Telling Time With the Sun

Equipment needed: Horizon Globe and sun

The Sun goes round and round creating day night. We can get more precise than just day and night, though. We can set the Horizon Globe to any particular hour we choose.

Turn the globe until the Sun reaches its highest point. This is *noon* (12:00 p.m.) for the Observer. Look at the photos on the next page to see noon and other examples of time shown on the Horizon Globe.

Now turn the globe until the Sun is at its lowest point (straight down, below the horizon). This is *midnight* (12:00 a.m.).

Halfway between midnight and noon is 6:00 a.m. Six a.m. is just about sunrise, or dawn. (It may be a little before or a little after dawn, depending on which month you placed the Sun on.)

Halfway between noon and midnight is 6:00 p.m., just about sunset or dusk.

You can get even closer by estimating. For example, a little past 6:00 a.m. is 7:00 a.m. Halfway between 6:00 a.m. and noon is 9:00 a.m.

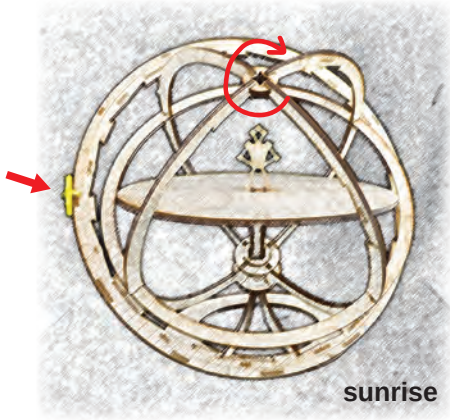
Become familiar with estimating time on the globe. It'll come in handy later when we're looking at the Sun and Moon together. Remember that it's the position of the Sun that determines what time it is!

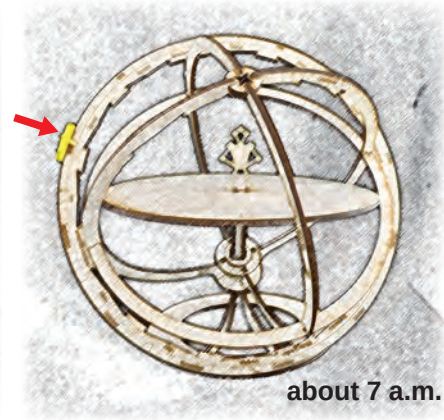
Exercise

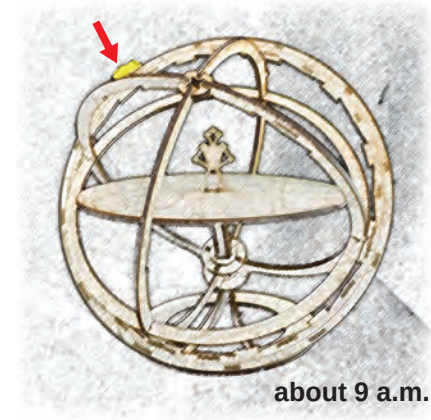
1. Put the Sun on the Ecliptic Ring, spin so the Sun rises and sets.
2. Leave Sun on Ecliptic Ring, spin globe to show various times.
3. Become familiar with sunrise, sunset, noon, and midnight.

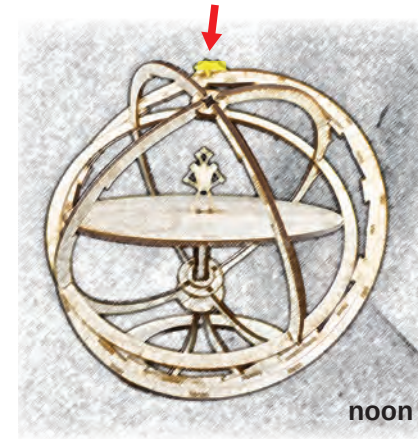
The oldest picture book in our possession is the Midnight sky

-E. Walter Maunder





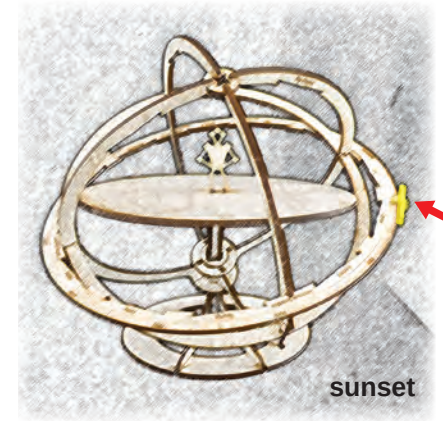


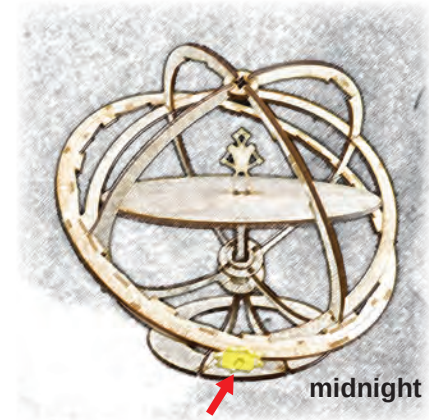


What time is it?

Can you tell time by the Sun when you are outside? Why not try it? You need a little more information to become really good at it though, and don't be surprised if your clock and the Sun don't match up perfectly.

(There is a reason for this that doesn't have much to do with astronomy that we'll look at in a later chapter.)





Telling Time With a Special 24-Hour Clock

As the Sun moves across the sky, you can think of it as the hand on a giant clock.

Not an ordinary clock, though. Our special clock has *noon* at the top, representing the time when the Sun is highest in the sky. Twelve hours later is *midnight,* which is at the bottom of our special clock. A full day has 24 hours, so our clock also needs to have 24 hours for one revolution of the Sun.

The top circle on the next page shows this special clock. The position of the Sun in the sky points toward the time of day, shown here as 9:00 a.m. Note that noon is at the top of the circle and sunset is around 6:00 p.m., where the color of the circle changes from light blue to dark. Midnight is shown at the bottom, while sunrise is 6 hours later at 6:00 a.m. Light blue represents daytime, dark blue is night. Keep in mind that day is not exactly 6:00 a.m. to 6:00 p.m., but it's approximately so on average.

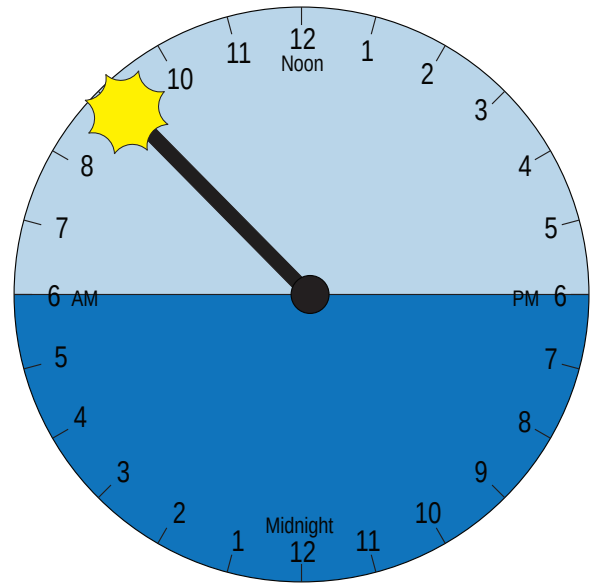
In the lower circle, we replace the clock hand with our Observer. If the Observer imagines this giant clock in the sky, he will be able to estimate by the Sun that it is about 9:00 a.m.

Exercise

1. Become familiar with 24-hour clock with noon at top, midnight at bottom.
2. Imagine 24-clock with Observer.
3. Estimate a few different times by Sun position.

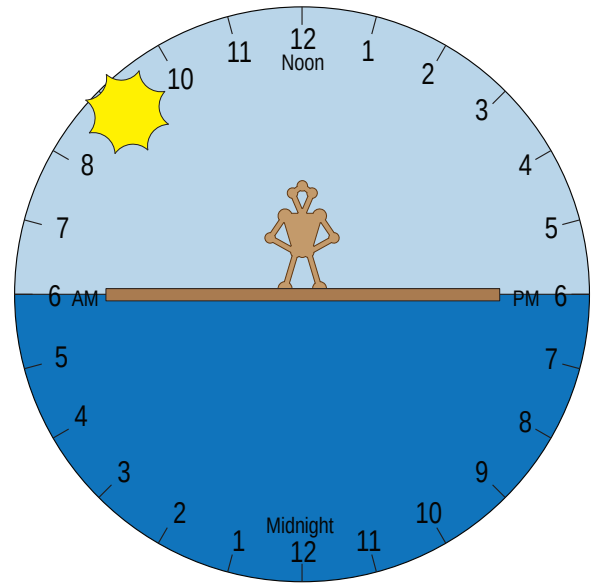
1

24-hour clock
(with a clock hand)
showing 9 a.m.



2

24-hour clock
(with clock hand replaced by Observer)
showing 9 a.m.



3

Where is the sun at 3:00 p.m.?
How about at 9:00 p.m.?
What does the Observer see?

Telling Time With the Horizon Globe

Equipment needed: Horizon Globe and sun

Now let's take a look at how the giant clock in the sky relates to our Horizon Globe.

Any time the sun disc is placed on the globe, it defines a particular time of day or night. In the day, we can estimate the time by the position of the Sun. In the night, we can estimate the position of the Sun by knowing the time.

In the following illustrations, the Observer imagines the giant clock to relate Sun position and time.

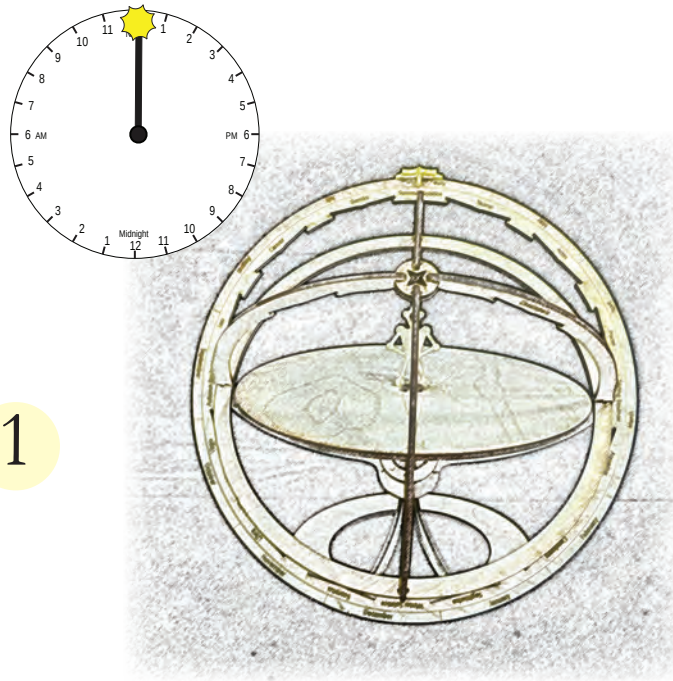
The midnight sun

Unlike the Observer, you can see the Sun at midnight on the Horizon Globe. Have you ever seen the Sun at midnight?

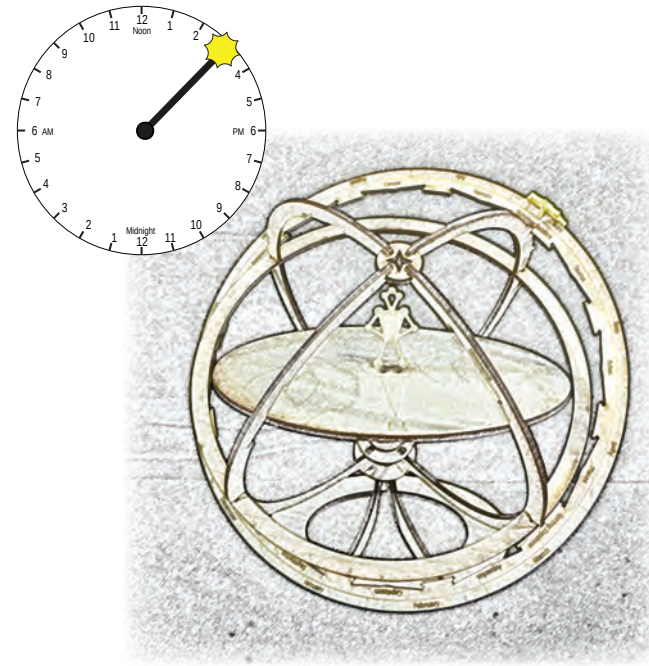
Exercise

1. Put Sun at noon. Observer can estimate by the Sun position that it's approximately noon. Repeat for 3:00 p.m.
2. Put sun at midnight. Observer knows by his watch that it's midnight, so he can estimate where the Sun is. Repeat for 4:00 a.m.

1

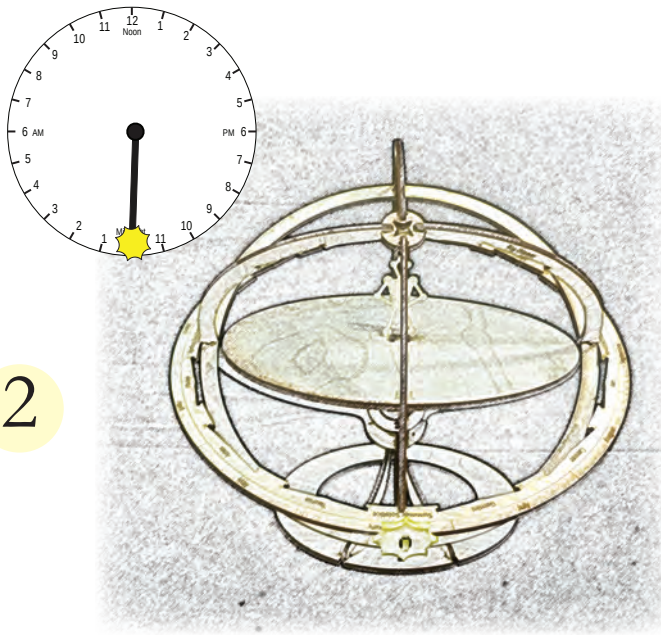


The Observer sees that the Sun is high in the middle of the sky, so he knows it's around **noon**

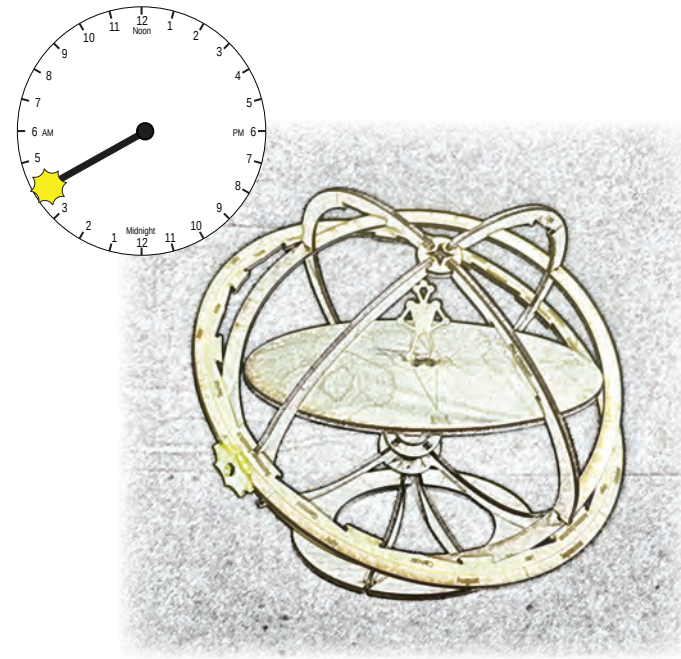


In mid-afternoon, the Observer can estimate it's about **3:00 p.m.** by looking at the Sun's position

2



The Observer knows by his watch that it is **midnight**, so he can estimate that the Sun is straight down



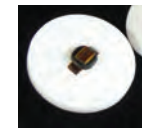
When the clock strikes **4 a.m.**, the Observer can estimate that the Sun is about ready to rise in the east

Now Add the Moon

Equipment needed: Horizon Globe, sun, full moon

Place both the Sun and Moon anywhere on the Ecliptic Ring.

Sun



Full Moon

Turn the globe clockwise. [Make sure the North Star is facing you. The Sun rises on the left (East) side.] Notice how the Moon travels. It does pretty much the same thing as the Sun. It rises in the East, sets in the West, and divides its time between being above the horizon and below the horizon.

Leave the Sun in one place and move the Moon to different places on the Ecliptic Ring. Try putting the Moon close to the Sun, then far away from the Sun.

When the Moon is close to the Sun how much of its time is spent in daylight vs. night? When the Moon is far from the Sun how much of its time is spent in the day vs. the night?

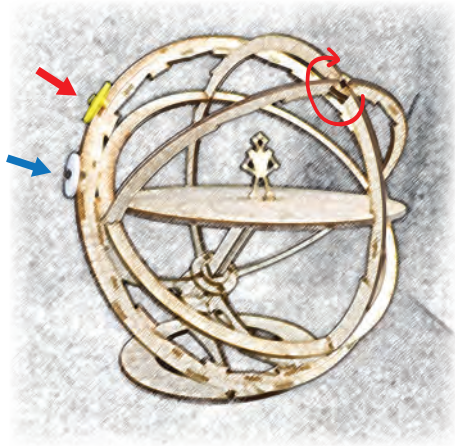
Notice what time the Moon rises and sets for each place you put it. (Remember, you can always tell what time it is by where the Sun is.)

In the next section we'll talk about a way to describe where the Moon is compared to the Sun. *Angular measurement* is the technique used to denote the distance between the Sun and Moon. Angular measurement is regularly used by astronomers to describe where things are in the sky. It'll help us understand what we see, too.

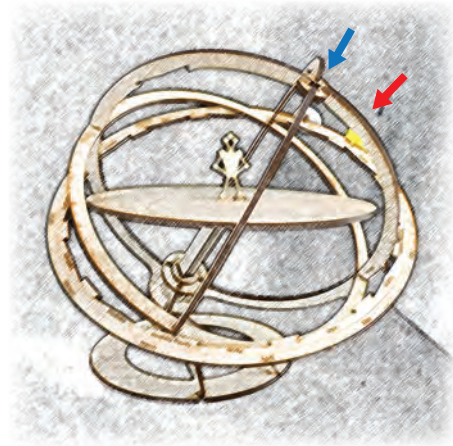
Exercise

1. Place both Sun and moon anywhere on Ecliptic Ring.
2. Rotate globe, see them move together.
3. Leave Sun in place, move the Moon to a new location.
4. Spin the globe, observe.

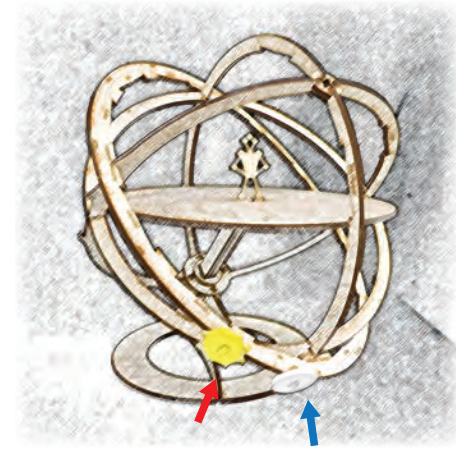
Introduce the moon.
Notice the moon travels much like the sun

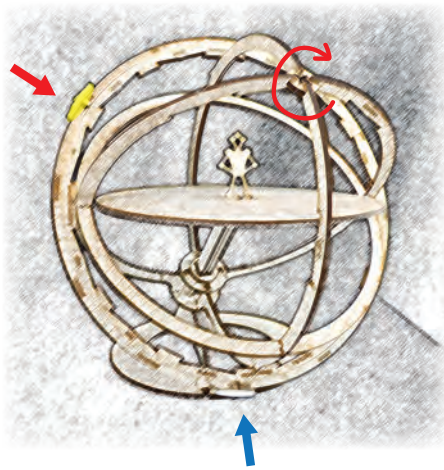


1 Place Sun and Moon anywhere on Ecliptic Ring

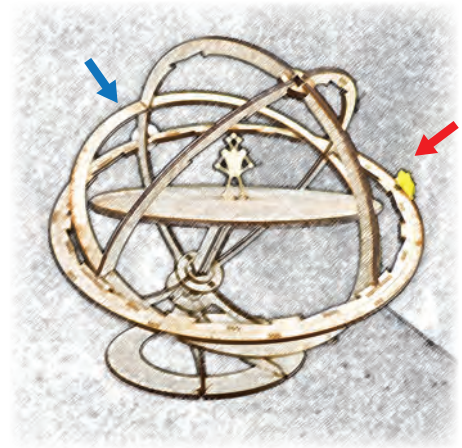


2 Spin Globe and watch Sun and Moon travel together

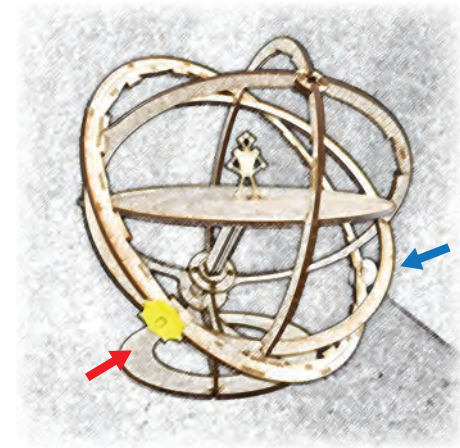




3 Move the Moon to a different location



4 Spin the Globe and watch the Sun and Moon make a revolution around the Observer



Moon sightings

Did you know that sometimes you can see the Moon during the day?

Have you noticed that some nights the Moon is nowhere to be found?

Measure Angles in Degrees

Now that we have two things in the sky, we need a way to talk about where they are.

Let's do a quick review of how to measure angles using degrees. In the next chapter we'll talk about how to measure angles in hours.

Like astronomers, we need a way to talk about where celestial objects are located. You could think of the Sun and Moon as located on the edge of a giant circle. Angles on a circle are easy to think about and measure, but let's just take a minute and review how it's done. A better understanding of how angles are measured on circles will help us grasp the relationship between the Sun and Moon.

Let's start with the series of green circles on the facing page. A complete circle like the solid green one is considered 360 degrees (360º). Following along in the pictures, the half circle is 180 degrees, the quarter of a circle is 90 degrees. The second row shows examples of obtuse angles and acute angles. An *obtuse angle* is one that is more than 90 degrees. An *acute angle* is less than 90 degrees.

The Ecliptic Ring is just like a circle. It, too, can be divided into 360 degrees. The lower half of the following page shows how the Ecliptic Ring can be divided into parts of a circle. One-half of the Ecliptic Ring is 180 degrees, while one-quarter of the ring is 90 degrees.

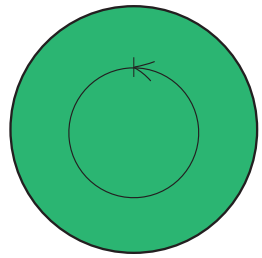
In a later section we'll put the Sun and Moon on our Horizon Globe and look at the various angles they make.

Exercise

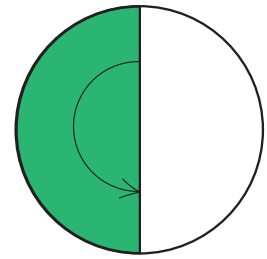
1. Become familiar with circles measured in degrees. Compare obtuse and acute angles.
2. Notice that the Ecliptic Ring is a circle and can be divided into degrees.

How to measure distance using angular degrees

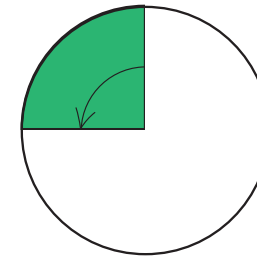
Full Circle = 360 degrees = 360º



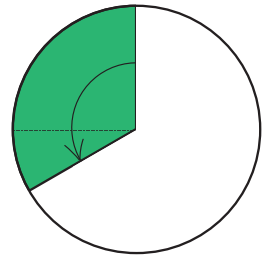
Half Circle = 180 degrees = 180º

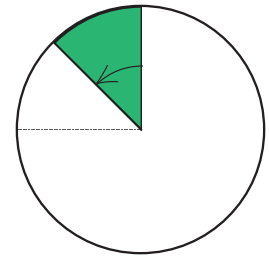


Quarter Circle = 90 degrees = 90º



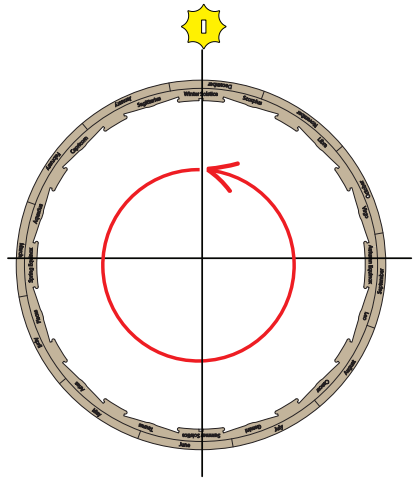
Obtuse Angle = more than 90 degrees



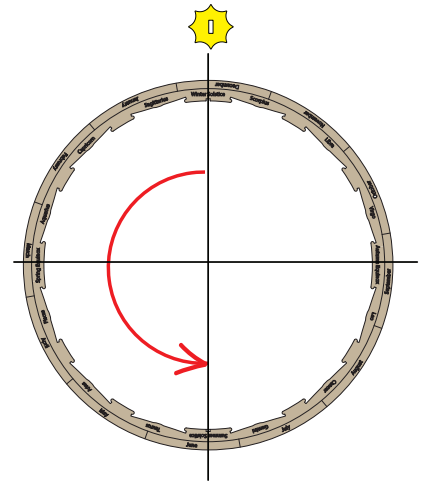


Acute Angle = less than 90 degrees

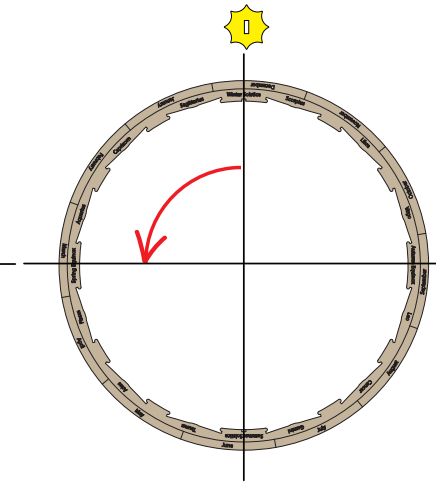
1 Parts of a circle can be measured in degrees



Full Circle = 360 degrees



Half Circle = 180 degrees



Quarter Circle = 90 degrees

2 The Ecliptic Ring can also be measured in degrees

Measure Angles in Hours

Sometimes astronomer use degrees to measure the distance between two objects. Other times they use hours instead of degrees.

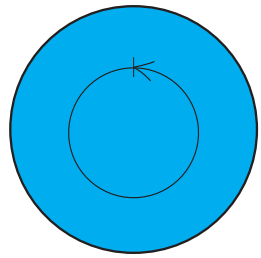
Since the sky turns once around in 24 hours, astronomers measure the east-west distance between objects in hours instead of degrees. That way, if you see one object in a certain place, say the noon position, you know how long it will take for the second object to reach the same position.

If you know angles in degrees, it's easy to convert to hours. Instead of saying a whole circle is 360 degrees we say it is 24 hours. A half circle, 180 degrees, is 12 hours. A quarter circle, 90 degrees, is 6 hours. More than 6 hours makes an obtuse angle, and less than 6 hours makes an acute angle.

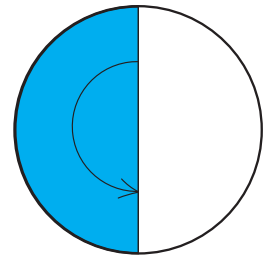
Exercise

1. Become familiar with circles measured in hours.
2. Notice how the Sun and Moon form angles that you can measure in hours.

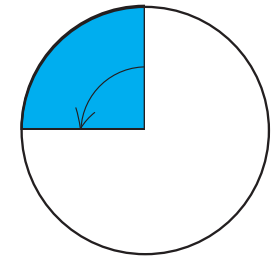
Full Circle = 24 hours



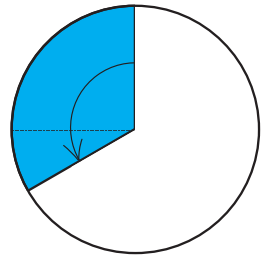
Half Circle = 12 hours

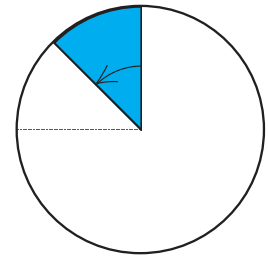


Quarter Circle = 6 hours



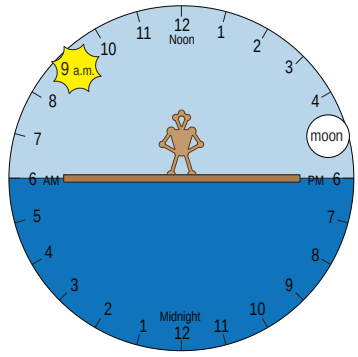
Obtuse Angle = more than 6 hours



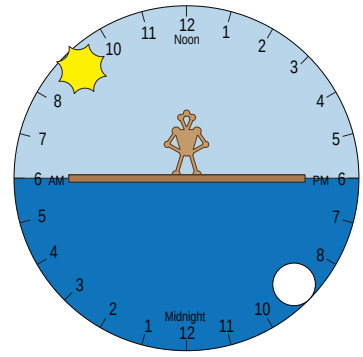


Acute Angle = less than 6 hours

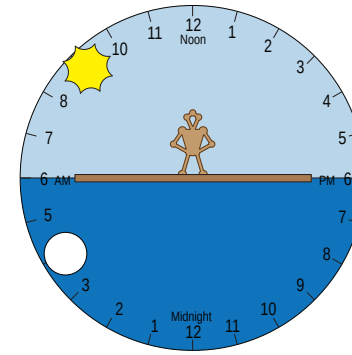
1 Parts of a circle can be measured in hours



Sun at 9 a.m. position*
Moon at 5 p.m. position
8 hour difference



Sun at 9 a.m. position
Moon at 9 p.m. position
12 hour difference



Sun at 9 a.m. position
Moon at 4 a.m. position
5 hour difference

**Remember that sun location determines the time of day*

2 Distance between Sun and moon can be measured in hours

Sun - Moon Angle

Equipment needed: Horizon Globe, sun, full moon

We can talk about the location of the Moon by what angle it forms with the Sun.

On the following page the Sun stays in one place while the Moon is attached to the Ecliptic Ring in various locations.

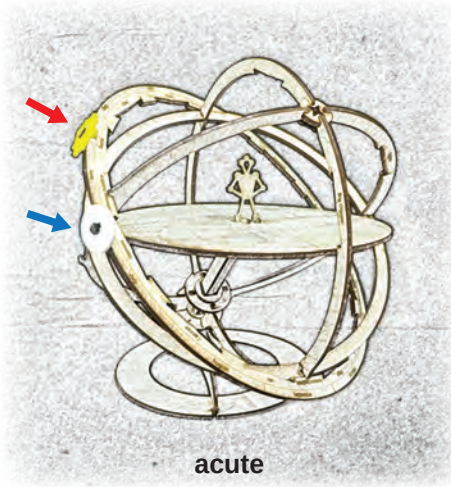
(Remember, for this exercise we are not spinning the globe, we are moving the Moon from place to place on the ecliptic.)

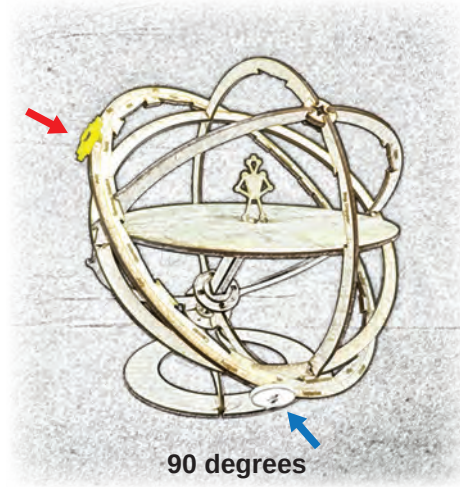
Get used to putting the Sun and Moon on the globe at different locations on the Ecliptic Ring. Notice the angle between the Sun and Moon.

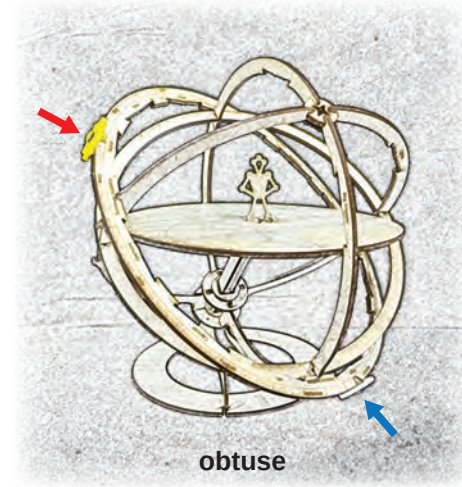
Exercise

1. Put the Sun and moon at an acute angle anywhere on the Ecliptic Ring.
2. Leave the Sun in place. Move the Moon to new locations and notice angle the Moon makes with the Sun.

Use angular measurement to describe the distance between the sun and moon







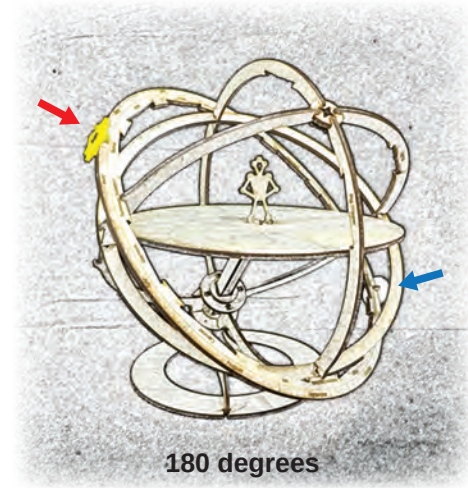
1

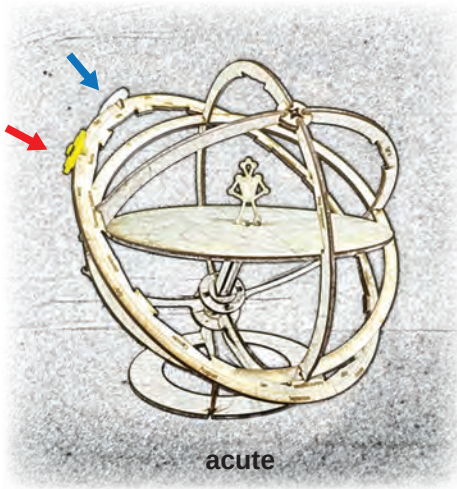
Place Sun and Moon anywhere on Ecliptic Ring so that they form an *acute* angle

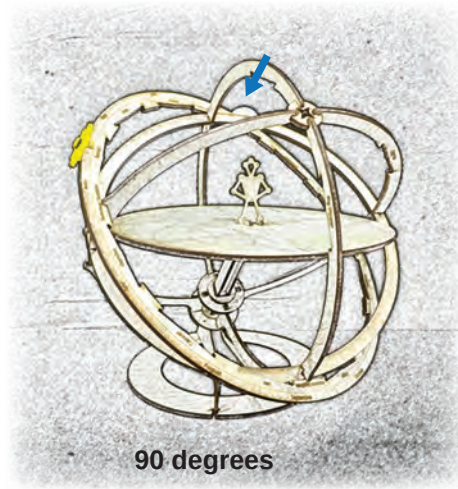
2

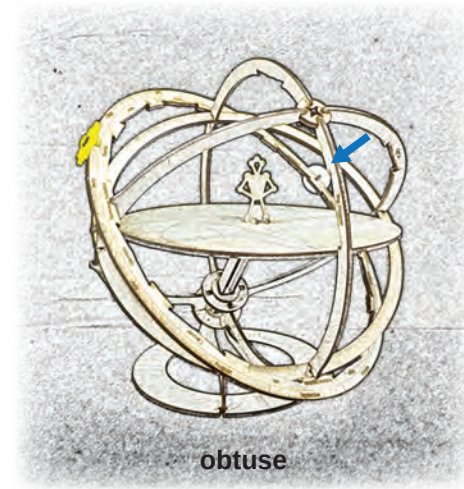
Now change the location of the Moon by taking it off the ecliptic ring and putting it back on in a new location. Notice the various angles that the Moon makes with the Sun.

Note: Leae the Sun in one place for this exercise, and don't spin the globe.









When the Moon is "Behind" the Sun

Equipment needed: Horizon Globe, sun, full moon

We can describe the Moon as being a number of hours "ahead of" or "behind" the Sun.

In these pictures, the Moon is a little more than 90 degrees, or about 8 hours behind (later than) the Sun. For this exercise the Sun and Moon stay in a constant location on the Ecliptic Ring while we spin the globe. At sunrise, the Sun is in the 6 a.m. position, while the Moon is below the horizon and invisible to us.

Spin the globe so the Sun is at around the 2 p.m. position. Notice that the Moon is rising. This is occurring about 8 hours later than sunrise, or about 8 hours *behind* the Sun.

Keep spinning the globe. Around 6 p.m. the Sun sets, while the Moon is at about the 10 a.m. position.

A few hours later the Moon sets, around 4 a.m. in the morning. Remember that the position of the Sun determines the time of day or night.

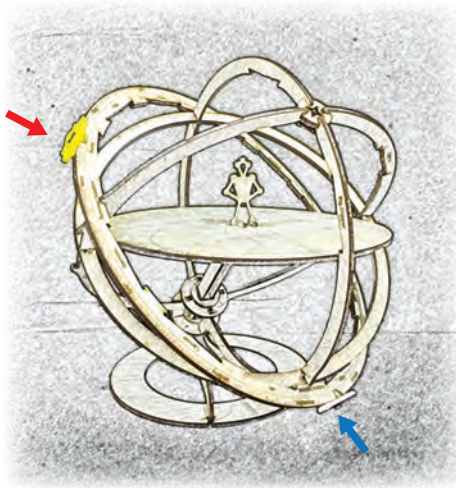
We can see as we spin the globe that the Moon trails *behind* the Sun. The Moon rises *after* sunrise, the Moon sets *after* sunset.

In the next chapter we'll take a look at what it means to be "ahead" of the Sun.

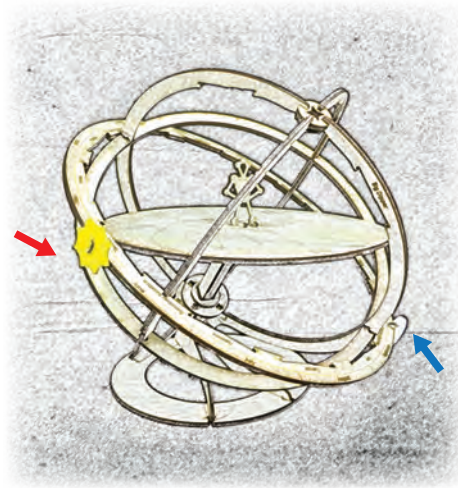
Exercise

1. Put the Sun on Ecliptic Ring with Moon 8 hours behind.
2. Spin the globe and observe relationship between Sun and Moon.
3. Notice moonrise and moonset. At what time do they occur?

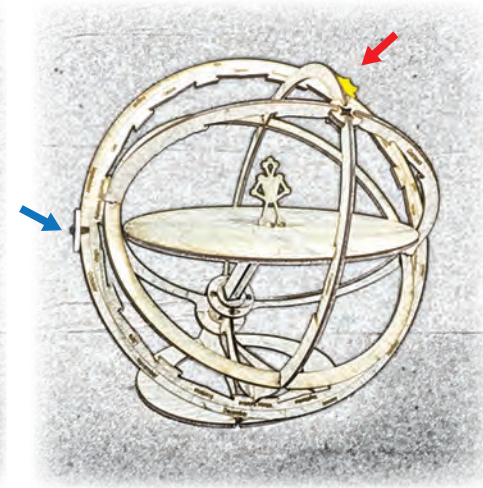
Moon location described by
how many hours behind the sun



Moon 8 hours behind Sun



sunrise



moonrise

1

Place Sun on Ecliptic Ring.
Put Moon 8 hours later than the Sun.

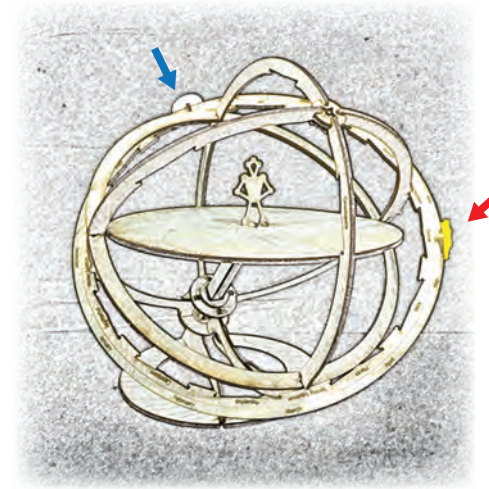
Note: Leave both Sun and Moon attached to the Ecliptic Ring in this position for the whole exercise.

2

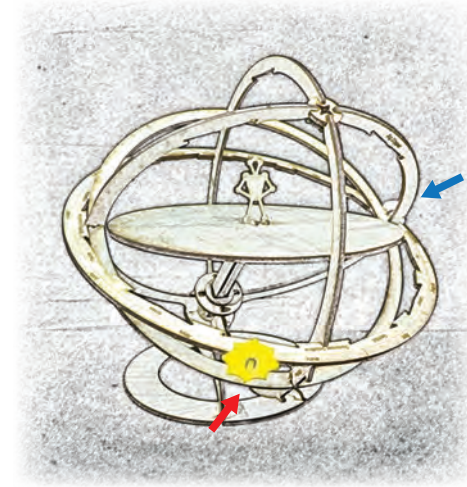
Rotate globe and observe relationship between Sun and Moon

3

Notice moonrise and moonset



sunset



moonset

Sun behind the moon

What time does the moon rise and set? It depends on where it is relative to the sun. Remember, the sun determines the time.

When the Moon is "Ahead" of the Sun

Equipment needed: Horizon Globe, sun, full moon

In the previous exercise we saw what the Sun and Moon look like when the Moon is "behind" the Sun. Now let's take a look at a time when the Moon is *ahead* of the Sun.

In these pictures, the Moon is a little more than 90 degrees, or about 8 hours ahead of (before) the Sun. For this exercise the Sun and Moon stay in a constant location on the Ecliptic Ring while the globe spins.

If we start at sunrise, the Moon is already high in the sky at the 2 p.m. position. We can say that the Moon is about 8 hours *ahead* of the Sun.

A few hours later, around 10 a.m., we can see that the Moon is setting.

The Sun sets later in the day, and the Moon is still out of sight, having set earlier.

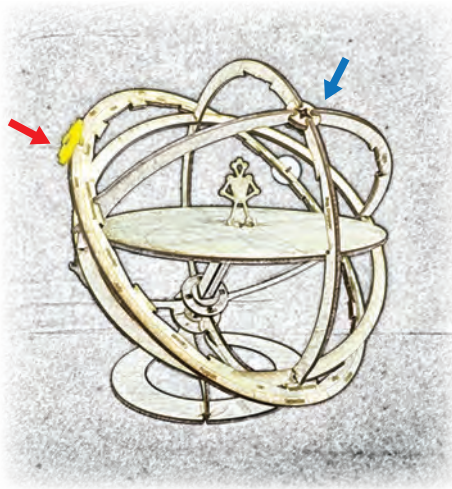
Just a little while later, around 10 p.m., we see the Moon rising.

We can see as we spin the globe that the Moon leads *ahead of* the Sun. The Moon rises *before* sunrise, the Moon sets *before* sunset.

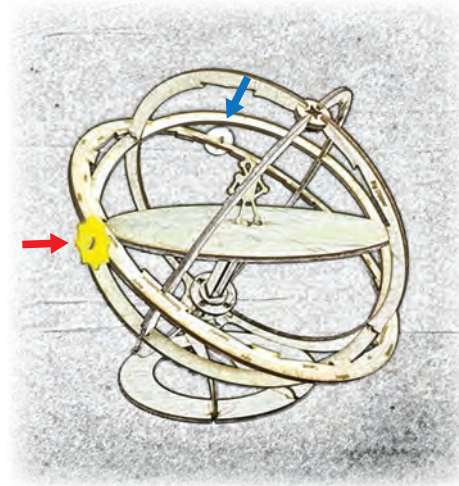
Exercise

1. Put the Sun on the Ecliptic Ring with the Moon 8 hours ahead.
2. Spin the globe and observe .
3. Look at the Sun location to know what time the moonrise and moonset occur.

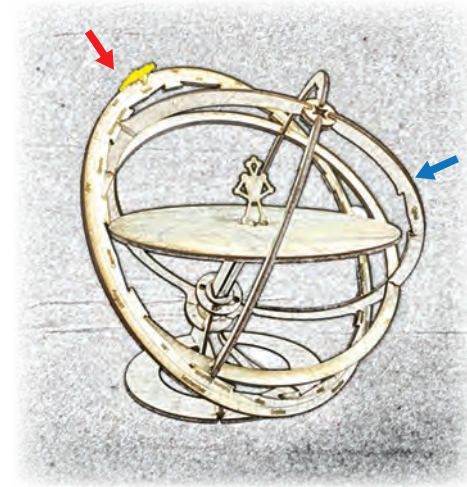
Moon location described by
how many hours ahead of the Sun



Moon 8 hours ahead of the Sun



sunrise



moonset

1

Place Sun on Ecliptic Ring. Put Moon 8 hours before the sun.

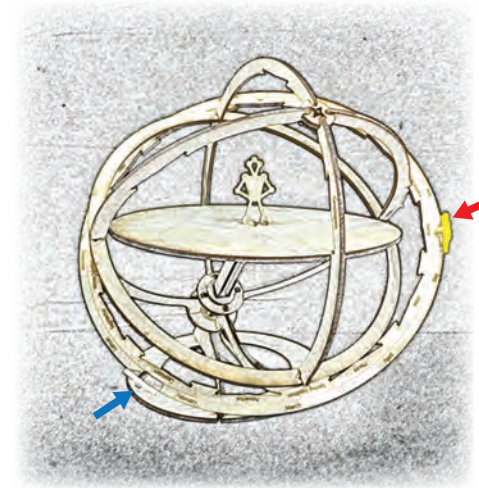
Note: Leave both the Sun and Moon attached to the Ecliptic Ring in this position for the whole exercise.

2

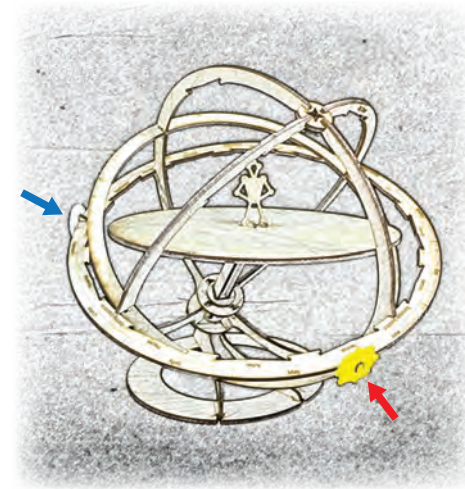
Rotate globe and observe relationship between Sun and Moon

3

Notice moonrise and moonset



sunset



moonrise

Sun ahead of the Moon

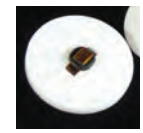
Knowing if the Moon is ahead of or behind the Sun will help us find it

The Moon is Slower than the Sun

Equipment needed: Horizon Globe, sun, full moon

Place the Sun anywhere on the Ecliptic Ring. Now place the Moon on the Ecliptic Ring as close as you can to where you put the Sun.

Sun



Full Moon

Turn the globe once around, stopping with the Sun at noon. Since the Moon was next to the Sun, the Moon did about the same thing as the Sun.

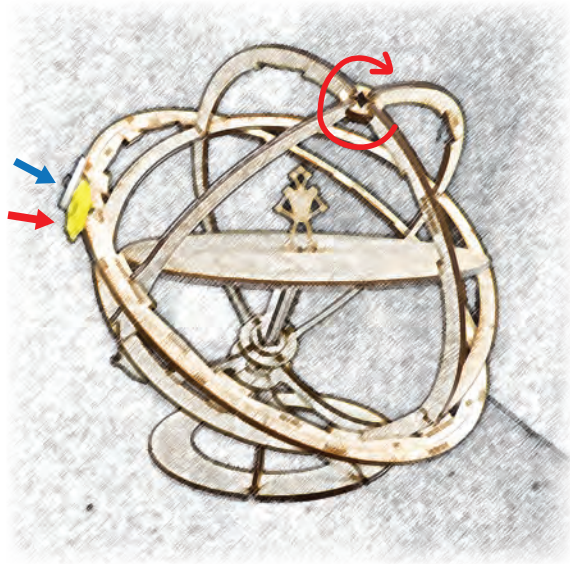
In the sky about you, this is close to what happens. The Moon travels like the Sun, but with a noticeable difference: the Moon is lazy. What does it mean for the Moon to be lazy? It means that it moves a little slower than the Sun.

As the Sun travels once around from noon to noon, the Moon doesn't make it quite as far because it's slower. When the Sun gets back to noon, the Moon has only made it back to about 11:00 a.m. Move the Moon on your globe to show this. (On the Horizon Globe, after one turn the Moon will be ½ of a month division farther East than, or behind, the Sun).

Turn the Globe again from noon to noon and the Moon falls back another hour (Move the Moon another ½ month division, or full month marker behind the Sun in total.)

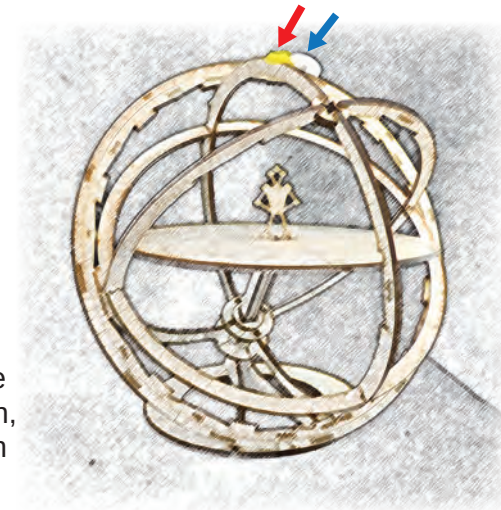
Exercise

1. Place Sun and Moon close together on Ecliptic Ring, spin globe.
2. Spin globe so that the Sun is at noon.
3. Moon falls behind one hour (~½ month division) per spin.
4. After 2 spins Moon falls behind by 2 hours (1 month division).

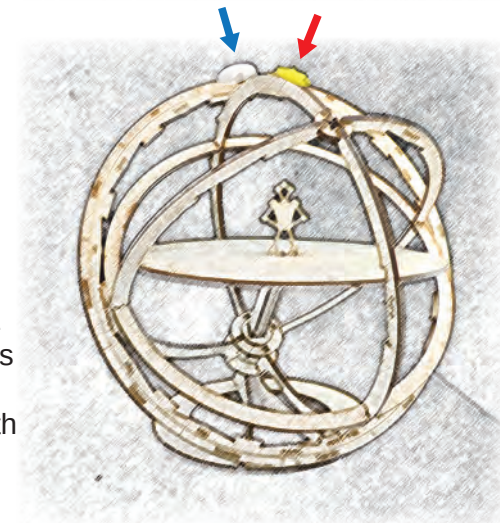


1 Place the Sun and Moon together on the Ecliptic Ring

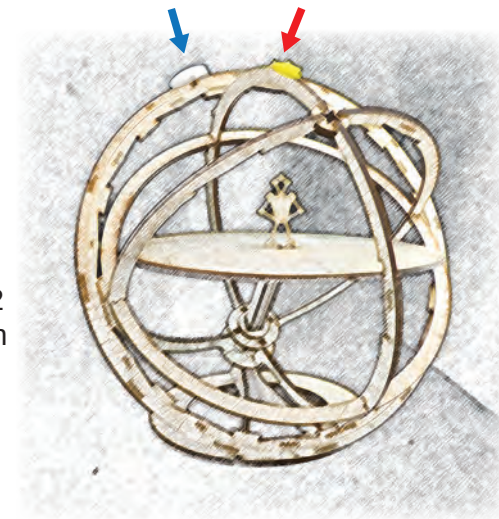
2 Spin globe so that the Sun is in the noon position, Moon is with Sun



3 After 1 spin (1 day), Moon falls behind by 1 hour, (1/2 month division)



4 After 2 spins (2 days), Moon falls behind by 2 hours (full month division)



The lazy Moon

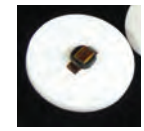
The Moon is like a lazy cow, trailing behind the Sun.

The Moon Takes a Month

Equipment needed: Horizon Globe, sun, full moon

Let's continue to look at how the Moon moves compared to the Sun. Place the Sun anywhere on the Ecliptic Ring.

Sun



Full Moon

Then place the Moon close to the Sun. Spin the globe so that the Sun is in the noon position, i.e. highest in the sky. Move the Moon back one hour (about ½ of a month division). Turn the globe again from noon to noon, and the Moon falls back another hour. Each turn of the globe, which represents one day, causes the Moon to fall back by almost another hour behind the Sun.

After about 7 days the Moon will be ¼ of a turn behind the Sun. Put it here and will just be rising at Noon.

After about 15 days the Moon will be opposite the Sun. Now the Moon is straight down at the midnight position when the Sun is at noon.

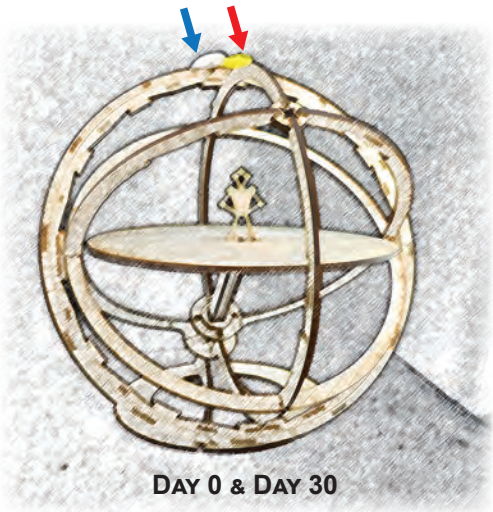
After about 22 days the Moon is ¾ of a turn behind, or ¼ turn ahead of the Sun. Now it will be rising at midnight and setting at noon.

After 30 days the Moon has fallen behind the Sun by one full turn so it is right back to being next to the Sun. Now the whole cycle repeats.

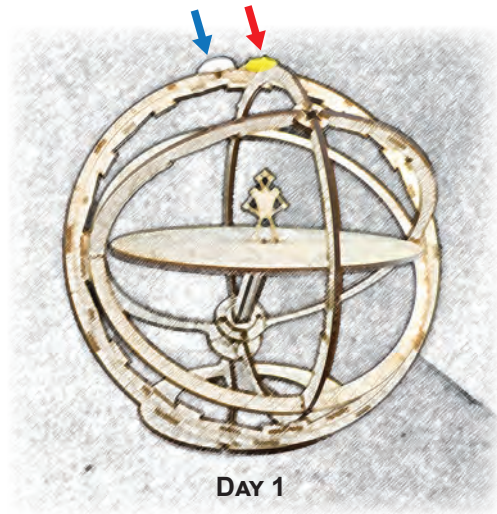
The period of time it takes for the Moon to lose one full turn relative to the Sun is called a *month*.

Exercise

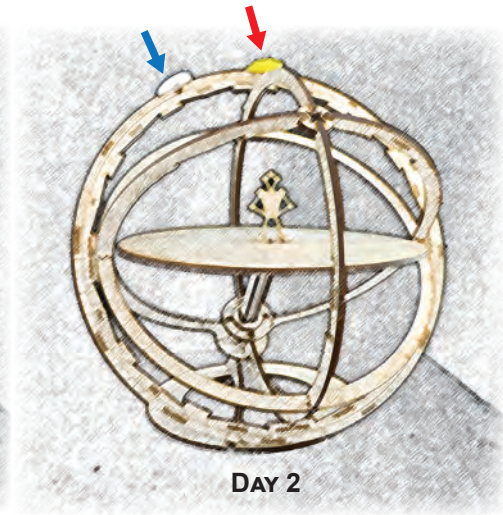
1. Put the Sun and Moon close together on Ecliptic Ring.
2. Spin globe noon to noon, move Moon back every turn.
3. Watch the lazy Moon go through a complete moon cycle.



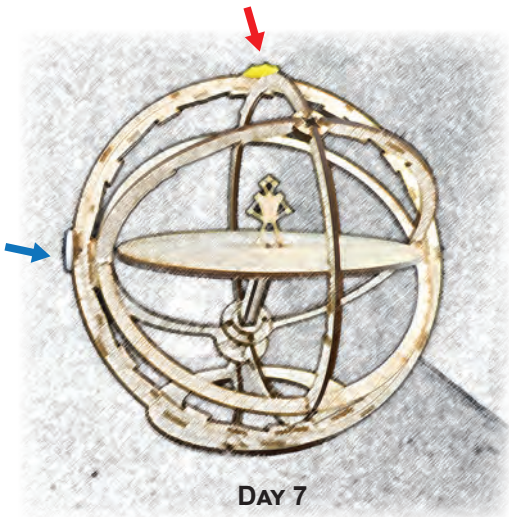
Sun is in the **noon** position, Moon is with Sun



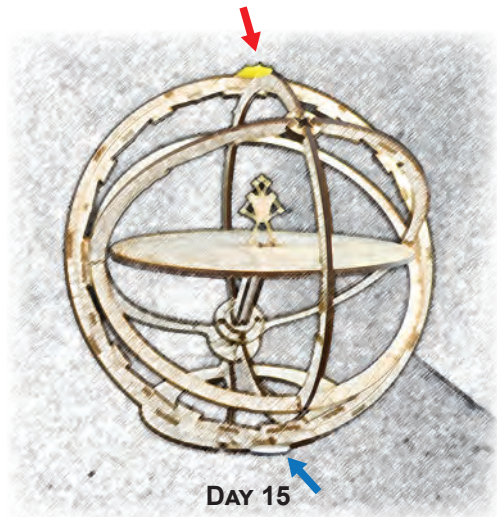
After 1 spin, Moon falls behind by ~1 hour, (½ month division)



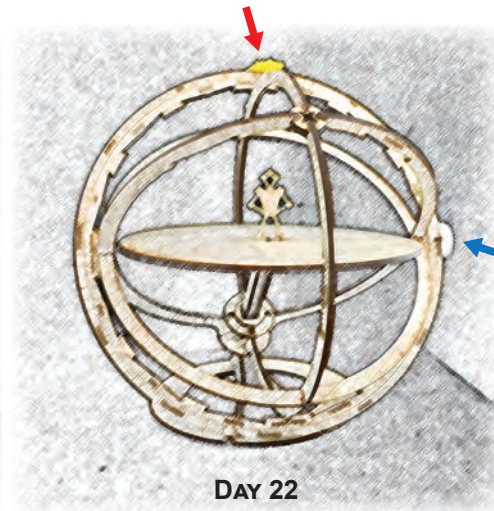
After 2 spins, Moon falls behind by ~2 hours (full month division)



After about 7 days, Moon falls behind by a quarter-turn



After about 15 days, Moon is opposite the Sun



After about 22 days, Moon falls behind by three-quarters of a turn

Moon month

The Moon is fun to watch. When it's at a quarter turn, you can see the Moon and imagine it lagging behind the Sun. A few days later it is opposite of the Sun. A few days after that when it's at ¾ of a turn, it looks like the Sun is catching the Moon!

Shapes of the Moon

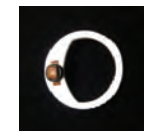
Equipment needed: all four moon shapes

So far we've been using just the Full Moon to show how the Sun and Moon ride together on the Ecliptic Ring, and how the moon moves relative to the Sun.


Full


Gibbous


Quarter


Crescent

But we know that the Moon doesn't always look the same to us--sometimes it's a full round circle, sometimes only part of a circle. The Horizon Globe uses different discs to represent the changing shape of the Moon.

Compare the sketches of Moon shapes with the photos of real moons on the facing page. Notice which parts are white and which parts are dark for each Moon shape. And for now, just focus on the shape and the name.

We know that during a month, the Moon slowly falls behind the Sun until the Sun passes the Moon and another month begins.

We also know that the shape of the Moon changes, as sometimes it is full and other times it has a different contour. What is it that's making the Moon change its appearance?

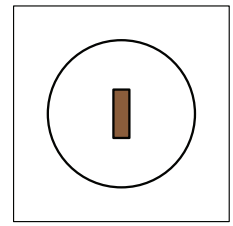
The fact that the Moon's angle relative to the Sun changes and the fact that the Moon's shape changes are definitely related. The shape, or *phase*, of Moon that we see depends on how far it is from the Sun.

On the next few pages we'll look at each Moon phase separately, starting with the Full Moon.

Become familiar with
the moon shapes

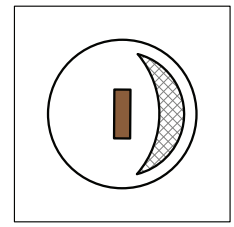
FULL MOON
white disc that is solid

Horizon Globe
Moon sketch

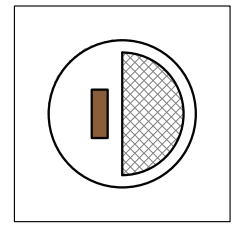


Real
Moon photo

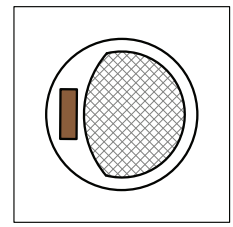
GIBBOUS MOON
white disc with a sliver missing



QUARTER MOON
white disc that is half solid



CRESCENT MOON
white disc with a large hole

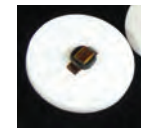


Full Moon

Equipment needed: Horizon Globe, sun,full moon

The brightest and most prominent moon is a Full Moon. It looks like a complete round circle.

Sun



Full Moon

The Moon looks full to us when it is opposite the Sun. We could also describe this position as 12 hours behind or ahead of the Sun.

On your Horizon Globe, place the Sun anywhere on the Ecliptic Ring. Next, place the Full Moon disc on the ecliptic opposite the Sun. The Moon will be 180 degrees or 12 hours from the Sun.

Turn the globe until the Sun is at the noon position. Where is the Moon? It should be straight down, at the midnight position. Now turn the globe until the Sun sets. Where is the Moon now? It should be just rising.

At midnight, when the Sun is straight down, the Moon will be high overhead. Keep turning the globe until the Sun rises. Notice how the Full Moon sets right at sunrise.

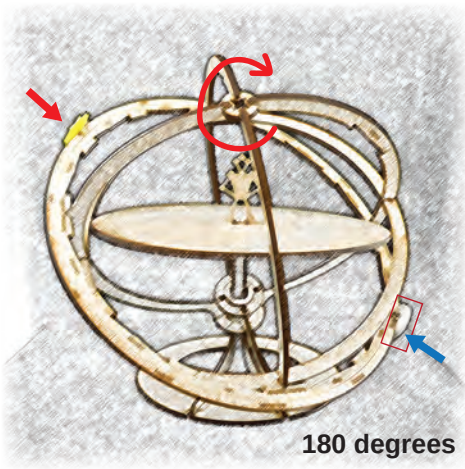
Technically, the Moon is only full for an instant when it is directly opposite the Sun, but it looks full for a few days every month when it is farthest from the Sun.

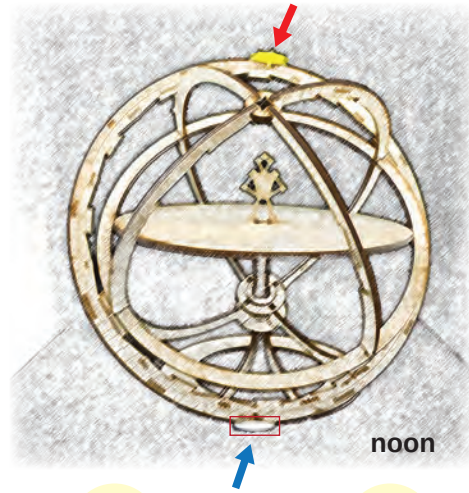
In the next section we'll take a look at the Sun and Moon when they are closer together.

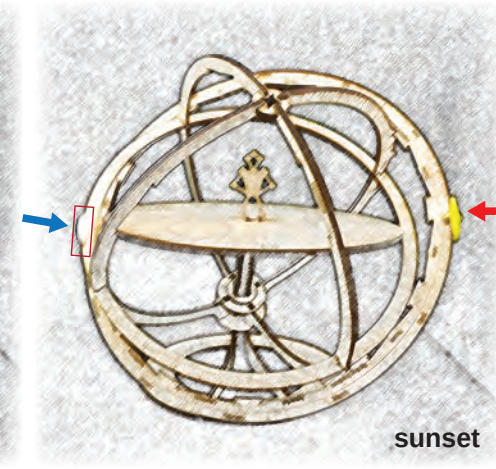
Exercise

1. Place Sun anywhere on Ecliptic Ring.
2. Place Full Moon 180 degrees from Sun on Ecliptic Ring.
3. Spin globe so Sun stops at noon. Observe Moon position.
4. Repeat for sunset, midnight, and sunrise.

During a Full Moon the sun and moon are 180 degrees apart







1 & 2

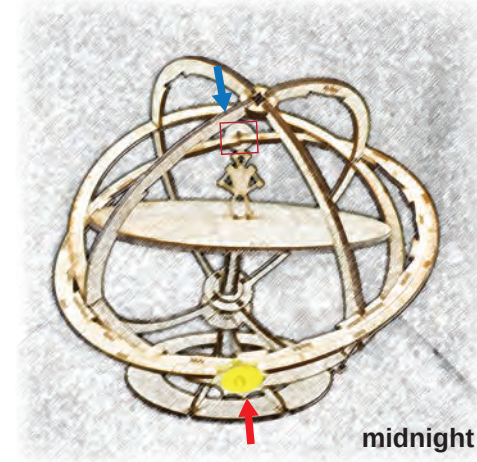
Place Sun and Moon anywhere on Ecliptic Ring 180 degrees apart

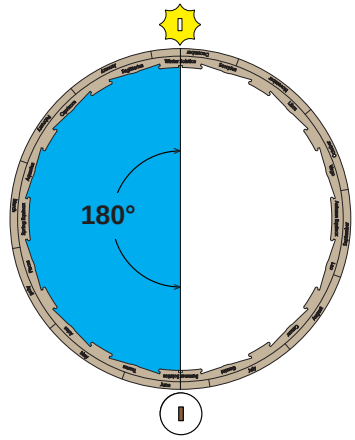
3

Spin the globe so that the Sun stops at noon position. Observe Moon location

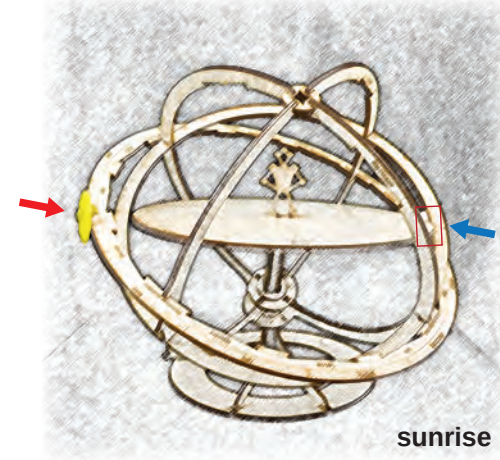
4

Repeat Step 3 for sunset, midnight, sunrise





Ecliptic Ring with Sun and Moon separated by:
a half-circle = 180º = 12 hours



Full Moon

A perfectly full Moon can only be seen at night.

Waxing Quarter Moon

WAXING = GROWING

Equipment needed: Horizon Globe, sun, quarter moon

A complete round moon is called a Full Moon, but a half-circle moon is not called a half Moon, it's called a Quarter Moon.

Quarter Moon

Sun

It's called a Quarter Moon because the Moon is a ¼ of the way through its monthly cycle. The Quarter Moon is a quarter turn from the Sun.

Place the Sun anywhere on the Ecliptic Ring. Turn the globe so the Sun is at noon. Now place the Quarter Moon on the ecliptic 6 hours behind the Sun. It will be near the horizon on the east side, halfway between the midnight and noon positions. A Quarter Moon that is 6 hours behind the Sun is waxing, or growing, and is called a *First Quarter Moon*.

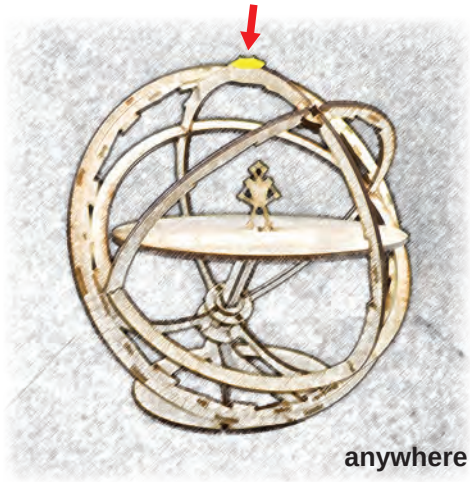
Make sure the solid side of the Quarter Moon disc is facing the Sun. With any partial Moon, crescent, quarter, or gibbous, the lighted side (represented by the solid side of the disc) always faces the Sun.

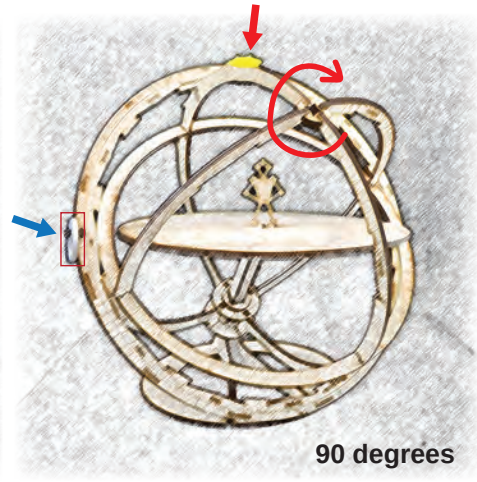
Turn the globe to sunset. Notice that the Moon is at its highest point. Keep turning to midnight, is the Moon setting now? Can you see the Moon at sunrise? When does the Moon reappear?

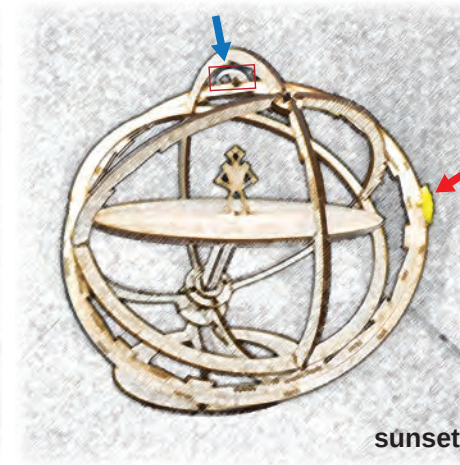
Exercise

1. Place Sun on Ecliptic Ring, rotate Sun to noon.
2. Place Moon on Ecliptic Ring 6 hours behind Sun.
3. Spin globe so Sun is at sunset. Observe Moon position.
4. Repeat for midnight.
5. Repeat for sunrise.

During a Waxing Quarter Moon the moon is 90 degrees from the sun and growing







1

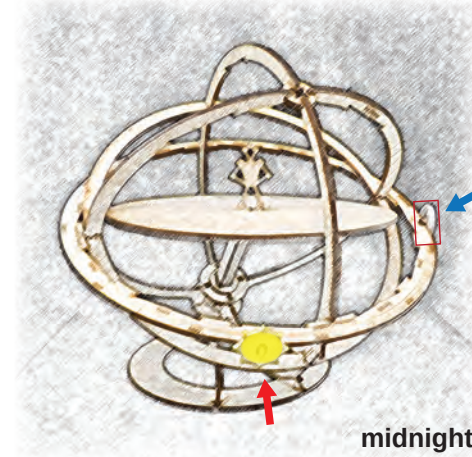
Place Sun anywhere on Ecliptic Ring and turn to the noon position

2

Place Quarter Moon 6 hours behind Sun, the 6 a.m. position

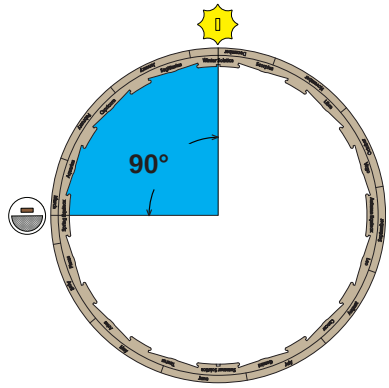
3

Spin globe to sunset, observe Moon position



4

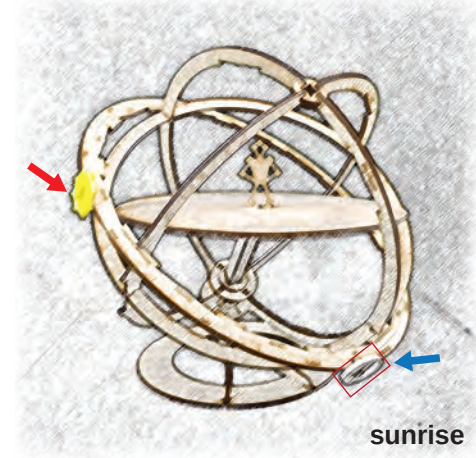
Spin globe to midnight, observe Moon position



Ecliptic Ring with Sun and Moon separated by:
a quarter-circle = 90º = 6 hours

5

Spin globe to sunrise, observe Moon position



Waxing Quarter

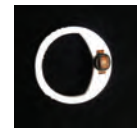
A waxing Quarter Moon is also called a First Quarter Moon. Can you guess why?

Waxing Crescent Moon

WAXING = GROWING

Equipment needed: Horizon Globe, sun, crescent moon

When the Moon is closer to the Sun than a Quarter Moon, it is a Crescent Moon.



Crescent Moon

Sun

The first week of a Moon cycle gives us a Crescent moon. When the Moon is first falling behind the Sun, before it grows to a Quarter Moon, we call it a *waxing* Crescent Moon. Waxing means growing, and the crescent of the Moon gets a little thicker each night.

Place the Crescent Moon disc on the globe between the Sun and where a First Quarter Moon would go. Notice that it forms an acute angle with the Sun. As always, make sure you put the Crescent Moon on the globe with the solid part facing the Sun.

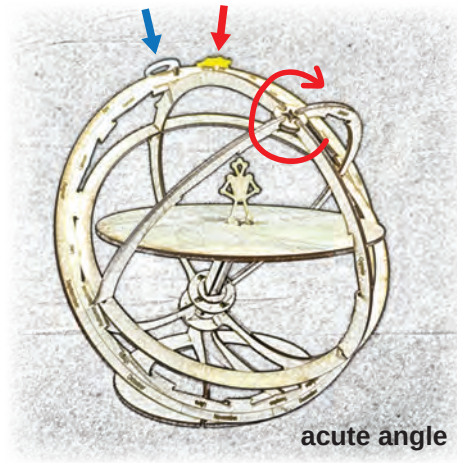
Turn the globe and notice that a waxing Crescent Moon rises just after sunrise and follows the Sun across the sky.

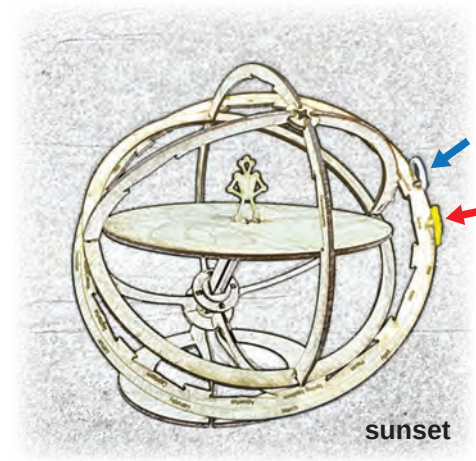
In the first couple of days after the Moon has fallen behind the Sun, it forms a very thin and dim crescent. When a waxing Crescent Moon is very thin you can only see it right around sunset, after the sky darkens, but before the Moon sets. As the Moon grows closer to a Quarter Moon it gets thicker and brighter and can easily be seen during the day.

Exercise

1. Place Sun on Ecliptic Ring, rotate Sun to noon.
2. Place Moon on Ecliptic Ring at an acute angle behind Sun.
3. Spin globe so Sun is at sunset. Observe Moon position.
4. Repeat for midnight.
5. Repeat for sunrise.

A Waxing Crescent Moon is at an acute angle with the sun and growing





1

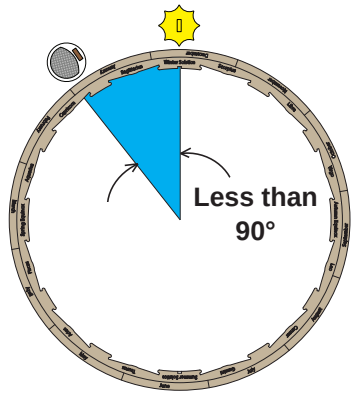
Place Sun anywhere on Ecliptic Ring and turn to the noon position

2

Place the Crescent Moon at an acute angle behind the Sun

3

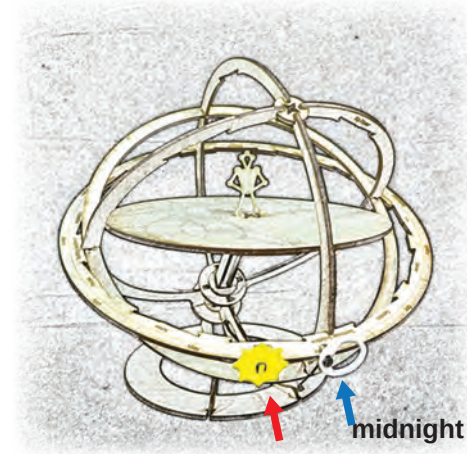
Spin globe to sunset, observe Moon position



Ecliptic Ring with Sun and Moon separated by:
an acute angle = less than 90º = less than 6 hours

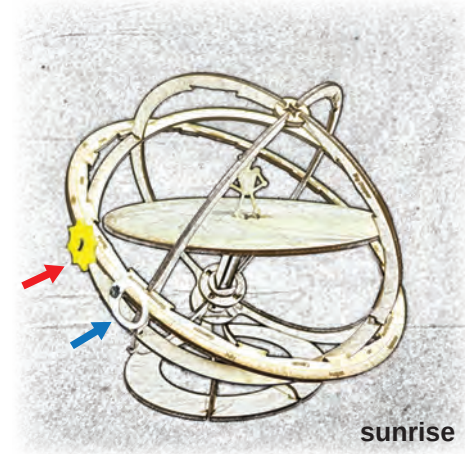
4

Spin globe to midnight, observe Moon position



5

Spin globe to sunrise, observe Moon position



Waxing Crescent

A thin Crescent Moon can be difficult to see. What time of the day would you be most likely to spot a waxing Crescent Moon?

Waxing Gibbous Moon

WAXING = GROWING

Equipment needed: Horizon Globe, sun, gibbous moon

When the Moon is more than a quarter, but not yet full, it is called a Gibbous, or "hump" Moon.

Gibbous Moon

Sun

Place the Gibbous Moon disc on the globe farther from the Sun than a First Quarter Moon, but not completely opposite like a Full Moon. A waxing Gibbous Moon rises in the afternoon. As with all partial Moons, make sure you put the Gibbous Moon on the globe with the solid part facing the Sun.

Turn the globe a few times to reveal the secrets of the waxing Gibbous Moon. When does it rise and set? When does it reach its highest point?

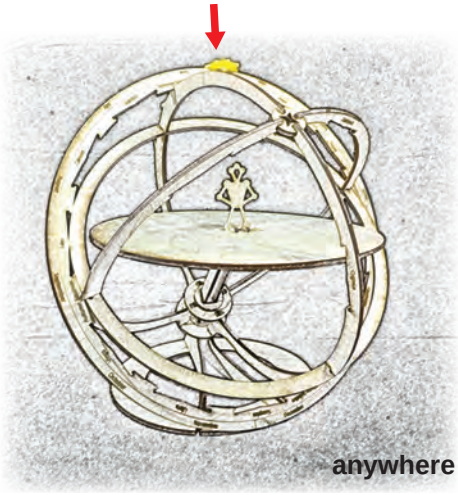
A waxing Gibbous Moon forms an obtuse angle with the Sun. It was recently a First Quarter Moon and is growing larger, but it won't be completely full until it is opposite the Sun.

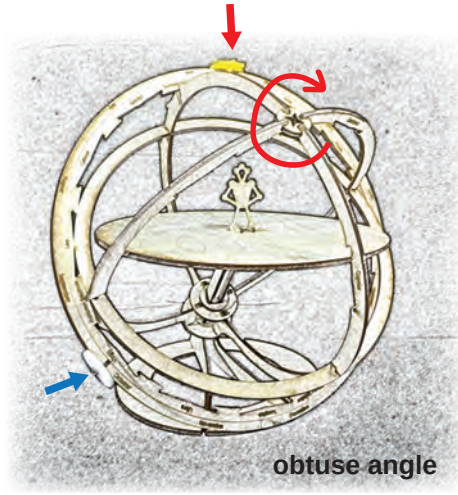
This Moon shape is always big and bright, so if its not cloudy and the Gibbous Moon is above the horizon you can easily see it, day or night.

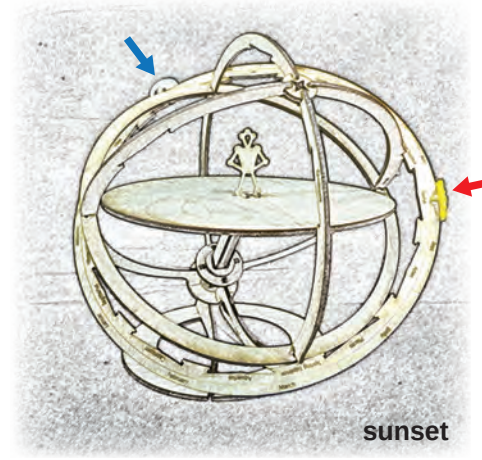
Exercise

1. Place Sun on Ecliptic Ring, rotate Sun to noon.
2. Place moon on Ecliptic Ring at an obtuse angle behind Sun.
3. Spin globe so Sun is at sunset. Observe Moon position.
4. Repeat for midnight.
5. Repeat for sunrise.

A Waxing Gibbous Moon is at an obtuse angle with the sun and growing







1

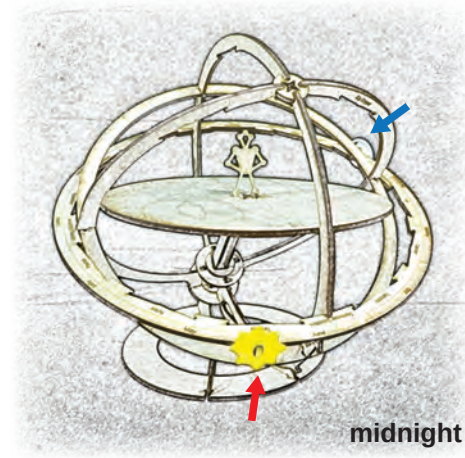
Place Sun anywhere on Ecliptic Ring and turn to the noon position

2

Place the Gibbous Moon at an obtuse angle behind the Sun

3

Spin globe to sunset, observe Moon position

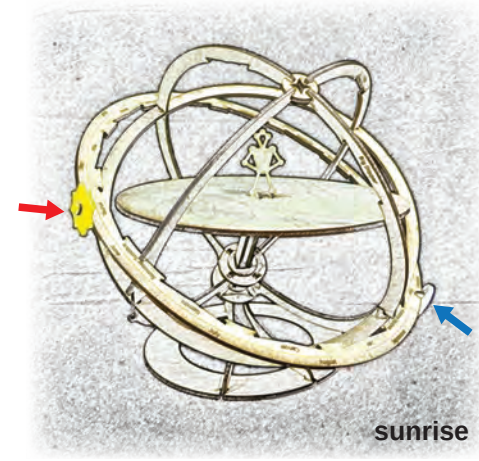


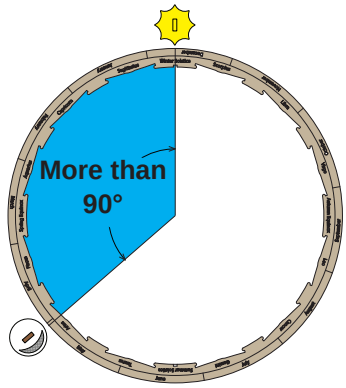
4

Spin globe to midnight, observe Moon position

5

Spin globe to sunrise, observe Moon position





Ecliptic Ring with Sun and Moon separated by:
an obtuse angle = more than 90º = more than 6 hours

Waxing Gibbous

Gibbous Moons are big and easy to find, once you know where to look.

Waning Quarter Moon

WANING = SHRINKING

Equipment needed: Horizon Globe, sun, quarter moon

We get a Quarter Moon when the Moon is a quarter turn from the Sun. Place the Sun anywhere on the Ecliptic Ring.

Sun

Quarter Moon

First let's review the waxing Quarter Moon from a previous chapter. Turn the globe so the Sun is at noon. Now place the Quarter Moon on the ecliptic 6 hours behind the Sun. It will be near the horizon on the east side, halfway between the midnight and noon positions.

Make sure the solid side of the Quarter Moon disc is facing the Sun. With any partial Moon, crescent, quarter, or gibbous, the lighted side (represented by the solid side of the disc) always faces the Sun.

Turn the globe to sunset. Notice that the Moon is at its highest point. Keep turning to midnight, is the Moon setting now? Can you see the Moon at sunrise? When does the Moon reappear?

There are two Quarter Moons per month. We just illustrated the first, which happens when the Moon falls behind the Sun by 6 hours. Now place the Quarter Moon disc one quarter turn, or 6 hours ahead of the Sun. Make sure the bright side faces the Sun.

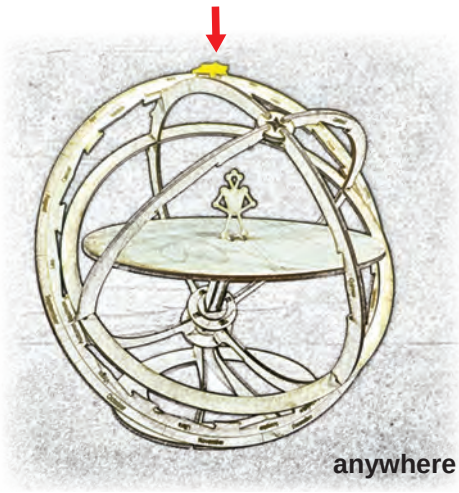
This is a Last Quarter Moon. A Last Quarter Moon is a quarter turn, or 6 hours ahead of the Sun (you could say it is ¾ of a turn behind the Sun). The Sun will catch this Moon in another week. Turn the globe to noon, sunset, midnight, and sunrise. When can you see a last Quarter Moon?

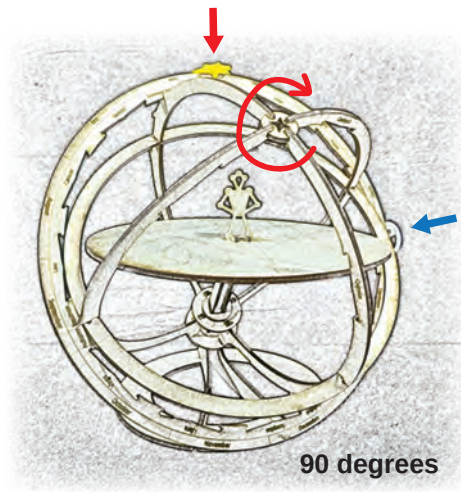
Exercise*

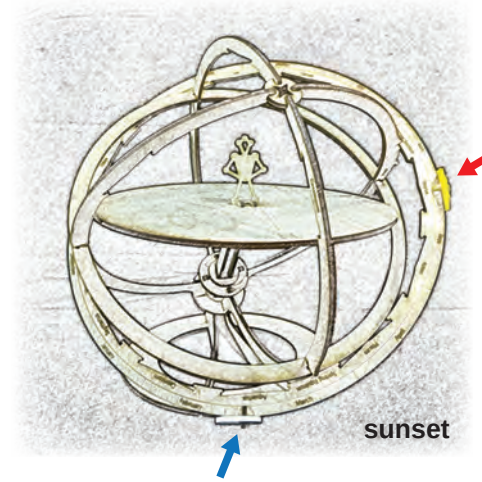
1. Place Sun on Ecliptic Ring, rotate Sun to noon.
2. Place Moon on Ecliptic Ring at an 90° angle ahead of Sun.
3. Spin globe so Sun is at sunset. Observe Moon position.
4. Repeat for midnight.
5. Repeat for sunrise.

*** note: review Waxing Quarter Moon from page 42**

A Waning Quarter Moon is
90 degrees from the sun and shrinking







1

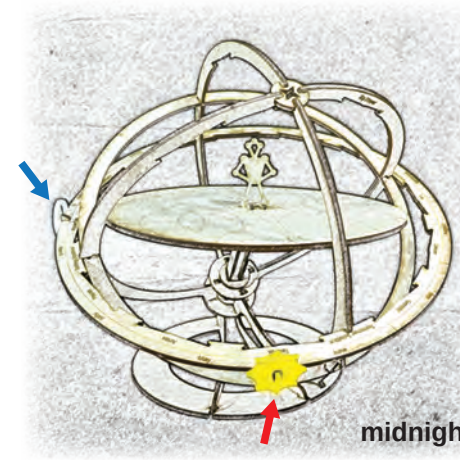
Place Sun anywhere on Ecliptic Ring and turn to the noon position

2

Place the Quarter Moon at a 90° angle ahead of the Sun

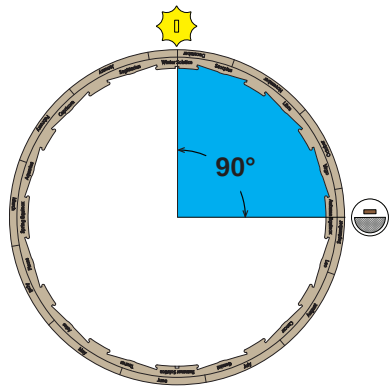
3

Spin globe to sunset, observe Moon position



4

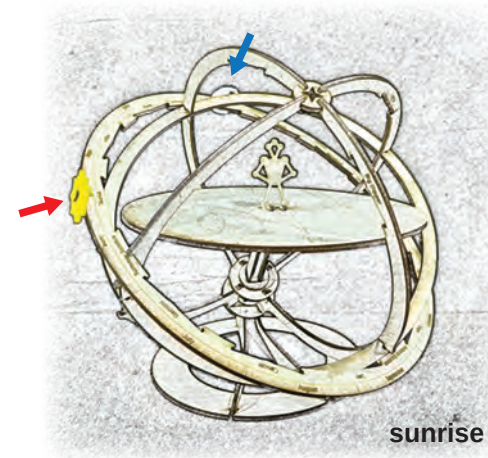
Spin globe to midnight, observe Moon position



Ecliptic Ring with Sun and Moon separated by:
a quarter-circle = 90º = 6 hours

5

Spin globe to sunrise, observe Moon position



Waning Quarter

A waning Moon is shrinking. You could make up a rhyme to help remember: *waning is draining*

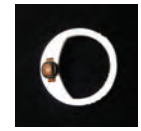
Waning Crescent Moon

WANING = SHRINKING

Equipment needed: Horizon Globe, sun, crescent moon

When the Moon is closer to the Sun than a Quarter Moon, then it becomes a Crescent Moon.

Sun



Crescent Moon

First let's review the waxing Crescent Moon from a previous chapter. The first week of a Moon cycle gives us a Crescent moon. When the Moon is first falling behind the Sun before it grows to a Quarter Moon we call it a waxing Crescent Moon. Waxing means growing, and the crescent of the Moon gets a little thicker each night.

Place the Crescent Moon disc on the globe closer to the Sun than a First Quarter Moon. The waxing Crescent Moon rises just after sunrise and follows the Sun across the sky. It is best seen just after sunset when it starts to get dark. As always, make sure you put the Crescent Moon on the globe with the solid part facing the Sun.

Now move the Crescent Moon marker to the other side of the Sun, between the Sun and the Last Quarter Moon. This Moon, which is running for its life just ahead of the Sun is called a waning Crescent Moon. A waning Crescent Moon starts out fat when it is near a quarter turn away from the Sun, and gets thinner as the sun catches up to it.

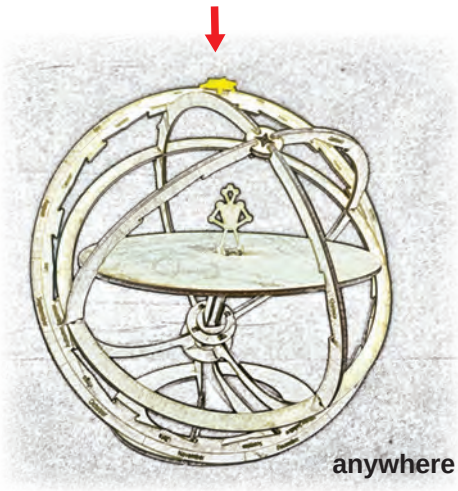
When is the best time to see a waning Crescent Moon?

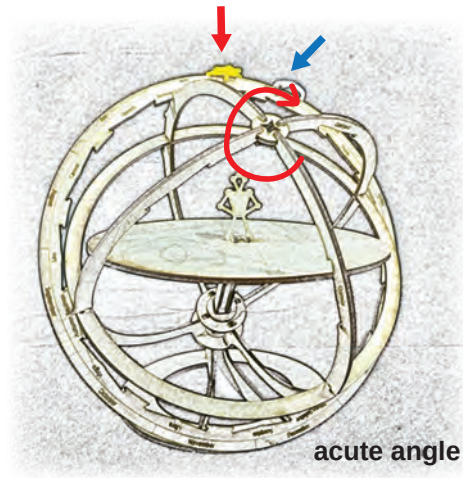
Exercise*

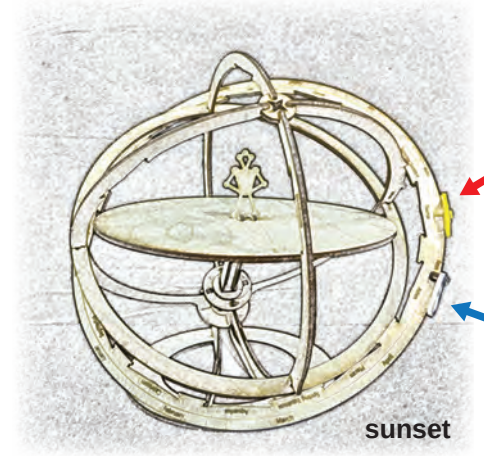
1. Place Sun on Ecliptic Ring, rotate Sun to noon.
2. Place Moon on Ecliptic Ring at an acute angle ahead of Sun.
3. Spin globe so Sun is at sunset. Observe Moon position.
4. Repeat for midnight.
5. Repeat for sunrise.

*** note: review Waxing Crescent Moon from page 44**

A Waning Crescent Moon is at an acute angle with the sun and shrinking







1

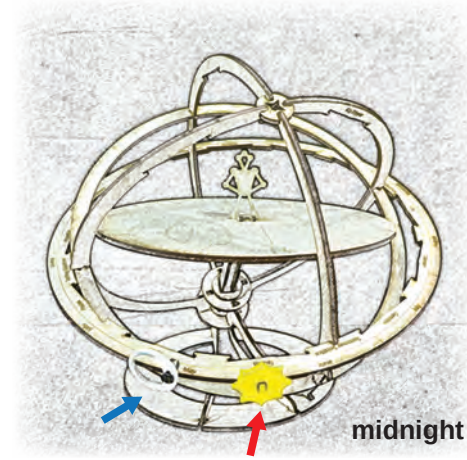
Place Sun anywhere on Ecliptic Ring and turn to the noon position

2

Place the Crescent Moon at an acute angle ahead of the Sun

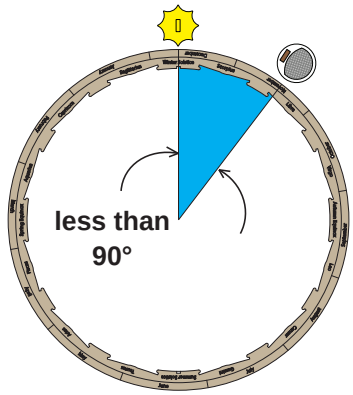
3

Spin globe to sunset, observe Moon position



4

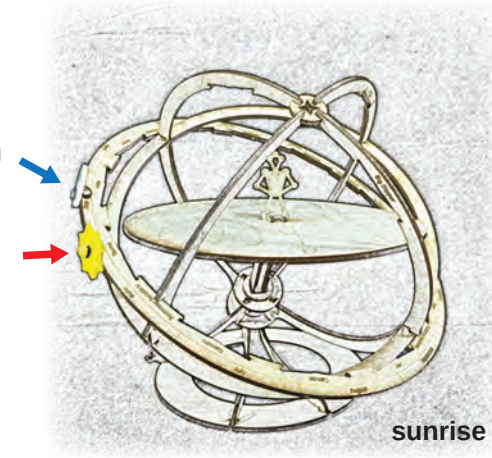
Spin globe to midnight, observe Moon position



Ecliptic Ring with Sun and Moon separated by:
an acute angle = less than 90º = less than 6 hours

5

Spin globe to sunrise, observe Moon position



Waning Crescent

A waning Crescent Moon is moving closer to the Sun every day and getting harder to see.

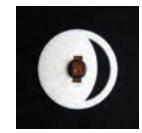
Waning Gibbous Moon

WANING = SHRINKING

Equipment needed: Horizon Globe, sun, gibbous moon

When the Moon is more than a Quarter, but not quite Full, it is called a Gibbous, or "hump" Moon.

Sun



Gibbous Moon

First let's review the waxing Gibbous Moon from a previous chapter. Place the Gibbous Moon disc on the globe farther from the Sun than a First Quarter Moon, but not completely opposite like a Full Moon. A waxing Gibbous Moon rises in the afternoon. As with all partial Moons, make sure you put the Gibbous Moon on the globe with the solid part facing the Sun.

Turn the globe a few times to recall the habits of the waxing Gibbous Moon, then move it to the waning side. Now your marker should be past full but not yet a Last Quarter Moon. Turn the globe to see how the waning gibbous behaves.

Except for when the Moon is full (directly opposite the Sun), all the time between the First Quarter and Last Quarter is the Gibbous phase.

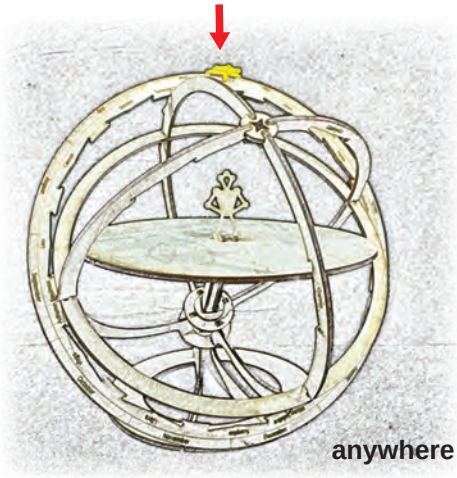
When is the best time to see a waning Gibbous Moon?

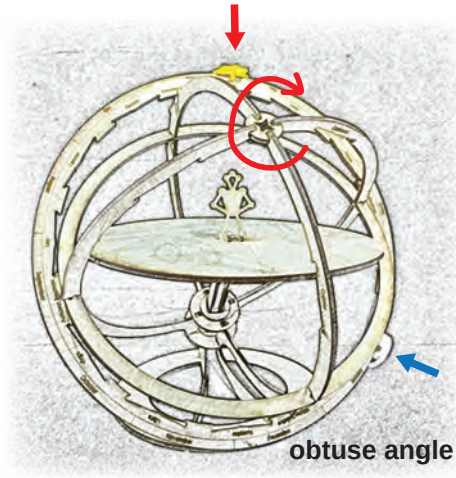
Exercise*

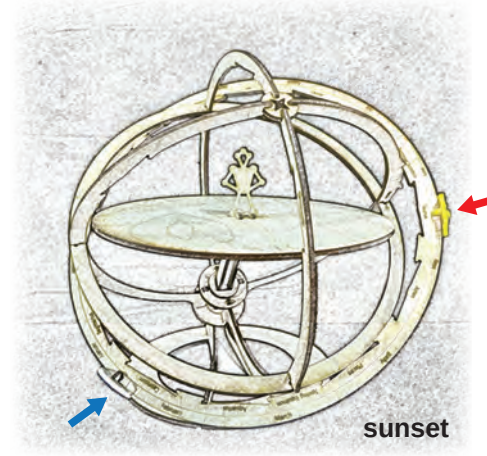
1. Place Sun on Ecliptic Ring, rotate Sun to noon.
2. Place Moon on Ecliptic Ring at an obtuse angle ahead of Sun.
3. Spin globe so Sun is at sunset. Observe Moon position.
4. Repeat for midnight.
5. Repeat for sunrise.

*** note: review Waxing Gibbous Moon from page 46**

A Waning Crescent Moon is at an obtuse angle with the sun and shrinking







1

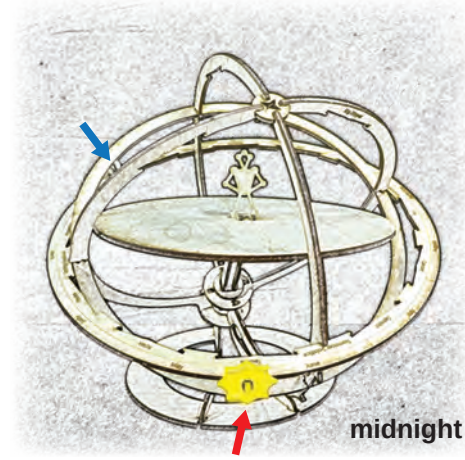
Place sun anywhere on Ecliptic Ring and turn to the noon position

2

Place the Gibbous Moon at an obtuse angle ahead of the Sun

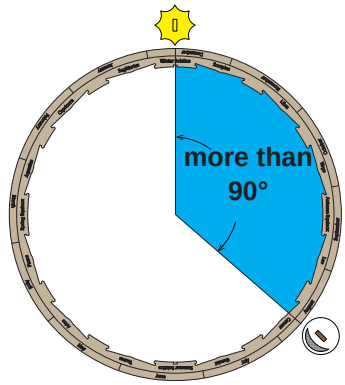
3

Spin globe to sunset, observe Moon position



4

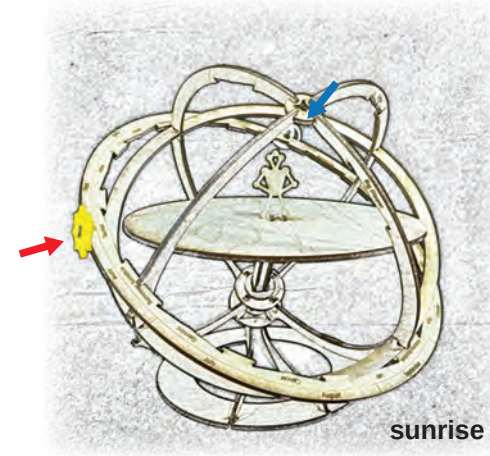
Spin globe to midnight, observe Moon position



Ecliptic Ring with Sun and Moon separated by:
an obtuse angle = more than 90º = more than 6 hours

5

Spin globe to sunrise, observe Moon position



Waning Gibbous

A waning Gibbous Moon is moving closer to the Sun every day. Next phase: waning Quarter Moon.

New Moon

Equipment needed: Horizon Globe, sun, crescent moon

Sometimes the Moon is so close to being in the same direction as the Sun that we can't see it at all. We call this a New Moon.

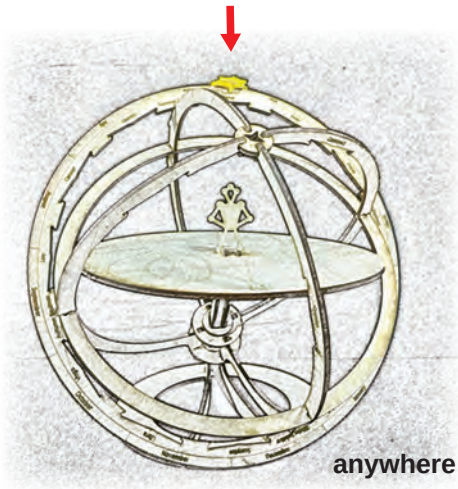
You can model a New Moon on your Horizon Globe by putting the Crescent Moon very close to the Sun and just understanding that in the real sky you can't see it this close to the Sun, or you can remove the Moon completely.

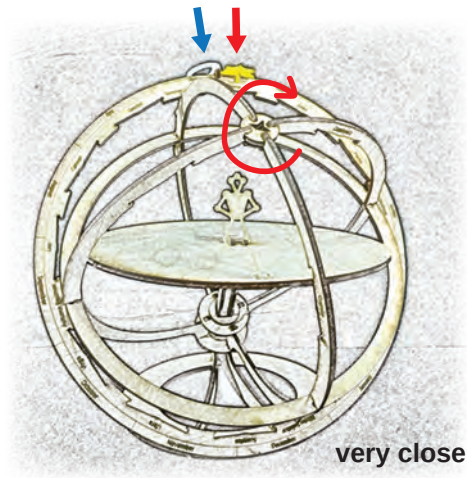
You can watch the Crescent Moon wane to nothing if you look for it just before sunrise, then it will be gone for a few days. The Moon will return as a very thin crescent, waxing in the evening sky.

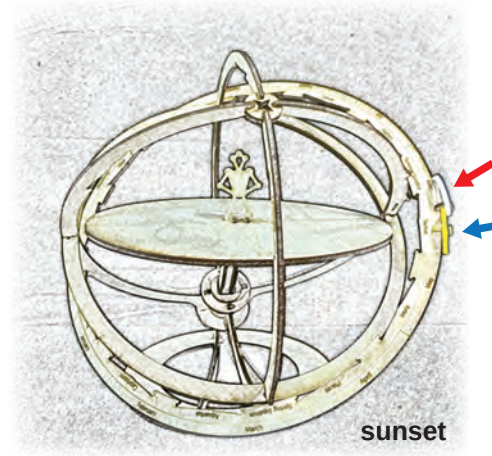
We begin counting each lunar cycle with the New Moon. It takes the Moon about 30 days to go through a full cycle of phases, from one New Moon to the next. In the next section we review the Moon phases to make them easier to remember.

Exercise

1. Place sun on Ecliptic Ring, rotate Sun to noon.
2. Place Moon on Ecliptic Ring as close as possible to the Sun (or just leave it off).
3. Spin globe so Sun is at sunset. Observe (or imagine) Moon position.
4. Repeat for midnight.
5. Repeat for sunrise.







1

Place Sun anywhere on Ecliptic Ring and turn to the noon position

2

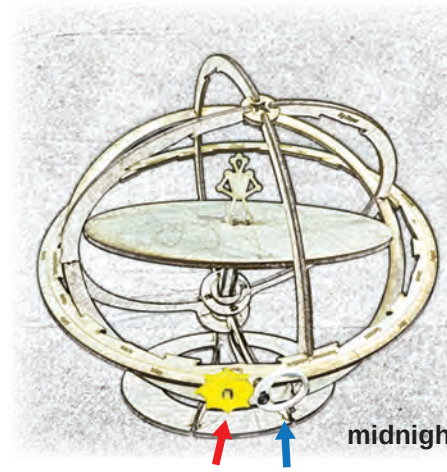
Place the Crescent Moon as close as possible to the Sun

3

Spin globe to sunset, observe Moon position

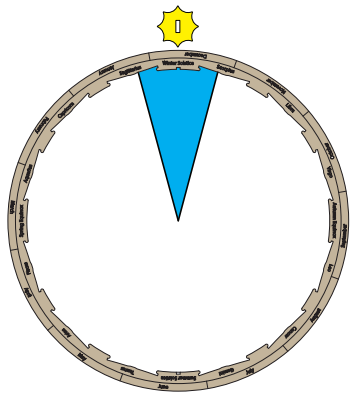
4

Spin globe to midnight, observe Moon position

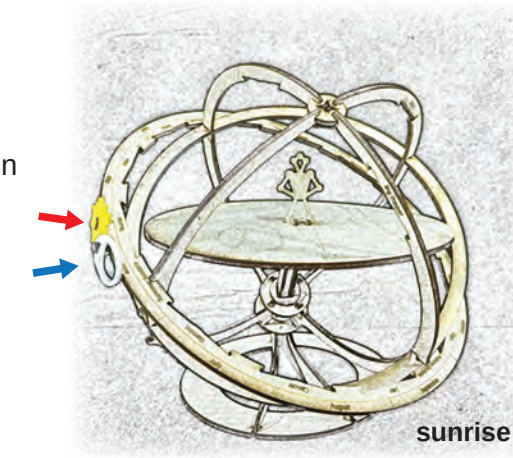


5

Spin globe to sunrise, observe Moon position



Ecliptic Ring with Sun and New Moon (not visible):



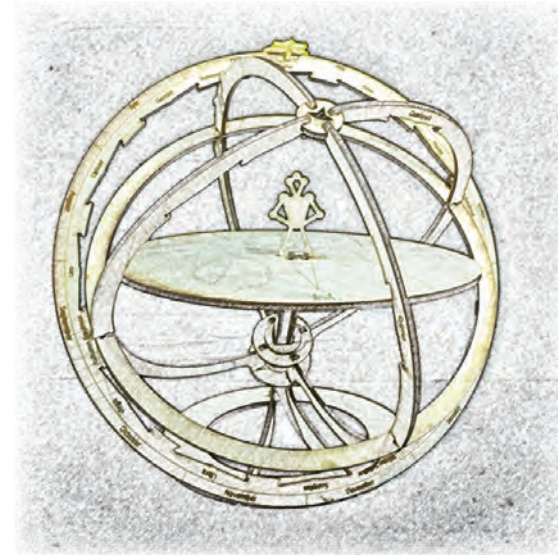
New Moon

The New Moon is hiding next to the Sun. You won't see a Moon again until the waxing Crescent Moon becomes visible in a few days.

The Monthly Moon Cycle

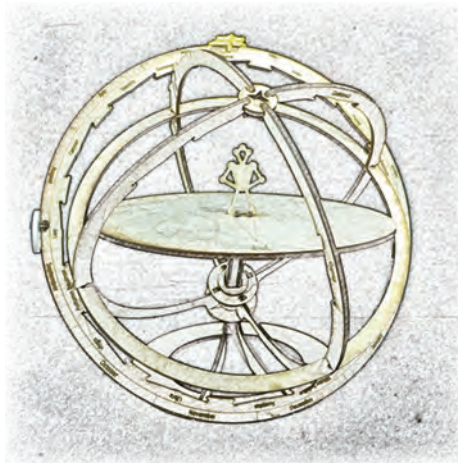
Moon watching can be one of the most fun and interesting parts of astronomy.

Just remember the Moon's monthly pattern and you will know where and when to look for it when you go outside.

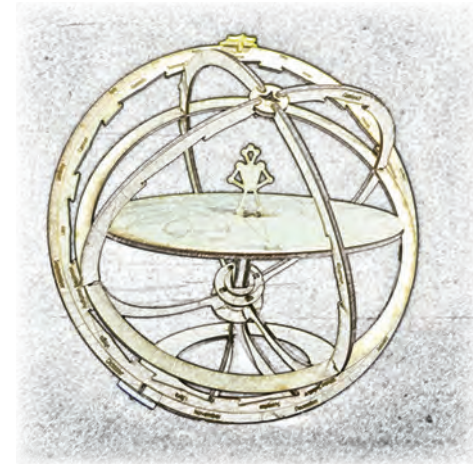


1 **NEW MOON**
Too close to the Sun to see

2 **CRESCENT (WAXING)**
after NEW MOON

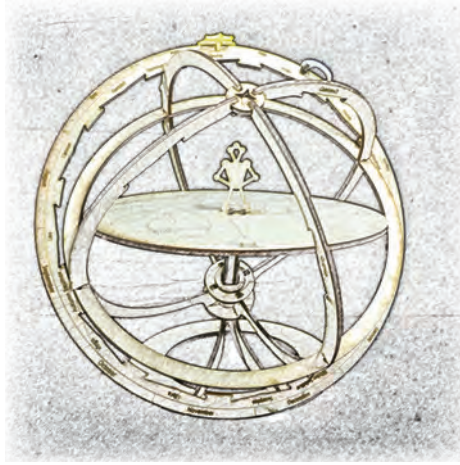


3 **FIRST QUARTER (WAXING)**
~7 days after NEW MOON

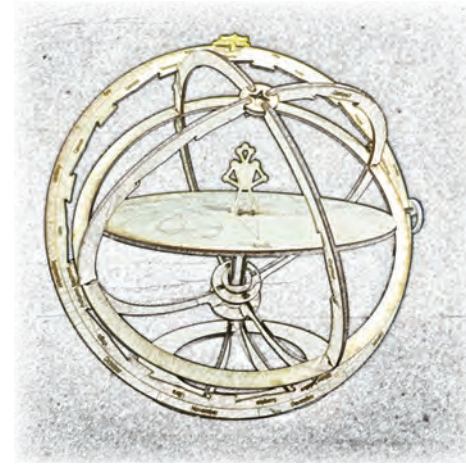


4 **GIBBOUS (WAXING)**
after FIRST QUARTER

The moon goes through a complete cycle every month

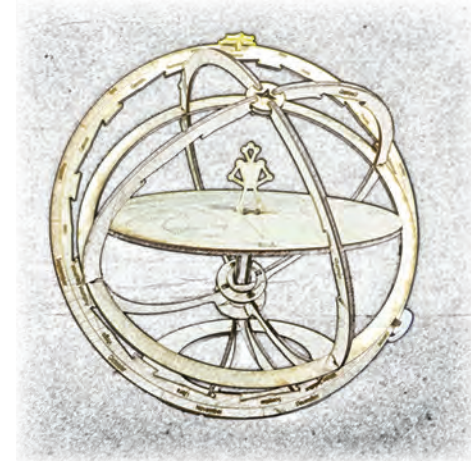


8 **CRESCENT (WANING)**
after LAST QUARTER



7 **LAST QUARTER (WANING)**
~7 days after FULL MOON

5 **FULL MOON**
Big round circle in the sky



6 **GIBBOUS (WANING)**
after FULL MOON

Moon and Planet Calendar

Understanding the Moon cycle and modeling it on your Horizon Globe is very rewarding. Now let's see how to find the Moon in the sky.

The Moon and Planet Calendar on the following page tells you what phase the Moon is in on any particular day. If you know the phase, you can both model it on your Horizon Globe and find it outside in the sky.

Appendix A has Moon Calendars for every month from now until the year 2030.

Let's see how the calendar works. Start by finding the year and month that interests you. In this example, we will look at July, 1969. That's when man first walked on the Moon.

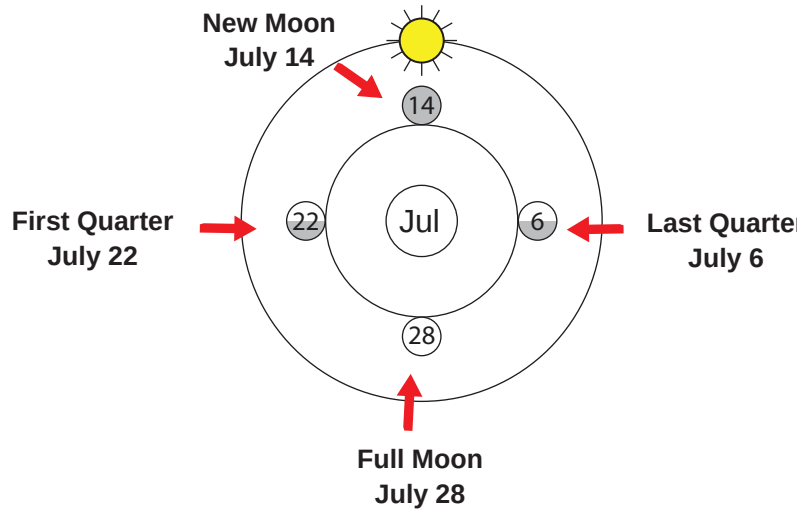
The circular calendar has the Sun at the top. The date of the New Moon is in the gray circle just below the Sun. In 1969 there was a New Moon on July 14. A week later, on July 22, the Moon had fallen back ¼ of a turn to a First Quarter Moon (the half-gray circle on the left). The Full Moon occurred on July 28 (the white circle near the bottom). The only Last Quarter Moon that occurred that month appeared before a week before the New Moon on July 6.

Keep in mind that even though months are based on the Moon cycle, calendar months don't usually match up with lunar months.

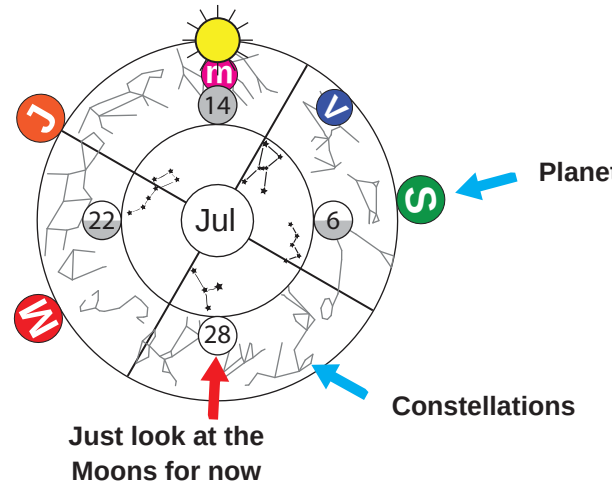
Exercise

1. Look at July 1969 on Moon Calendar, notice Moon phases.
2. Look at Moon and Planet Calendar, ignore everything but Moon phases for now.

The Moon Calendar
tells you the phase of the moon



This Moon Calendar for 1969 shows the date of the New, Full, and Quarter Moons for a particular month. Notice each Moon's angle with the Sun



In Appendix A of this book, the Moon Calendar is part of a Moon and Planet Calendar that shows the Moon, planets, and constellations.

Note: For now, just ignore everything except the Sun and Moon

Using the Moon and Planet Calendar

Using the Moon Calendar, it's easy to find the New, Full, and Quarter Moons. But that is only 4 days out of 31 days in July. What about the rest of the days? What about the Crescent and Gibbous Moons?

To find the Moon phase for the other days of the month we can use a process called interpolation. Interpolation is estimating a value using the surrounding values.

For example, what was the phase of the Moon on July 20, 1969, the day men first walked on the Moon? If we look at the Moon Calendar for that month, we see that the New Moon was on July 14 and the First Quarter was on July 22.

Between a New Moon and a First Quarter Moon is a Crescent Moon.

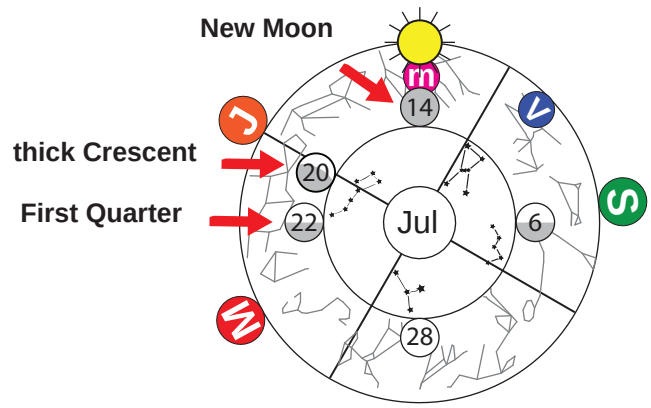
July 20, 1969, was two days before the First Quarter Moon and 5 days after the New Moon, so the Moon was a thick crescent on that day. Keep in mind that there are about 7 days between the New and First Quarter Moons, so on the 20th of July that year the Moon was 5/7 of the way between New and Quarter, closer to Quarter than to New.

From the Moon Calendar diagram, you can see that the thick Crescent Moon on July 20 was following the Sun by about 4 hours. To model that day on your Horizon Globe, place the Sun on the July part of the Ecliptic Ring, a little closer to August than June. Then place the Moon about 4 hours behind the Sun. Turn the globe and imagine astronauts walking on the Moon that Sunday afternoon.

Apollo 11 returned to Earth on July 24. Try using the Moon Calendar to find the phase on that day.

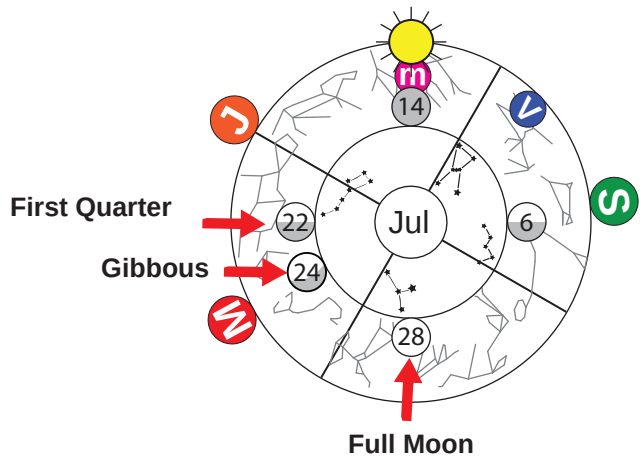
Exercise

1. Look at July 1969 on the Moon Calendar and determine the Moon phase on July 20.
2. Determine moon phase 3 days later, July 24.
3. What phase will the Moon be in on your birthday this year? How about on Christmas Day?



1969

To find phases between New, Full, and Quarter, find the closest day on the calendar, then estimate where the Moon will be.



On July 24, 1969, the Moon was 2 days past First Quarter and 5 days before Full. That means it was a Gibbous Moon when the astronauts returned.