Activity 1: Where Do Lunar Phases Come From?

The phases of the moon have fascinated people for thousands of years. They have appeared in myths, art, medicine, and science writings. How do phases originate? The activity below lets you discover their origin.

You have started keeping a lunar log. When you look up in the sky at the same time each day will you always see the Moon?

When you do see the Moon, is it always the same shape? Explain.

Why does the Moon appear to change shape?

LET'S EXPLORE!

1. Set up a bright light at one end of a darkened room. Face the light holding a ball on a stick at arm's length between you and the light. The light represents the Sun, the ball is the Moon, and you are an observer on Earth. You will be changing the position of the Moon (ball) to simulate its revolution around the Earth (you).

When you are looking at the light, it represents daylight for you on Earth. When you are mostly or totally turned away from the light (you can’t see it if you don’t turn your head) you are in darkness on Earth (or we will say you are at night).

How much of the Moon's surface (the ball) that you see is illuminated?

Draw only any illuminated section of the ball in the chart below for 0°. If there is no illuminated section, draw a dotted circle. Don’t worry about filling in the phase at this point unless you know it.
2. Turn your body 90° counter-clockwise. Observe again and sketch what you see.

3. Turn 90° counter-clockwise again. You should now have your back to the light and are at 180° from the starting point. You may have to raise the ball up to get it out of your shadow. Draw any illuminated surface.

4. Turn 90° counter-clockwise one more time (now at 270°). Record what you see in the chart below.

<table>
<thead>
<tr>
<th>ROTATION</th>
<th>0°</th>
<th>90°</th>
<th>180°</th>
<th>270°</th>
</tr>
</thead>
<tbody>
<tr>
<td>ILLUMINATION SKETCH</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PHASE</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The first position you observed represents the new moon. The 90° position gives the 1st quarter moon. At the 180° position you will see a full moon. At the final position you will see a repeat of position 2 with the illuminated side reversed and this is called the 3rd quarter moon. Now fill in the phase in the chart if you haven’t already.

5. Repeat the turning and recording procedure again but this time, turn only 45° counter-clockwise each time (stop after going half as far each time). Label each phase that you can in the section provided.

<table>
<thead>
<tr>
<th>ROTATION</th>
<th>0°</th>
<th>45°</th>
<th>90°</th>
<th>135°</th>
</tr>
</thead>
<tbody>
<tr>
<td>ILLUMINATION SKETCH</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PHASE</td>
<td></td>
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<td></td>
<td></td>
</tr>
</tbody>
</table>

How much of the Moon's surface is actually illuminated at any given time (even if you can’t see it)? Explain.
Between new and quarter phases you will see the **crescent phase**. In the crescent phase, less than half of the surface you see is lit. Between quarter and full, you will see the **gibbous phase**. In the gibbous phase, more than half of the surface you see is illuminated. This entire cycle takes about 28 days.

Half of the surface is always lit by sunlight. However, because of our position with respect to the Sun and Moon, we will see a varied amount of illumination in the course of a month.

6. Go back to the 90° position and slowly rotate through to 270°. What happens to the amount of illumination we see? How is it different before and after the full moon?

Would you expect it to be the same for crescent phase? Explain why or why not.

We distinguish between first and second occurrences of the crescent and gibbous phases by indicating how the illumination is changing. If the amount of illuminated surface is increasing we say the Moon is **waxing**. If the illuminated surface decreases we say the Moon is **waning**.

Now, let's see if we can understand why you can't see the Moon at the same time every day.

7. Place yourself so that you are facing 180° from the light. Image a circle on the floor surrounding you. Think of the circle as a 24 hour clock that runs counter-clockwise. The 12:00 midnight position is the direction you are facing. When a position is directly in front of you it is the same as being highest in the sky. If you do not turn your head but look out of the corners of your eyes on either side it would be as if you were looking at points on the horizon.

a. Slowly turn counter-clockwise, simulating Earth rotation. You must keep your head forward at all times but you can move your eyes. As you first catch sight of
the light (Sun) it is sunrise. When the light (Sun) is directly in front of you it is noon. As the light disappears it is sunset. Thinking about the floor clock, at what approximate times are sunrise and sunset?

Now place the Moon ball on an object (or have your partner hold it) so that it will maintain the first quarter position as you rotate.

b. Approximately what time would it be when you see the 1st quarter moon highest in the sky? (That means you would be looking at the Moon straight on.)

c. Move the Moon to full phase position. Is it day or night? Could you see a full Moon in the day time? Explain.

d. Move the Moon to a position between 3rd quarter and new Moon when you expect to see a crescent Moon. What part of the day is it? Could you see a crescent Moon at night? Why or why not?

If you can see it would it be high in the sky or near the horizon? (high if you can see it without moving your eyes much; low if you have too look sideways)

e. For each lunar phase, list the approximate time that the Moon will be highest in the sky and the approximate range of times that you will be able to see it in the table below.

<table>
<thead>
<tr>
<th>Lunar Phase</th>
<th>Time when it is highest in the sky</th>
<th>Approximate time range over which phase is visible</th>
</tr>
</thead>
<tbody>
<tr>
<td>Full</td>
<td></td>
<td></td>
</tr>
<tr>
<td>New</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1st quarter</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3rd quarter</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Waxing gibbous</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Waning crescent</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

As you now have discovered, certain phases will be prominent at different times of the day. Most people remember a full moon because it is most striking late at night when it is very
dark. On the other hand, a new moon is hard to see because it is visible during the day when the light of the Sun overwhelms the light reflected from the Moon. In fact, when you see a new moon, you are seeing earthlight (not sunlight) reflected from the surface of the Moon. Crescent phases are best seen in early morning. Gibbous phases are prominent in early evening.

If you see a full moon from Southern Maryland, what phase will people in South Africa see during their next night? Explain.

Activity 2: Earthly Phases

The moon is not the only celestial body to show phases. We can use the same terms (full, new, crescent, and gibbous) to describe the phases of any celestial body.

1. Can any of the planets show phases to an Earth-based observer? (Think about the position and revolution of the Earth and inner and outer planets.) Explain your response.

2. Suppose you are an astronaut on the Moon and you are gazing out at Earth. What a sight! Your friends on Earth are looking at the Moon and are seeing a gibbous phase. What phase of the Earth are you seeing from the Moon? Explain.

If the phase of the Moon is full from the Earth, what phase of the Earth will you see from the Moon?

Can you say anything in general about the simultaneous phases of the Moon and Earth? Explain.
Some interesting information about lunar misconceptions

1. Many people believe that lunar phases are caused by the shadow of the Earth falling on the Moon. As you see through Activity 1, shadows are not the cause. Our position with respect to the Moon and Sun dictates the amount of illuminated surface we will see.

   Sometimes students assigned to do a lunar phase log will cheat a little and may draw something like this.

   Can this phase exist? Did you observe it?

2. The diagram shown here is very common in books for all age levels. However, it should not be substituted for a hands-on activity. In this diagram the reader is looking from a perspective other than Earth and must project him or herself to the middle of the diagram to understand the phases. This is very difficult for most children (and many adults).

3. Another common misconception is that the same side of the Moon is illuminated all the time. This is false. Since the Moon's rotation rate is the same as the time it takes to revolve around the Earth, we see only one side from the Earth. However, at some point during a month every part of the Moon's surface is illuminated.

Activity 3: Do it Yourself Eclipses

Now you have seen how the alignment of the Sun, Earth, and Moon can lead to the lunar phases we see through the period of a month. Some of these alignments can also cause eclipses.

Have you ever seen an eclipse of the Moon or Sun? Explain what you saw if you have.

How do they happen?
LET'S EXPLORE!

1. Obtain two balls on sticks, one larger to represent the Earth and one much smaller to represent the Moon. Position yourself so that the balls are in the path of a bright light.

![Image of light source, Moon ball, and Earth ball](image.png)

2. Line up the balls as above and see if you can cast a shadow of the Moon ball on the Earth ball.

Does the shadow fall on all of the Earth ball or only part?

How can you make the shadow fall on more or less of the Earth's surface?

You have set up eclipse conditions. Did you generate a solar or lunar eclipse? Explain.

What is the phase of the Moon you would see from Earth immediately before and after the eclipse?

3. Now reverse the positions of the Earth and Moon balls. Try to cast a shadow on the Moon ball.

Is it easier or harder? Why?

What kind of eclipse did you form this time?

What is the phase of the Moon now?
4. Move the Moon ball up or down a little so that it is not in line with the Earth ball and light. What happens to the location of the shadow?

![Diagram of solar eclipse alignment]

**Alignment for a solar eclipse**

When you cast a shadow of the Moon on the Earth ball you were simulating a solar eclipse. If you were standing on the Earth, it would appear as if the Moon had blocked out the Sun. As you were making the shadow, you noticed that the shadow will only fall on part of the Earth. This is why an eclipse can only be seen in select parts of the Earth's surface. If only part of the shadow strikes the Earth we will see a partial eclipse.

Why are total solar eclipses so rare? Shouldn't we see one with each new Moon?

Because the Moon is so much smaller than the Earth, the shadow will only fall on the Earth if the alignment is perfectly correct. The Moon revolves around the Earth in an ellipse. This ellipse falls on a plane that is tilted with respect to the equator of the Earth. It is rare for the Moon to be in the new Moon position and in line for the shadow to fall on Earth.

If the Moon is far away enough from the Earth that it cannot appear to cover the whole surface of the Sun, we may see the Sun with a ring of light around a dark inner circle. This type of eclipse is referred to as an annular solar eclipse.

If the Earth casts a shadow on the Moon you will see a lunar eclipse from the Earth. Explain why you can see a lunar eclipse more often.