the first month of the year, is the one which has the 15th day which follows after the vernal equinox. This day is the Passover, which is categorized as a full moon.

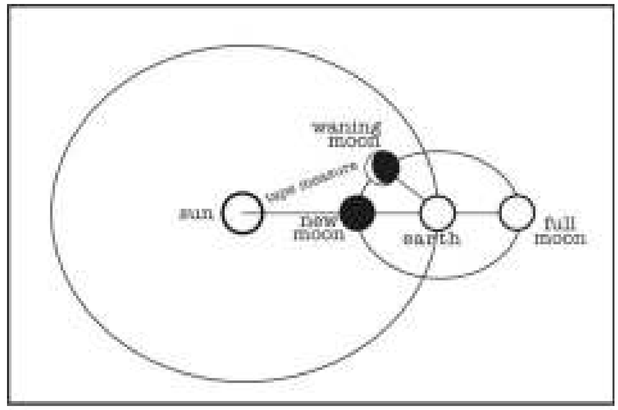
Many people will tell us that we need specialized mathematical abilities in order to be able to determine when the conjunctions will occur. Everyone who can multiply times 2 and divide by 24 can determine the day and the hour of the next conjunction - easily!

## The Conjunction

We will be speaking below about the conjunction of the sun and the moon and the earth. In astronomy, conjunction (or to be conjoined), means when there is a meeting of two or more heavenly bodies in the same longitude, or right ascension.

This is termed the ‘new moon’, when the moon is between the earth and sun, and is termed the ‘full moon’, when the earth is between the sun and moon.

This should be clear from the images below. The new moon cannot be seen while the full moon reflects a full measure from the reflected light of the sun.






Although the proportions above are incorrect, the image above shows that at the conjunction the sun, moon and earth look like they are on a geometric line with their centers pierced. They are all on the same longitude and we are ignoring the latitude. At the time of the new moon the centers of the sun, moon and earth are in complete alignment.

The time of the conjunction is a precise time everywhere on the planet, according to our local time zone. Therefore, it will be in a two day period using local time. This is the reason that the day which is set apart or made Holy is the day during which time this event happens within Jerusalem’s time frame.

> *Philo of Alexandria* [tr. by F H Colson (Harvard University Press, Loeb Classical Library, Cambridge, MA, 1937); *The Special Laws, II, XI,41*] writes: "The third [feast] is the new moon which follows the conjunction of the moon with the sun". And in *II, XXVI,140*: "This is the New Moon, or beginning of the lunar month, namely the period between one conjunction and the next, the length of which has been accurately calculated in the astronomical schools".

It should be noted that the popular Hendrickson Publisher’s edition (1993), of C D Jonge’s 1854 translation, does not have the same information that the Colson translation gives.

Philo was a Jewish historian who was writing at the time of Christ.

As we can see, the conjunctions were declared to be the determining factors in deciding the first day of the month, and not the crescent moon. Note that at the time of Christ this length of time was being accurately calculated in the astronomical schools.

Maimonides' book, "Sanctification of the New Moon", (Book Three, Treatise 8, page 89, chapter 6) which was written about 1200 CE, states:

> "the molad is defined as `the moment in which sun and moon, in their uniform motion, become conjoined in a certain part of the sky, which occurs in the same way everywhere - in contrast to the varying times at which the new crescent first becomes visible - in different areas'."

This statement also defines the conjunction. At the same time Judaism, in general, did not, and today do not keep the New Moon as a Sabbatical Holy Day. They and Islam, attempt to start the month by a crescent observation (see the paper *The Sin of Crescent Moon Observation* ).

The lunisolar conjunction can take place at any time during the earth's twenty-four hour solar rotation. As Maimonides points out it occurs in the same way, at the same time, everywhere on the planet.

The time that this event takes place during Jerusalem's twenty-four hour time zone sets apart that New Moon Day at the conjunction as a Sabbath (Am. 8:5; Isa. 66:20-23; Ez. 46:3; Ps. 81:3; Col. 2:16).

This study is important so that everyone can learn to easily determine any upcoming New Moon Holy Day, if the published times are not available.

The precision with which this event could be predicted, allowed all seafaring communities and naval forces to gauge their coming and going. This is important to them because the moon's cycles govern the ocean's tides.

Throughout the world, the conjunction is on the day that begins the new astronomical month.

The fact is that we are coming out of a Trinitarian induced *dark age.*

The proponents of Trinitarian Christianity have intentionally removed most of the knowledge people had from ancient times.

The book, *Maps of the Ancient Sea Kings*, 1966, by Charles Hapgood, is a useful reference. It shows and explains many of the ancient maps and records from Alexandria. It explains the detailed extensive geographical knowledge, and navigational understanding, that the ancient peoples possessed.

All naval and fishing people everywhere on the earth have understood this luni-solar timing and the tide's relationship with the moon's journey. It is only recently that people generally have abandoned this knowledge that was also necessary for travel.

## The Lunar Cycle

The moon's apparent daily travel around the earth takes 24 hours and 50 minutes. This causes the oceans to rise and fall at fairly regular intervals. On the average, the period between two successive high tides is 12 hours and 25 minutes, or one half the time it takes the moon to circuit the earth. The ocean's tides are caused primarily by the moon's gravitational pull.

At the conjunction the moon is lined up with the sun from outside our point of view on earth. We see the dark side of the moon, or rather we don't see the moon at all because the extreme brightness of the sun outshines the extremely dim moon.

A new moon occurs when the apparent longitudes of the moon and sun differ by 0°.

As the moon moves eastward away from the sun in the sky, we see a bit more of its sunlit side each night. So a few days after a new moon we can see a thin crescent in the western evening sky. At this point, and for the next few nights, we can see the dark side of the moon faintly illuminated by sunlight reflected off the earth.

The first quarter moon is the crescent moon continuing to wax, or grow fatter.

When half the moon's disc is illuminated we say the moon has reached first-quarter phase. That term comes from the fact that the moon is a quarter of the way through lunation.

At first quarter, the moon is 90 degrees east of the sun along the ecliptic, so we're looking at the sunlit side of the moon from off to the side. At this time, 50% of the moon's visible surface is illuminated.

Because it is 90 degrees from the sun, the first-quarter moon sets approximately halfway through the night.

The waxing gibbous moon continues to wax (grow fatter), but it's no longer a crescent. During this period after first quarter, we say we have a *gibbous* moon.

The full moon is opposite the sun in the sky and we see all of the moon's sunlit side. The full moon is 180 degrees around the ecliptic from the sun in the sky. At this time 100% of the moon's visible surface is illuminated.

It rises almost exactly as the sun is setting, and sets almost as the sun rises the next morning.

The second half of the moon's journey is the inverse of the first. Now the moon is waning, or growing slimmer, and it's once more described as gibbous.

A waning gibbous moon is the second half of the moon's journey, and is the inverse of the first. Each evening it rises later and later, after sunset.

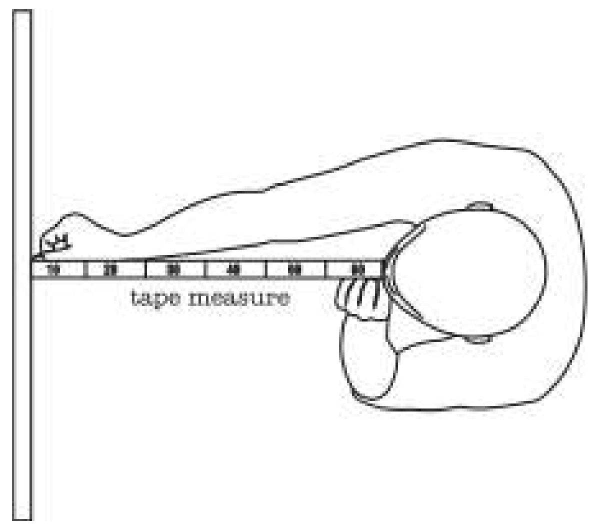
The third quarter moon is three-quarters of the way around its journey, and the moon once again shows us one side of its disc illuminated and the other in darkness. However, the illuminated side we see now is the one that was in darkness at first-quarter phase. The last quarter occurs when the apparent longitudes of the moon and sun differ by 270°. At this time, 50% of the moon's visible surface is illuminated.

The moon rises around midnight, and crosses the local meridian around sunrise. As it approaches new moon, the phase of the moon is a waning crescent, until we can't see it at all. It then becomes a new moon and then repeats the cycle.

We won't see the last crescent moon much after an age of maybe 28 days or so. We seldom see the new crescent moon until it has an age of more than 24 hours.

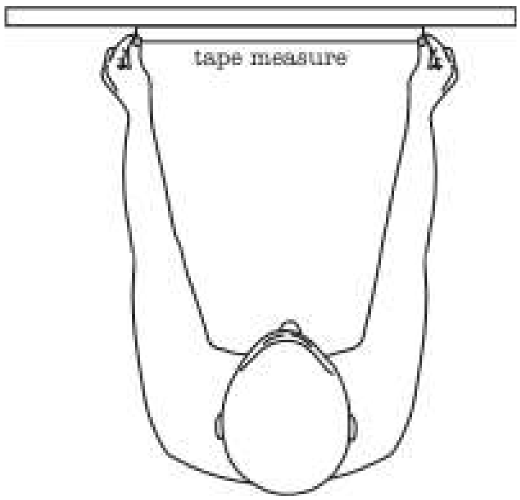
### How to Calibrate the Tape Measure

We should hold a tape measure at arm's length, directly in front of our face. Typically, the distance between our eyes and the ruler at arm's length is about 60 centimetres for the average adult.




In order to calibrate the tape measure for our body size, we stand facing a wall and measure 60 cm between our eyes and the wall. If we have long or short arms we will need to adjust as this measure is important for gauging degrees and therefore time at a distance; the sun and moon’s distance in our case.

At that distance, a one centimetre division on the ruler will present an angle of 1/60 radian. Since one degree is equivalent to 1/57.295 radian, the angle subtended by a 1 cm object at arm's length is a quite reasonable approximation to one astronomical degree. For example, the apparent diameter of the full moon would be about 0.5 cm when viewed with a ruler held at arm's length.




Hold the tape measure flat against the wall with two hands at this 60cm distance. Adjust hands, arms, shoulders, hips and neck so that we can touch the wall flat with the tape but our eyes remain the original 60cm distance. Remember this position for accuracy when performing the measurement between the rising sun and the waning (growing slimmer) crescent moon.

Angles can be estimated to a reasonable approximation by holding a ruler at arm's length, or by using the hand itself.

A clenched fist (excluding the thumb) spans about 10 degrees while a full-spread hand spans about 20 degrees, from the tip of the thumb to the tip of the little finger. For smaller angles we can use other guidelines. For example, at arm's length the width of our smallest finger is roughly one degree. A thumb's width facing us is about two degrees and on its side is one degree, and the distance from the tip of our thumb to its first joint is about three degrees.

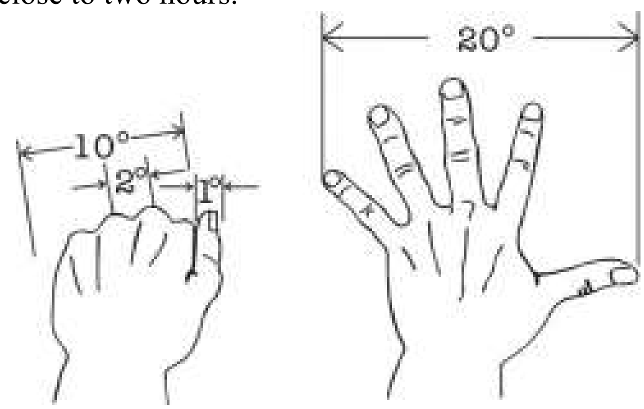
Although everyone's hands and arms are different, of course, it is still easy enough to take our own measurements of arm length, hand span and so on, and to calibrate our own natural guides to help us estimate angles in the sky.

*Adapted from an article in (British) Astronomy magazine* by Iain Nicolson.

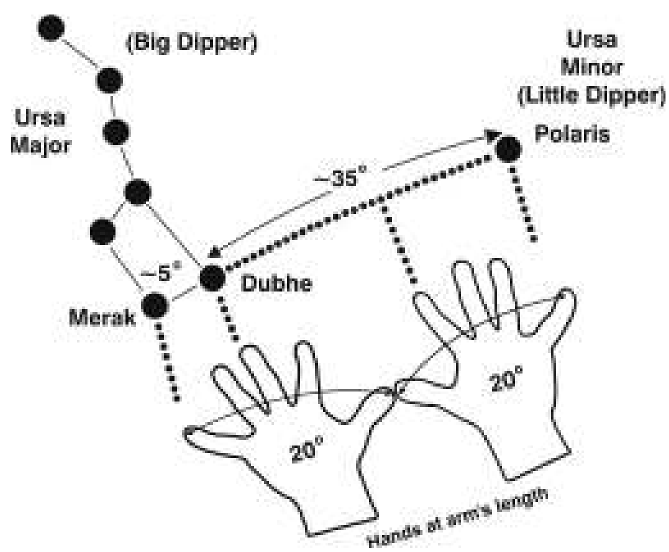
The pictures below will help us understand the concept being discussed.

Remember, one centimetre is equal to one degree of astronomical movement.

This astronomical movement of the moon takes close to two hours.




In the northern hemisphere the North Star, Polaris, is always in line with the two stars on the outside of the dipper. This is true north and this can readily be seen in the picture below and with a bit of practice can easily be located.




For our review, if the angle is shown in degrees, between the sun at sunrise and the moon in any day of its last quarter are used instead of Polaris and Merak, the concept can be readily understood.

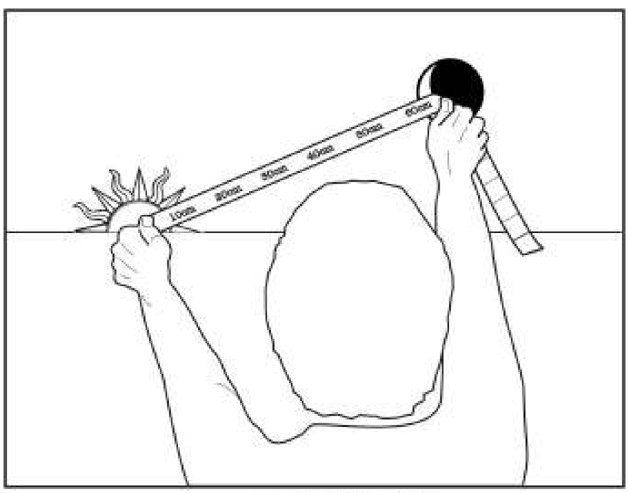
Please try this at sunrise even a few times and most of the fundamental points being discussed in this paper will also become plain.

## How to Determine the Day

For our purposes we will use a one metre, (100 centimetre) tape measure, as it is inexpensive and easy to carry. Using it does not require much practice, just good weather and good vision.

When the sun is rising, take a measurement in centimeters between the center of the sun and the center of the waning crescent moon.

Record the day, and the correct local time to the minute and the number of centimeters showing.



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The moon moves close to .5 cm per hour, so we multiply the number of centimetres shown by 2. This measure will give us the approximate number of hours, which we must convert into the number of days until the next conjunction.

We do this by dividing the above number of centimeters by 24 hours to provide the whole days. Then add the remaining hours and we will know which local day and approximate local time the next lunar New Moon occurs.

This measurement can be done anytime after the full moon, but in the third quarter with 7.4 days remaining until the conjunction is easiest.

The 7.4 days equates to 177 hours and 36 minutes. Seven full days are 168 hours and .4 of 24 hours is 9 hours and 36 minutes.

This measure will give us the number of hours that we must convert into the number of days until the next conjunction in our local time.

If this puts the conjunction close to dark in Jerusalem, then do the calculations below, that is divide by .51°, to get a more precise result.

For most days multiplying by 2 is adequate.

The moon moves relative to the sun by an amount almost equal to the moon's diameter every hour, which equals the .51° or .5 cm.

This equates closely to a movement of 12.2° every twenty-four hour day, for the monthly journey.

Using a tape measure in centimeters provides a very accurate estimation, but even using our fingers will provide us with a remarkably close approximation.

Dividing by the .51° rate of change per hour will provide a more precise result. It is a bit less (one or two hours less) than simply multiplying by two.

If multiplying by two puts the time of the conjunction near the end of the day, which is close to dark, or EENT, then do the calculations to get the necessary more precise result.

The rate of change per hour will equal the future time of conjunction, in hours, from the time we took our measurements.

We must adjust this local time of conjunction to Jerusalem time and adjust the day if required.

This is done so that all of the Churches of God presently, and eventually all of humanity, will be observing a uniform day of worship on our round planet.

Above is a picture of the crescent moon on April 14th 2004 at 06:46 local time in Southern Ontario, Canada.

Sunrise was at 06:40 with daylight savings, which had commenced on April 4th at 2:00 AM, added. This was day 24 of the cycle, with a waning crescent moon in the third quarter phase.

The moon was full on April 5th at 06:03 AM local time. After dark, on the evening of April 4th was the 15th day of the first month. This was the Night to be Much Remembered or the night of the actual Passover Meal. The time for the last quarter moon was on April 11th at 10:46 evening, and the moon was to be new at 08:21 AM local time on April 19th, 2004.

This event took place at 13:21 GMT, which is 15:21 or 3:21 PM in Jerusalem's time zone. This is seven hours difference in time of day from local time but in the exact same day of the week.

Lunar information is published by, http://aa.usno.navy.mil/data/docs/MoonPhase.html#y2004.

The measure on the tape was gauged to be 62 centimetres. 62 x 2 will indicate 124 hours. 124 divided by 24 (hours) is 120 hours for five complete days with 4 remaining hours. Adding four hours to 06:46 gives us an estimated 10:46 on April 19th for the projected local time of the conjunction. This is 2 hours 25 minutes later than the published time but well within the correct day.

If we needed a more precise time then we would divide 62 by .51. This gives us 121.6 hours. This means we add 1 hour 36 minutes to the 06:46 and get 08:22, or one minute late compared to the published times for the upcoming conjunction.

The sun and crescent moon images above are exaggerated to be more readily seen.

The greater the angular distance is between the Moon and the Sun, the more of the Moon's illuminated side we can see. A very slender crescent moon would indicate that only days remain until the New Moon.

## Background

Angular measure means any measure of the separation of two objects as seen from a specified point. This is expressed in angular units (degrees, minutes of arc, or seconds of arc).

Angular measurements are used by astronomical observers to describe the positions of celestial objects in the sky. For our purposes these objects are the Sun and Moon, and their angular separation as viewed from earth during the moon's last quarter. This is measured in degrees of separation.

When the angular distance is less than 90° separation, we will see less than half of the Moon's illuminated side. It will look like a curved sliver of light and is called the waning crescent phase.

The number of these degrees between the rising sun and waning moon equate to a length of time in hours until the upcoming conjunction.

For the rough estimates that are to be used for estimating the time remaining until the next conjunction, the widely accepted rules are very simple. They are also amazingly accurate in estimating the day of the next conjunction.

As more time is spent in observing the moon's movement in the sky, as the ancients did, we would be familiar with the different cycles of the moon's movement. We would then be able to more accurately know at which points in its cycles the moon moves faster or slower than the average of 29.53 days a month.

We would use these modified figures to come up with a very accurate conjunction time, as the ancients were able to achieve.

Using simple mathematics, meaning dividing by .51, will only be required when the time of the conjunction is close to dark, at the end of evening nautical twilight, EENT.

The rest of the time we need to simply multiply the angular separation by two.

Anciently, Aristarchus also determined the angle between the quarter phase Moon and the Sun.

## Aristarchus of Samos

Aristarchus of Samos (ca 310 BC) in his book "On the Sizes and Distances of the Sun and Moon" tried to determine the relative distance between the Earth and the Sun by noting from simple geometry that the Earth-Moon-Sun formed a right triangle with the 90 degree angle's vertex at the position of the Moon when the moon was at quarter phase (1/2 of its disk illuminated by the Sun).

This means that if you could measure the Moon-Earth-Sun angle, you could work out what the relative length of the hypotenuse of this triangle was between the Earth and the Sun, in terms of the length of the Earth-Moon distance. The problem is that this angle is very close to 90 degrees and in fact is about 89 degrees. Even a 1 degree error on such a skinny triangle creates a sizeable error.

So how did Aristarchus measure this angle?

He attempted to measure the time interval between the first and third quarter Moons, and computed their difference which by the geometry of the situation would give you twice the angle of Moon-Earth-Sun.

The problem is that although this works in principle, the Moon's orbit is not circular and the Moon does not travel at constant speed.

These factors caused Aristotle to get a distance of 18 - 20 times the Earth-Moon distance as the distance to the Sun rather than (93 million/240,000) = 3900.

1997 Dr. Sten Odenwald

## Estimating Angles by Eye

As we saw above from the work of Aristarchus of Samos, angular measure was used anciently and was understood and used by all.

Today it is used by astronomers as well as navigators.

If Aristarchus had more precise measuring tools he would have had a closer projection, but this example shows that the concept was understood.

Everyone is at least familiar with sundials. Perhaps the most accurate of all earlier sun type dials is the 'star' dial. It is called the Nocturnal dial.

They were used as early as the $15^{th}$ century by navigators, who told time by the position of stars, as well as by the movement of the sun and the moon.

The Nocturnal dial works so well in the northern hemisphere because it is based on the North Star, which is called Polaris.

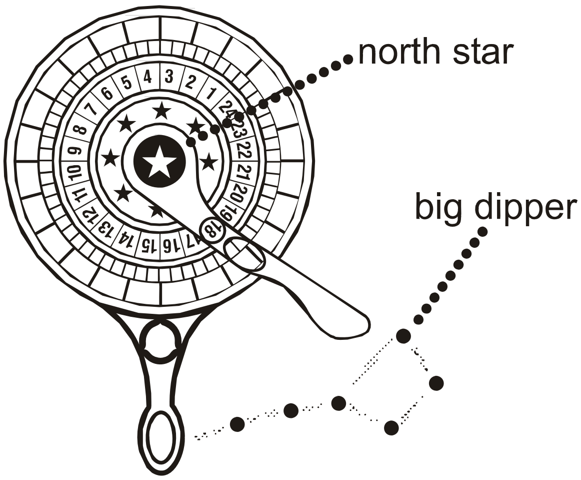
Polaris is almost directly on the axis of the earth's tilt and always appears in the same position in the sky.

The big dipper rotates in a complete circle around the northstar, Polaris. Therefore, whenever we look for the North Star, the dipper, in whatever position it holds in the sky, will correctly point Polaris out.

This is done by using the two outer stars of the cup of the dipper, Merak and Dubhe, and aligning them with the North Star.

This is not much assistance for people living in the southern hemisphere but it makes the point quite well.

The alignment shown in the tool below is to be understood in our local time.




- **Set the middle wheel to the month**
- **Hold the dial upside down**
- **Sight the North Star through the centre hole**
- **Align the top of the arm with the side stars of the big dipper to read the time**
- **During daylight savings time, add 1 hour**

## Sun, Earth and Moon Angles

One way to chart the Moon's behaviour is to chart its position with respect to the Sun and the Earth. Specifically, we can measure the angle between the Moon and the Sun, with the Earth as the vertex of the angle. At a time when both the Moon and the Sun are visible, we can measure the angle between the Moon and the Sun from our observing location.

Each time we measure and record the angle, we should also observe and record the shape (phase) of the Moon, and notice whether the lit or unlit portion of the Moon is nearest the Sun.
The ages during the phases of the lunar cycle show a complete cycle takes approximately 29.53 days. The synodic month and the age of the moon in any phase will always be less than 30 days.

The first quarter will correspond to an age of about 7.4 days, the full moon to about 14.8 days, and third quarter to about 22.1 days. This leaves about 7.4 days until the conjunction.

7.4 days is seven days and .4 x 24=9.6 hours and .6 x 60=36 minutes. This would indicate that from the third quarter there will be 7 days 9 hours and 36 minutes until the next conjunction.

## A few Definitions

*Altitude* is the measurement in degrees of a celestial object's angular separation from the horizon.

*Azimuth* is the measurement in degrees of the position of a celestial object around the horizon from North.

*EENT is* the end of evening nautical twilight.

*Ellipse* is a regular oval shape, traced by a point moving in a plane so that the sum of its distances from two other points is constant.

*Horizon* is the circle around an observer where the sky and ground meet.  A celestial object can only be seen if it is above the horizon.

*Latitude* is the angular distance of a place north or south of the earth's equator, or of the equator of a celestial object, usually expressed in degrees and minutes.

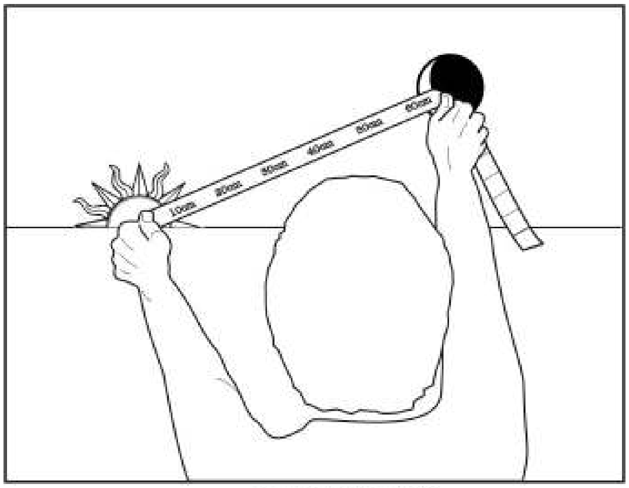
*Longitude* is the angular distance of a place east or west of the Greenwich meridian, or west of the standard meridian of a celestial object, usually expressed in degrees and minutes.
*Lunation* is another term for a lunar month.

*Meridian* is the line across the sky that meets the horizon due north of the observer, extends through the meridian and meets the horizon again at a point due south of the observer.

*Radian* is a unit of angle, equal to an angle at the centre of a circle the arc of which is equal in length to the radius.

*Zenith* is the point in the sky directly above the observer's head.

## The Practical Application





When the sun is rising, use a 100 centimetre tape measure to take a measurement in centimeters between the center of the sun at sunrise and the center of the waning (getting slimmer) crescent moon to the south east.

Record the day and the correct local time to the minute and the number of centimeters showing on the tape.

Multiply the number of centimetres times two to get the approximate number of hours until the next conjunction in local time.

This angular measure will give us the approximate number of hours that we must convert into the number of days, until the next conjunction.

Divide the number of hours by 24 to provide the whole days remaining. Then add the remaining hours and we will know which local day and approximate local time the next lunar New Moon occurs.

Convert this local time to Jerusalem's time zone and we will know which day is the upcoming Holy Day of the Sabbatical New Moon.

*Acknlowledgements*:

Thanks to Norman Gray for the illustrations, which are used for conceptual purposes only, and to Kirk Woodside for his insight.

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