8.15. 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 well-reasoned answers.

Materials: Paper, pencil, eraser, etc.

Task 1: Role playing activity

"Orbit" is a regular path or trajectory that an object in the space takes around the other. The path taken by Earth around the Sun is called Earth's orbit around Sun. Similarly, the path taken by the Moon around the Earth is Moon's orbit around Earth. Figure 1 shows the orbit of the Earth around the Sun, and the orbit of the Moon around Earth. 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^{o}.

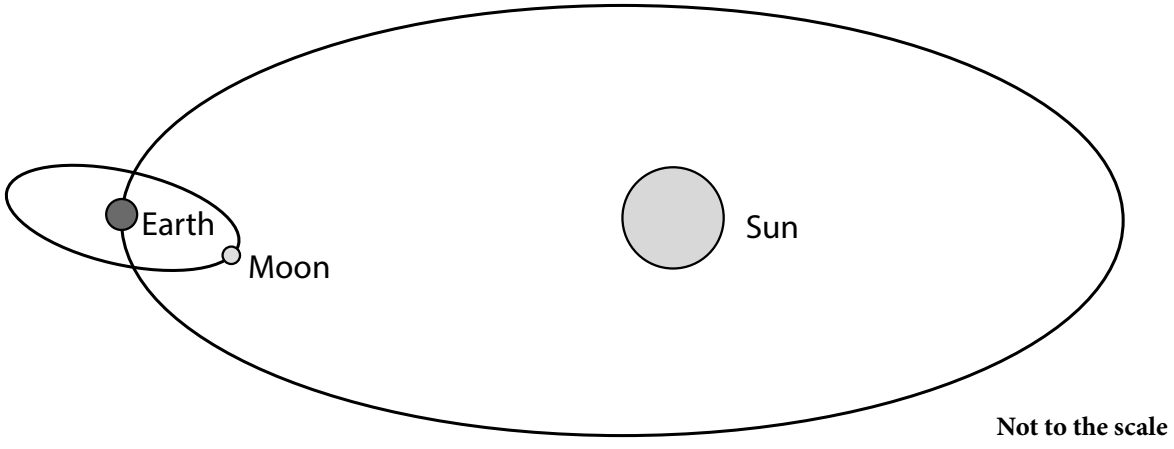

Figure 1 *Illustration of the Sun-Earth-Moon orbit*

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.
- 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. (They 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 student playing the Sun's role to indicate the direction of sunlight.
- The student 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 student can rotate on his/her position itself as per the need to observe the Moon's phase.
- To begin with, let the Moon be between Earth and the Sun. Now make the Moon go around in its orbit with its face towards the Earth.
  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. 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).

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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

Sr. No.	**01**	**02**	**03**	**04**
Image of the 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 the 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 the 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

Table 1 *Images of the Moon taken on different dates along with rise and setting times. Depending on the time and the position of the Moon in the sky, the actual appearance may be different from what is shown above.*

a. In table 2, fill the columns 4 (Moon shape) and 5 (Boundary) using the information given in table 1.

Date	Moon-rise time	Moon-set time	Moon shape (crescent / half / more than half (gibbous) / full / not visible)	Boundary of Bright and Dark region of Moon is (convex / concave / straight)
18/02/2018	08:02	20:00		
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	3:32		
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		

Table 2 *Observation Table*

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, the Moon rises around one hour after sunset.

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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 on a separate page if needed. By looking at this 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? Explain.

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?

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