TAKE-HOME EXP. # 3

Naked-Eye Observations of the Moon

(See also Take-Home Exp. #4 which can easily be done at the same time as this one.)

You have already seen what the Moon looks like in its various phases, but you may not realize it can be "out" in the day as well as the night. Nor are most people familiar enough with the geometry of the Sun-Moon-Earth system to draw it as easily as you will be able to by the end of this experiment.

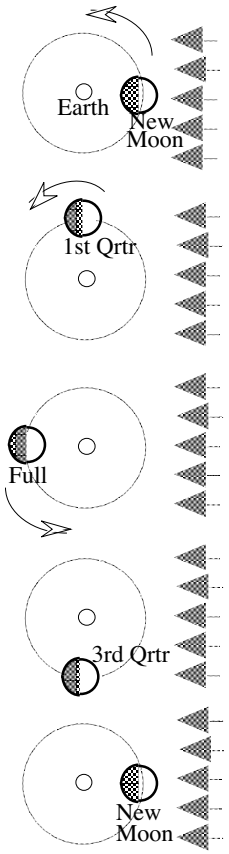
a. When to make observations of the moon's phases:

nytime you can find the Moon, make an observation. These observations do <u>not</u> have to occur only at the principal phases. Anytime and anywhere you can see the Moon is a good time to make a sketch and record the requested information.

b. Dates of the Principal phases of the Moon, Times of Moonrise, and Moonset:

When doing this experiment, check your newspaper everyday for the times of moonrise and moonset; they are listed on the weather page. Many calendars show the days of occurrence of the principal phases--new, first-quarter, full, third quarter--of the Moon. Most newspapers have the principal phase dates listed every day.

In the view of Earth pictured to the right, the Moon's orbit is the circle, and incoming sunlight is from the right. The Moon moves counterclockwise around the Earth, taking 28 days to complete its cycle. Starting at the topmost diagram, a "New Moon" phase, seven days elapse between each succeeding diagram.



c. What is wanted: six (6) or more observations spaced out over a month.

Your data should range over at least 30 days, so one observation every 4 or 5 days is appropriate. Each of the six observations will contain:

1) *a horizon drawing* of your actual observation, as perceived, with directions and altitude of the Moon clearly marked

2) *a "geometric overhead" view of the earth-moon-sun relationship* as viewed from the celestial northern hemisphere. It must clearly mark the position of the observer at the observation time and the position of the moon in its orbit. This is the geometry that "causes" the perceived view.

3) *A data table* with a name for the perceived phase, time of observation, sky conditions, altitude, and other pertinent information.

Look up! Look up! The Moon is out in the daytime, just as often as it is out in the night. Be prepared to record the appropriate information whenever you see the Moon.

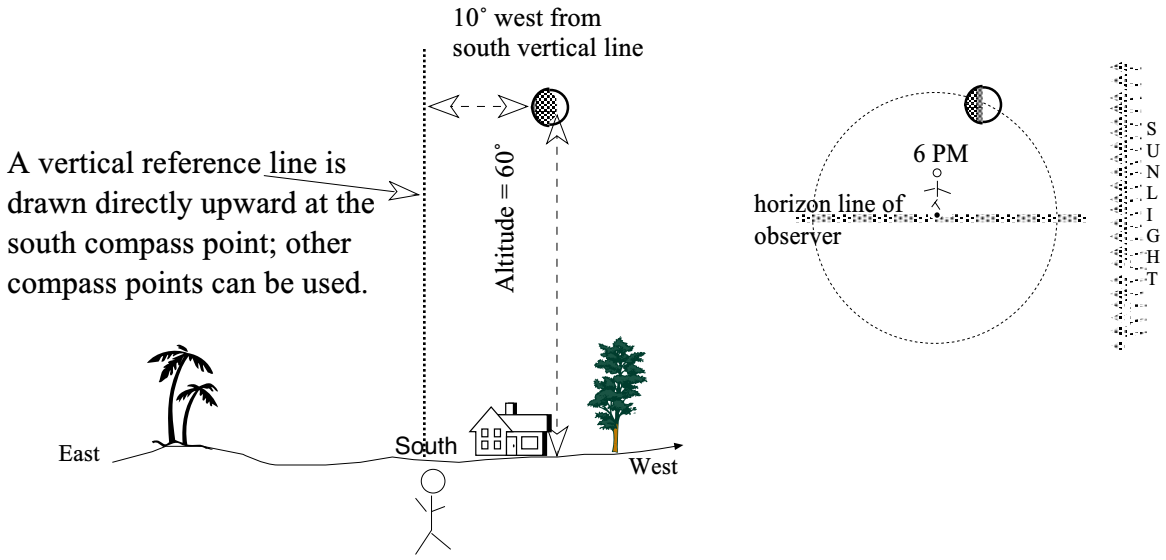
In making your "phase" diagram, start by **facing south**, putting west on the right and east on the left of your diagram. Sometimes this won't work because the Moon is too far to the side, but then you can face either east or west or north as needed. Make sure your diagram states clearly which you are facing

Use your outstretched arm and hand as described in T.H.E. #1 to estimate and record angular distances. Obtain the altitude in degrees of the Moon directly above, perpendicular to, the horizon line. Also, check the angular width of the Moon at every observation with your outstretched arm and little-finger, and convince yourself that the Moon is always the same size objectively, despite the fact that we may perceive it as larger or smaller.

AN EXAMPLE of a **Data Sheet** for reporting one Moon observation is given on the next page. **You need six of these observations, each having the three numbered items.**

Data Sheet Requirements:

1. You need a "perceptual diagram" like that to the left below. It provides what you actually see when you face in one of the compass directions and measure an angle to the left or right of a straight vertical line drawn perpendicular to the horizon. If you are facing south, that vertical line is called a "meridian", a line of longitude that can be drawn from the South Pole to the North Pole.



2. You also need a "geometric overview diagram" like that to the right above for each observation. It provides the reason that you see the Moon the way you do at the time and date of your particular observation. Your "geometric overview" diagram must show the Sun-Earth-Moon geometry and the observer's position and horizon line at the time the observation was made. **For a description of how to draw this diagram see the next page.**

3. You also need a Data Table with the following information.

MOON DATA TABLE:

1. DATE AND TIME: 2/8/2000, 6 PM

2. PHASE: One day before first-quarter moon.
   (Aside: Check its angular width with your little finger held at a straight-arm's length.)

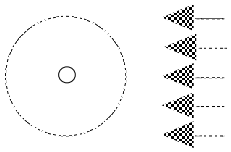
3. E-W POSITION RELATIVE TO MERIDIAN: Moon's position is about 10˚ west of the vertical line drawn at the south compass point to the zenith (your personal meridian).

4. ALTITUDE: The altitude of the Moon above the horizon is 60˚.

How to create a geometric overview of the Sun-Moon-Earth relationship that produces the phases of the Moon

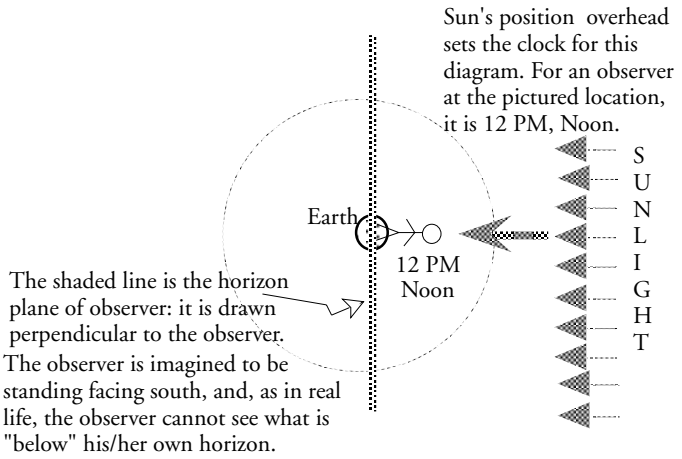
1. The basic diagram that every drawing starts with is shown to the right. This is a view from high above the north pole of the Earth. The Earth is the tiny dot at the center of the circle. The circle is the path of the Moon around the Earth (if we take the Earth as our fixed observation point—and we will). The Sun's light is shown coming in from the right

   In this view from the region of the celestial north pole, the Earth rotates counterclockwise about its internal N-S polar axis once every 24 hours. The Moon also moves counterclockwise along its orbit path.

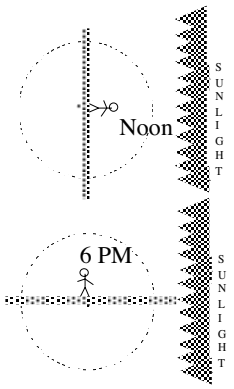


THE BASIC STARTING DRAWING NEEDED FOR EVERY OBSERVATION.

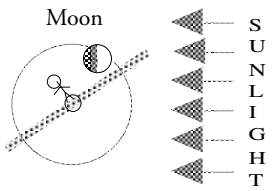
2. After doing the basic drawing, the next step is place yourself as observer in the diagram at the observation time. **The incoming sunlight sets the Earth clock in these diagrams.** Fore example, at noon, the sun is at its highest point at your location, and that is indicated in the diagram to the right by placing the observer so that the sunlight falls directly on top of her/his head. (Imagine the observer to be facing south, so we are looking at the back of the observer's head.) The observer's horizon line is another very important reference line, essentially representing the ground under the observer's feet. It is shown in the diagram by the shaded line drawn perpendicularly to the standing observer. The observer can only see what is "above" the line for her/him, and cannot see anything "below" it.



3. In the viewpoint of these diagrams, we are looking down on the Earth-Moon system from above the North Pole, and the Earth rotates counterclockwise. Imagine the standing observer to be similar to the hour hand of a 24-hour clock, except that this "hour hand" turns backward. In 6 hours, one-quarter of this 24-hour clock cycle, the Earth will turn the observer as shown in the diagram to the right.

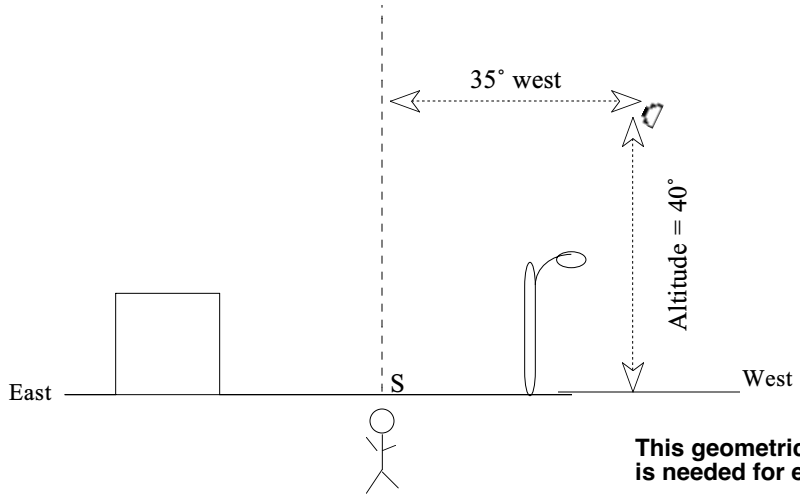


4. Finally, if you haven't already done so, place the Moon at its proper location along the orbit at the time you make the observation. The weather page of most newspapers will give you the dates of the principal phases (new, 1st quarter, full, and 3rd quarter). After some practice, this drawing becomes quick and easy. In the example to the right, the date is such that the Moon is about 2 days before the 1st-quarter date. Can you see that the observer made the observation at about 8 PM?

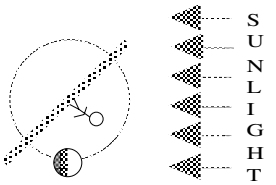


APPENDIX:

SAMPLE DATA SHEET



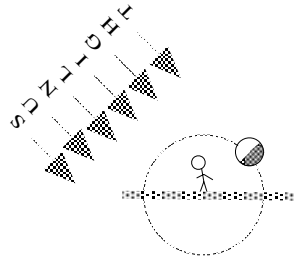
This geometric overview drawing is needed for each observation.



MOON DATA TABLE:
(The titles in bold are not needed on your sheets.)

1. **Date and time:** 6/17/98, 9 AM
2. **Phase**: Third-quarter moon.
3. **E-W of Meridian:** When facing directly south, the Moon's position is about 35˚ west of the meridian.
4. **Altitude:** The altitude of the Moon above the horizon is 40˚.

Note how the geometric overview diagram mimics what you actually see. Rotating the entire geometric overview counterclockwise until the observer is upright most easily shows this fact. It then looks like this:



At 9 AM, the sunlight is coming from the east, and the lighted part of the Moon is facing east, and it's about 40˚ from a vertical line at the directly-south-facing observer position.

TAKE-HOME EXP. #4
"Facing" the Moon

(See also Take-Home Exp. #4 which can easily be done at the same time as this one.)

The variations in shading on the lighted parts of the Moon are sometimes difficult for some to see at first glance. You will probably have to look carefully after your eyes have become somewhat dark-adapted. Try out your own imagination, and see if you can see the things others have seen, or if you can see something else in the pattern of light and dark on the face of the Moon.

YOU HAVE TO LOOK WITHIN THE *LIGHTED* PORTION OF THE MOON, SO THESE OBSERVATIONS ARE BEST DONE BETWEEN THE FIRST-QUARTER AND THIRD-QUARTER PHASES OF THE MOON.

This experiment is interested in what the face of the Moon looks like *to you, with your naked eyes, in its near full-moon phase*. But, if you have binoculars, please don't hesitate to use them also. What you can see may astound you.

This work will result in a visual mnemonic for the shaded areas on the face of the full Moon. A mnemonic is a pattern that helps remembrance like Every Good Boy Does Fine, EGBDF, for remembering the lines on a musical staff, or ROY G. BIV , for Red, Orange, Yellow, Green, Blue, Violet. In this case, the visual mnemonic will be a pattern you find in the darker areas of the lighted part of the Moon.

A. What Do You See On The Face Of The Moon?

This experiment asks you to make a more-or-less accurate rendering of the major shaded and lighter areas of the face of the moon, while at the same time allowing your imagination the freedom to form those shapes into something recognizable. It should be recognizable not only to you, but also to others.

While you are creating your own form, you might look to see whether you can see anything like the face of the "man in the moon" or the widespread appearance of a rabbit. Remember, your shadings and imagined forms must stay within the constraint of a more-or-less accurate rendering of the way the pattern of lighter and darker areas actually looks on the surface of the lighted part of the Moon. The full pattern can be seen at the full-moon phase, but pieces of the pattern can be seen at any phase. Check the full-moon phase as soon as possible.

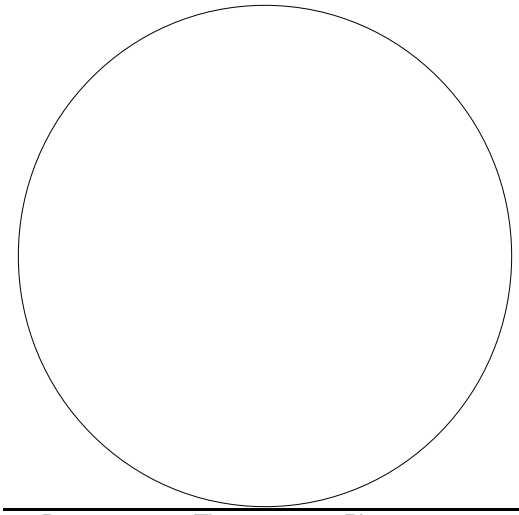
We supply some circles for the sketches. Record dates, times, and the approximate phase of the Moon at the times of your observations, as shown on the following page.

What is wanted is the pattern of shading on the lighted face of the Moon. Look carefully. Roughly outline the darker areas as you are observing. Do this with a partner (who doesn't necessarily need to be taking this class), and check whether they agree with your outline.

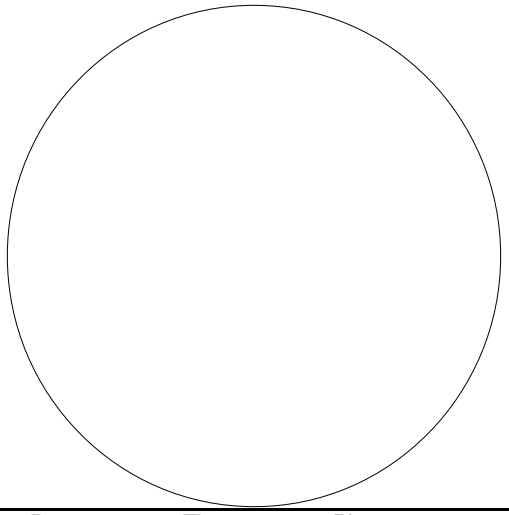
NAME(print) _____ ID# _____

DATA SHEET: The circles represent the surface of the Moon.

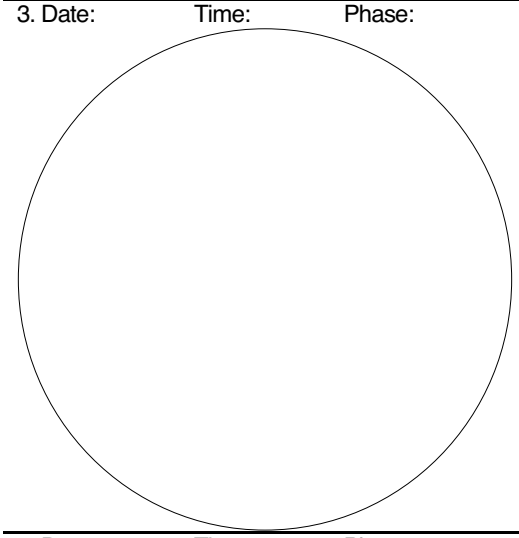
1. Date: Time: Phase:



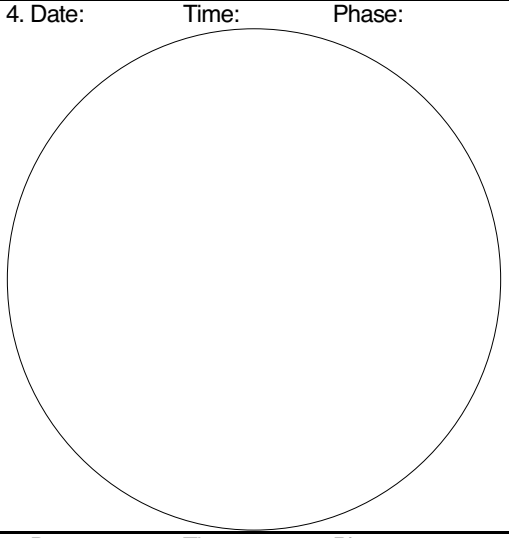
2. Date: Time: Phase:



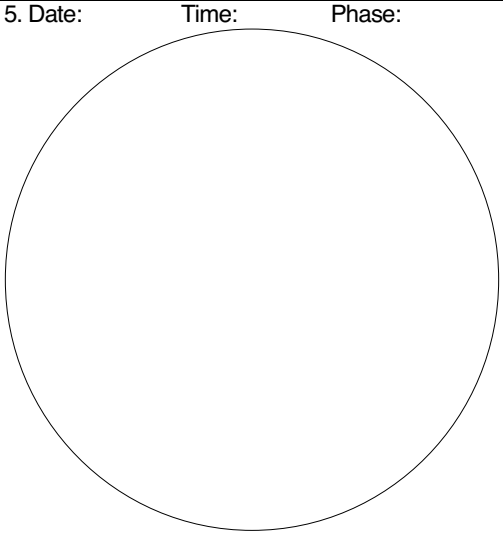
3. Date: Time: Phase:



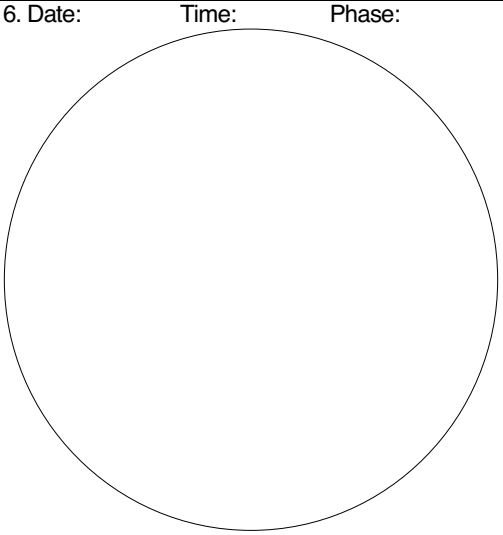
4. Date: Time: Phase:



5. Date: Time: Phase:



6. Date: Time: Phase:



DATA SHEET

B. Questions

1. Do we always see the same side of the Moon facing us? A simple "yes" or "no" is unacceptable. State and cite your evidence, in your data, and your drawings. Please explain clearly and explicitly, using complete sentences. What conclusion does your data support? If your data does not support a conclusion, say so, and say why not.

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_____(If needed, continue on another sheet.)

2. Does the Sun always "see" the same surface of the Moon? State your reasoning explicitly. A simple "yes" or "no" is unacceptable.

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_____(If needed, continue on another sheet.)

Helping and instructing are encouraged, but copying is completely inappropriate and unacceptable. *Do your own graphs and drawings and answer questions in your own words*. ***It is OK to make a reasoned mistake; it is wrong to copy.***

APPENDIX:

Moonlight and Earthlight

“Earthlight” is like moonlight in that both are created by light reflected from the Sun. We can see our own earthglow in a rather indirect, but beautiful, phenomenon, namely, the lighting of a dark part of the moon. This event is particularly visible within a few days after the new moon date, within about an hour after sunset (or a few days before the new-moon date, within about an hour before sunrise). The brilliant silvery crescent of the moon means that most of the moon's surface that faces us is shadowed. Such a phase is visible near the western horizon at sunset, or, later that same month, near the eastern horizon just before dawn. The part of the Moon not directly lit by the Sun still seems lighted, but with a soft, dim glow: some have said it looks as if it is "the old moon in the arms of the young moon".

How does it happen? Let's draw the geometry for a Moon that is in a phase that's about a day after the new moon position. A representative light ray from the sun to the earth reflects, or scatters off, the Earth and its atmosphere—now it can be called "*earthlight*"—and heads toward the Moon. It again reflects or scatters off matter on the Moon, finally coming back and landing right in your eye. (It has to land in your eye, otherwise you will not see the effect.) So we can say, as I did when I was first astonished by noticing this event: "Wow!"