

Moon and its shape

Introduction

We have observed that the Moon changes shape gradually every day, from full Moon to new moon and back to full Moon again over a period of about one month. The changing shapes of the Moon are referred to as the “phases of the Moon”. In this unit, we will understand some ideas related to the phases of the Moon, by doing some tasks and exploring answers to some related questions. After we finish writing the answers, we will discuss all the answers together and try to arrive at a well-reasoned answers.

Materials: Paper, pencil, eraser, etc.

Task 1: Role playing activity

Figure 1 shows the orbit of the Earth around the Sun, and the orbit of the Moon around Earth.

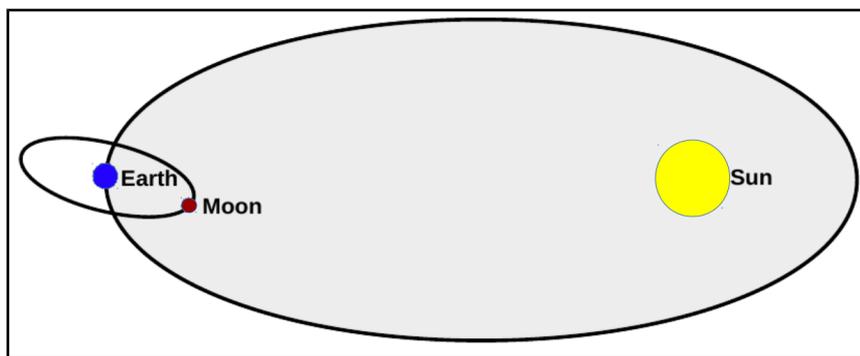


Figure 1: Illustration of the Sun-Earth-Moon orbit

“Orbits” are the paths taken by Earth and the Moon as they move around the Sun and Earth respectively. Note that the figure is not to scale. (The sun is shown much smaller than its proportionate scaled-down size. It is also shown much closer to Earth than its proportionate scaled-down distance.)

The orbit of Earth makes a plane in which both Earth and the Sun lie. Similarly the orbit of the Moon makes a plane in which both Earth and the Moon lie. These two planes are actually different planes. The plane of orbit of the Moon is tilted with reference to the plane of Earth’s orbit around the Sun, at an approximate angle of 5° .

Let us play a game which helps us understand the different positions of the Moon between the Sun and Earth, during its different phases.

Instructions

- Three students will play the roles of the Sun, Earth, and the Moon. Other students, who are not playing any roles, will observe the activity from a distance.
- Head of the student playing Earth's role represents the planet Earth, and his/her nose is an imaginary person on Earth’s surface.
- The student playing the Moon's role will draw a circle around Earth, to represent the Moon’s orbit around Earth (This is not absolutely essential, but it will help).
- The student playing the Sun will stand at some distance away from the Earth and the Moon. This student’s head should be at a slightly higher position than the heads of the other two students. (He/She could be taller or stand on a small stool or chair.)
- Here is some information. If you are looking from the side of Earth’s north pole down at the plane of Earth’s orbit, you will see that the Moon moves around Earth in an anti-clockwise direction, Earth moves around the sun in an anti-clockwise direction, and the

Earth rotates around itself also in an anti-clockwise direction. Keep this information in mind as you play the game.

- Fix the position of the person playing the Sun’s role to indicate the direction of sunlight.
- The person playing Earth’s role need not go around the Sun and can remain stationary at one position, as we want to focus on the phases of the Moon. This person can rotate on his/her position itself as per the need to observe the Moon’s phase.
- Now make the Moon go around in its orbit with its face towards the Earth. To begin with, let the Moon be between Earth and the Sun.

Guess which part of the Moon's head will be illuminated, and which part will be dark due to the absence of sunlight?

- Now let the Moon take a position such that Earth is between the Moon and the Sun, and all the three are aligned.

Discuss which part of the Moon is illuminated, and which is not.

- Now let the Moon take various positions in its path. Let the students guess which part of the Moon is illuminated and which is not.

• **Full Moon and new Moon**

At which position in the orbit of the Moon will a person on Earth (who is at the position of the nose of the student playing Earth’s role) see full Moon (or new Moon)?

Where should the Moon be, so that it is full Moon (or new Moon) for an imaginary person at a point on the back of the head of the student playing Earth’s role? (The orientation of the Moon is important to note here).

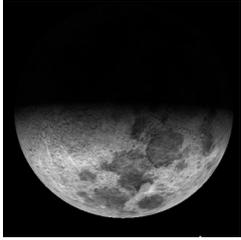
• **Half Moon**

Guess at which position there would be a half Moon, and discuss it in your group.

Discuss that during the motion of the Moon in its orbit, the bright portion of the Moon (as seen from Earth) increases for some time, and then decreases for some time. When the bright portion of the Moon (as seen from Earth) is increasing it is called as the waxing of the Moon, and when it is decreasing it is called as the waning of the Moon. Now, guess in which half of the Moon’s orbit it would be waxing and in which half it would be waning. Explain this by role play. Notice that when the Moon is going from full Moon to new Moon it is waning, and when it is going from new Moon to full Moon, it is waxing (*krishna paksha* and *shukla paksha*, respectively).

Task 2: Analysing a data table

Table 1: Images of Moon taken on different dates along with rise and setting times. In all pictures, west is top and east is down. However, depending what time of the day the image is taken (and hence if the Moon is in western or eastern sky), the brighter part of the Moon may be visible upward or downward, or slightly rotated.

Sr. No.	01	02	03	04
Image of Moon				
Date	18/02/2018	20/02/2018	23/02/2018	24/02/2018
Rise Time	08:02	10:01	12:15	13:07
Set Time	20:00	22:39	00:31	01:31
Sr. No.	05	06	07	08
Image of Moon				
Date	26/02/2018	28/02/2018	01/03/2018	02/03/2018
Rise Time	15:04	17:10	18:12	19:12
Set Time	03:32	05:27	06:19	07:08
Sr. No.	09	10	11	12
Image of Moon				
Date	04/03/2018	05/03/2018	07/03/2018	09/03/2018
Rise Time	21:06	22:01	00:13	01:54
Set Time	08:36	09:18	12:06	13:29

1) In Table 2, fill the columns 4 (Moon shape) and 5 (Boundary) of using the information given in the first three columns.

Table 2: Observation Table

Date	Moon-rise time	Moon-set time	Moon shape (crescent / half / more than half (gibbous) / full / absent)	Boundary of Bright and Dark region of Moon is (convex / concave)
18/02/2018	08:02	20:00	crescent	concave
20/02/2018	10:01	22:39		
23/02/2018	12:15	00:31		
24/02/2018	13:07	01:31		
26/02/2018	15:04	03:32		
28/02/2018	17:10	05:27		
01/03/2018	18:12	06:19		
02/03/2018	19:12	07:08		
04/03/2018	21:06	08:36		
05/03/2018	22:01	09:18		
07/03/2018	00:13	12:06		
09/03/2018	01:54	13:29		

2) Study the table and state if the following statements are true or false.

- a) The bright part of the Moon is always towards the Sun. _____
- b) The boundary of dark and bright part of the Moon is always concave. _____
- c) The Moon does not rise at the same time everyday. _____
- d) The Moon does not rise on a new Moon day. _____
- e) On the day after full Moon, we expect the Moon to rise around one hour after sunset. _____
- f) On the day before new Moon, we expect the Moon to rise around one hour before sunrise. _____
- g) In a waxing fortnight (*shukla paksha*/bright fortnight), the Moon is already in the sky at sunset. _____
- h) In a waning fortnight (*krishna paksha*/dark fortnight), the Moon is already in the sky at sunrise. _____

3) Imagine that we are astronauts and have gone in space above the plane of our solar system, and we are observing Earth and the Moon from above. Rays of the Sun are falling on Earth and the Moon from the left of the page and are parallel to the bottom edge. In the diagram (figure 2), draw appropriate diameters of Earth and the Moon, to separate the parts **receiving** sunlight and the parts **not** receiving sunlight. Shade the dark part with your pencil. Next, assume a tiny observer "O" on the surface of earth, exactly along the line connecting the centres of Earth and the Moon. Draw an appropriate diameter of the Moon to show which part of the Moon will be visible to this observer.

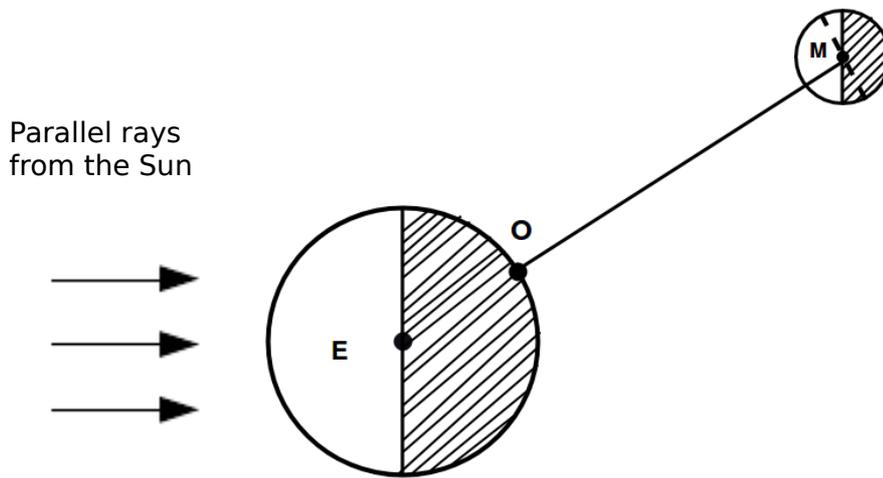


Figure 2 Moon phase for observer O

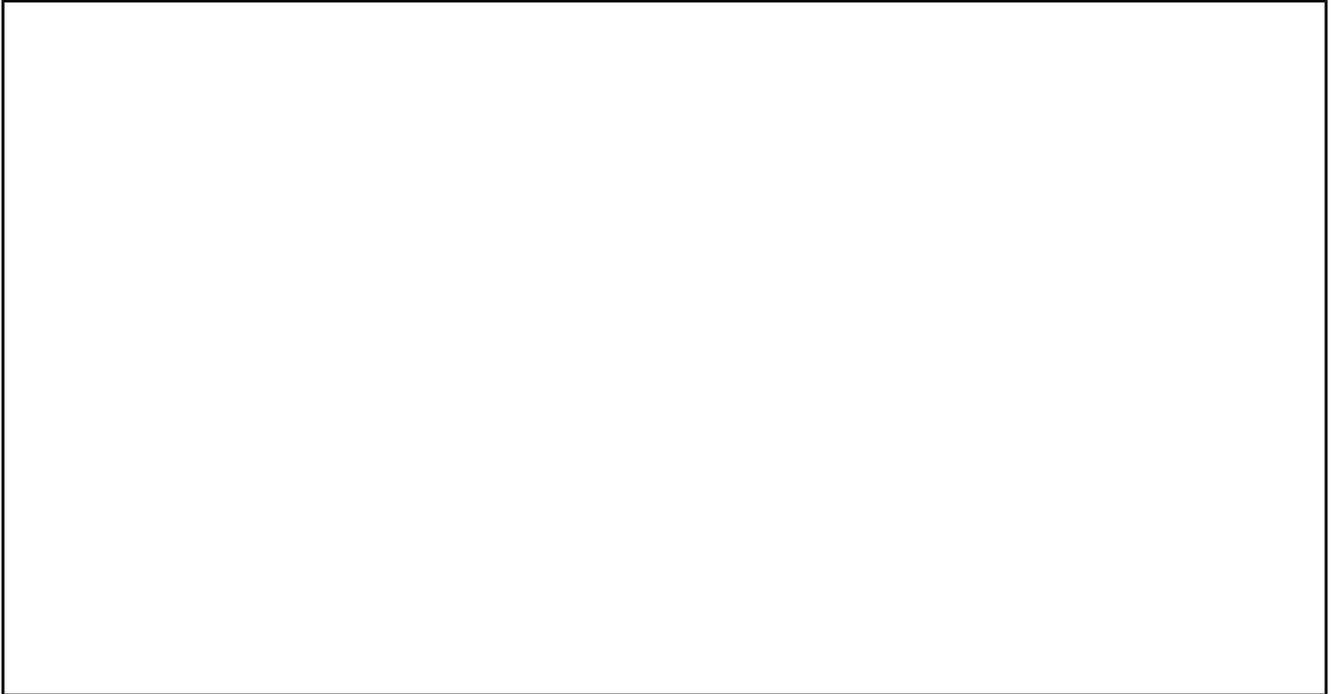
4) Based on your diagram, answer the following:

a) Is the observer in the bright part or the dark part?

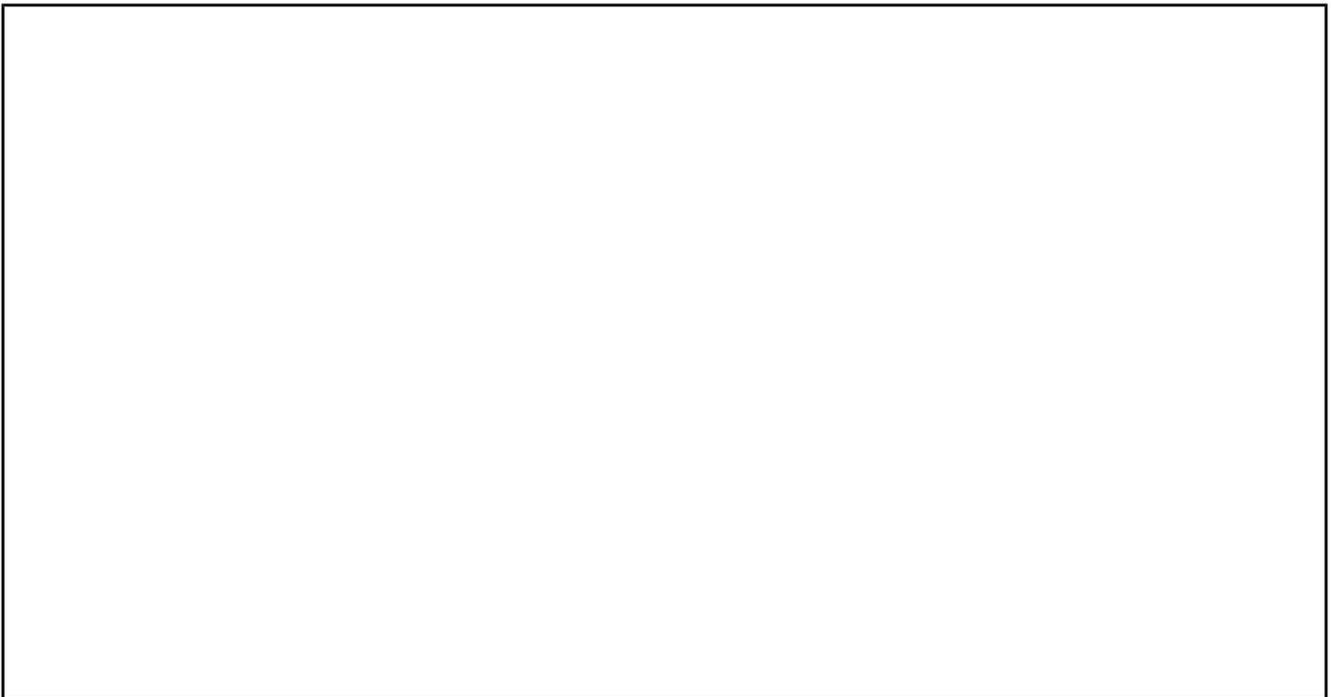
b) As seen by this observer, how much of the Moon's disc is bright (less than half/more than half).

c) Let us assume that the diameter of the Moon is 2 mm. Then the diameter of Earth will be approximately 7 mm. At this scale, the distance between Earth and the Moon will be about 23 cm. Draw a diagram of the relative sizes and the distance between Earth and the Moon. By looking at the diagram, it is possible to conclude that observers at any location on Earth will see approximately the same phase of the Moon. Do you agree?

d) Where will the Moon be on the full moon day? In your diagram, mark the position with a circle, and label it as F.



e) Where will the Moon be on the new Moon day? In your diagram, mark the position with a circle, and label it as N.



f) Will the shadow of Earth fall on the Moon on a new Moon day?

g)As seen by astronauts, Earth rotates anticlockwise. In question no. 3, now place a second observer on the surface of Earth, on the upper edge of the dark part. Does this second observer see a sunrise or a sunset?

h)As seen by astronauts, direction of the Moon's revolution is also anti-clockwise. So is this a waxing fortnight or a waning fortnight?

i) Can you guess this?

(i)During a lunar eclipse, the Sun, Earth, and the Moon get aligned. But we don't see a lunar eclipse on every full Moon day. What do you think is the reason for this?

(ii)Do we see a solar eclipse on every new Moon day? Give reasons.