The Phases of the Moon

Observing the Moon from night to night, you will notice that different fractions of its visible surface appear illuminated, that is, the Moon goes through phases. Since the source of illumination (the Sun) and the viewpoint (Earth) are fixed relative to one other, the phase of the Moon depends on where the Moon is situated in its month-long orbit around Earth. On the worksheet are several diagrams that will help reveal how the Moon’s phases come about.

**Practice Run**

1. The circle at the top of Figure 5-1 on the worksheet represents a top-down view of a ball that is uniformly illuminated by light coming from the right, as indicated by the arrows. This ball will be viewed from three different positions, represented here by eye-symbols labeled a, b, and c. That is, for each position a, b, and c, you can imagine laying your head sideways on the paper and aligning your eye to the given eye-symbol.

   a. Shade in the portion of the circle at the top of Figure 5-1 that represents the portion of the ball that would remain in darkness if illuminated from the right.

   b. Now imagine viewing the illuminated ball at the top of Figure 5-1 from each of three viewpoints, a, b, and c. Envision how the ball would appear to you in each case. In the circle next to each viewpoint, shade in the portion of the ball that would appear dark.

**The Real Thing**

2. Figure 5-2 on the worksheet represents a top-down view of the Moon at a number of locations in its orbit around Earth. (The figure is not to scale.) The Sun’s rays illuminate the Moon from the right-hand side of the page, as indicated by the arrows. With the Sun so far away, its rays are virtually parallel when they arrive at Earth and the Moon, as shown.

   a. Shade in the portion of Earth that is not illuminated by the Sun. Note: The shaded side corresponds to nighttime on Earth, and the unshaded side to daytime.

   b. For each of the Moon’s orbital locations, labeled here A through H, shade in the portion of the Moon that is not illuminated by the Sun. (Do not shade in the Moon’s phases here; that comes next.) For positions A and E, assume that the Moon is not exactly in a line between the Sun and Earth; that is, no eclipse occurs at these positions.
c. In each of the circles A through H in Figure 5-3 on the worksheet, shade in the portion of the Moon that would appear dark, as viewed from Earth. The unshaded part within each of these circles represents the visible phase of the Moon: A—new Moon; B—waxing crescent; C—first quarter (commonly called a half Moon); D—waxing gibbous; E—full; F—waning gibbous; G—last quarter; H—waning crescent.

■ Last Lap

3. In Figure 5-2, Earth is labeled with times of day. Noon occurs on Earth’s surface where the Sun appears at its highest daily altitude in the sky, and midnight is the point on Earth that is opposite noon. Sunset, here assumed to take place around 6 pm, occurs at the point where Earth’s rotation carries us from our planet’s daylight side to its nighttime side; that is, the Sun appears to drop below the horizon. Sunrise, around 6 am, occurs where Earth’s rotation brings us back from night into day; here, the Sun appears to rise above the horizon. Studying Figure 5-2, estimate the rising and setting times for the Moon in the phases specified on the worksheet. List the time when the particular phase is first visible from Earth and the time when it is no longer visible from Earth. For example, when the Moon is at point C in its orbit, it rises at around noon and sets around midnight. Hint: When the Moon is visible from Earth, you should be able to draw a line between the two bodies that does not pass through any portion of Earth itself; in other words, Earth does not get in the way of your view of the Moon.
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All work must be shown to receive credit.

1. [Diagram of Earth's orbit with phases labeled A to E]

Figure 5-1 Phases of an illuminated ball.

2. (a, b) [Diagram of Earth's orbit with phases labeled F and G, and Sunlight and Moon's orbital motion indicated]

Figure 5-2 Top-down view of the Moon's orbit around Earth.
3. B: rises ______/sets ______
   E: rises ______/sets ______
   G: rises ______/sets ______