Chapter 2: Patterns in the Sky—Motions of Earth and the Moon

LEARNING OBJECTIVES

Define the bold-faced vocabulary terms within the chapter.
Multiple Choice: 1, 3, 4, 5, 6, 10, 26, 44, 50, 64, 69
Short Answer: 16, 22

2.1 Earth Spins on Its Axis

Identify the locations of the north celestial pole, south celestial pole, celestial equator, zenith, meridian, and horizon on the celestial sphere.
Multiple Choice: 2, 8, 14
Short Answer: 3, 4

Show the path that a star follows on the sky, from the time it rises until it sets.
Multiple Choice: 9, 15, 16
Short Answer: 1

Illustrate how the motion and visibility of stars change with the one's location on Earth.
Multiple Choice: 33, 34
Short Answer: 2, 5, 7

Demonstrate how knowledge of the sky permits one to know latitude and direction on Earth.
Multiple Choice: 7, 11, 12, 13
Short Answer: 6

Illustrate how one event will look in two different frames of reference.
Short Answer: 8

2.2 Revolution around the Sun Leads to Changes during the Year

Identify the path of the ecliptic, the solstices, and the equinoxes on the celestial sphere.
Multiple Choice: 17, 19
Short Answer: 10, 11, 12, 15

Relate Earth's position around the Sun to the zodiacal constellations we observe in the night-time sky.
Multiple Choice: 18, 36, 37, 38, 39, 40, 41

Explain why Earth's axial tilt causes seasons.
Multiple Choice: 20, 21, 24, 25, 29, 30, 31, 35, 42
Short Answer: 9, 13

Illustrate how the height of the Sun and the length of a day vary with the season and your latitude.
Multiple Choice: 22, 23, 27, 28, 32
Short Answer: 14

2.3 The Moon's Appearance Changes as It Orbits Earth

Define the phases of the moon.
Multiple Choice: 45
Short Answer: 18

Explain what causes us to observe moon phases.
Multiple Choice: 47, 48, 49, 52
Short Answer: 17, 20

Illustrate the Sun-Moon-Earth geometry needed to produce each Moon phase.
Multiple Choice: 43, 46, 51, 53, 54
Short Answer: 19, 21

2.4 Calendars Are Based on the Day, Month, and Year

Compare and contrast solar and lunar calendars.
Multiple Choice: 58
Short Answer: 23, 24

Illustrate the need for our current pattern of leap years.
Multiple Choice: 55, 56, 57

2.5 Eclipses Result from the Alignment of Earth, Moon, and the Sun

Illustrate the Sun-Moon-Earth geometries needed to produce solar and lunar eclipses.
Multiple Choice: 59, 60, 61, 62, 68, 70
Short Answer: 25, 26, 28

Relate the geometry of solar and lunar eclipses to their visibility across Earth.
Multiple Choice: 63, 65, 66, 67
Short Answer: 27, 29

Working It Out 2.1

Use proportional reasoning to estimate a characteristic of the whole based on measurement of a part.
Short Answer: 30

MULTIPLE CHOICE

1. There are _________ constellations in the entire sky.
   a. 12
   b. 13
   c. 88
   d. hundreds of
   e. thousands of

   ANS: C DIF: Easy REF: Section 2.1
   MSC: Remembering
   OBJ: Define the bold-faced vocabulary terms within the chapter.

2. What defines the location of the equator on Earth?
   a. the axis around which Earth rotates
   b. where the ground is the warmest
   c. the tilt of Earth's rotational axis relative to its orbit around the Sun
   d. the orbit of Earth around the Sun
   e. all of the above

   ANS: A DIF: Easy REF: Section 2.1
   MSC: Remembering
   OBJ: Identify the locations of the north celestial pole, south celestial pole, celestial equator, zenith, meridian, and horizon on the celestial sphere.

3. Circumpolar stars are stars that are
   a. always below the horizon.
   b. always on the celestial equator.
   c. always at the north celestial pole.
   d. sometimes above the horizon.
   e. always above the horizon.

   ANS: E DIF: Easy REF: Section 2.1
   MSC: Remembering
   OBJ: Define the bold-faced vocabulary terms within the chapter.

4. The point directly below your feet is called the
   a. meridian.
   b. celestial pole.
   c. nadir.
   d. circumpolar plane.
   e. zenith.

   ANS: C DIF: Medium REF: Section 2.1
   MSC: Remembering
   OBJ: Define the bold-faced vocabulary terms within the chapter.

5. Declination is a measure of a star's location relative to
   a. zenith.
   b. ecliptic.
   c. nadir.
   d. celestial equator.
   e. line of nodes.

   ANS: D DIF: Medium REF: Section 2.1
   MSC: Remembering
   OBJ: Define the bold-faced vocabulary terms within the chapter.

6. Right ascension is a measure of a star's location on the celestial sphere that is most closely similar to which measurement of location on Earth?
   a. meters
   b. longitude
   c. latitude
   d. degrees
   e. radians

   ANS: B DIF: Medium REF: Section 2.1
   MSC: Remembering
   OBJ: Define the bold-faced vocabulary terms within the chapter.

7. If the star Polaris has an altitude of 35°, then we know that
   a. our longitude is $+55°$.
   b. our latitude is $+55°$.
   c. our longitude is $-35°$.
   d. our longitude is $+35°$.
   e. our latitude is $+35°$.

   ANS: E DIF: Easy REF: Section 2.1
   MSC: Applying
   OBJ: Demonstrate how knowledge of the sky permits one to know latitude and direction on Earth.

8. The direction directly overhead of an observer defines his or her
   a. meridian.
   b. celestial pole.
   c. nadir.
   d. circumpolar plane.
   e. zenith.

   ANS: E DIF: Easy REF: Section 2.1
   MSC: Remembering
   OBJ: Identify the locations of the north celestial pole, south celestial pole, celestial equator, zenith, meridian, and horizon on the celestial sphere.

9. No matter where you are on Earth, stars appear to rotate about a point called the
   a. zenith.
   b. celestial pole.
   c. nadir.
   d. meridian.
   e. equinox.

   ANS: B DIF: Easy REF: Section 2.1
   MSC: Remembering
   OBJ: Show the path that a star follows on the sky, from the time it rises until it sets.

10. The apparent path of the Sun across the celestial sphere over the course of a year is called the
    a. prime meridian.
    b. ecliptic.
    c. circumpolar plane.
    d. celestial equator.
    e. eclipse.

    ANS: B DIF: Easy REF: Section 2.1
    MSC: Remembering
    OBJ: Define the bold-faced vocabulary terms within the chapter.

11. At a latitude of +50°, how far above the horizon is the north celestial pole located?
    a. 0°
    b. 40°
    c. 50°
    d. 90°
    e. It is not visible at that latitude.

    ANS: C DIF: Medium REF: Section 2.1
    MSC: Applying
    OBJ: Demonstrate how knowledge of the sky permits one to know latitude and direction on Earth.

12. At what latitude is the north celestial pole located at your zenith?
    a. 0°
    b. +30°
    c. +60°
    d. +90°
    e. This occurs at every latitude.

    ANS: D DIF: Medium REF: Section 2.1
    MSC: Applying
    OBJ: Demonstrate how knowledge of the sky permits one to know latitude and direction on Earth.

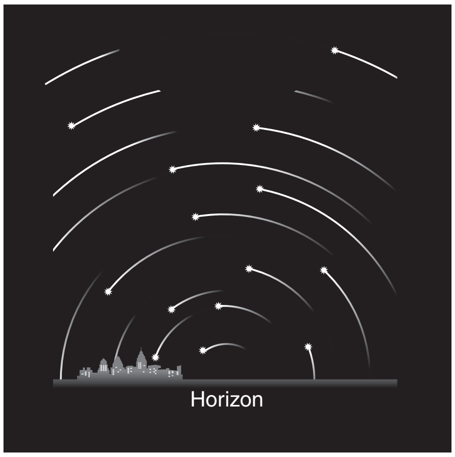
13. At what latitude is the north celestial pole at your horizon?
    a. 0°
    b. +30°
    c. +60°
    d. +90°
    e. This can never happen.

    ANS: A DIF: Medium REF: Section 2.1
    MSC: Applying
    OBJ: Demonstrate how knowledge of the sky permits one to know latitude and direction on Earth.

14. The meridian is defined as an imaginary circle on the sky on which lie the
    a. celestial equator and vernal equinox.
    b. north and south celestial poles.
    c. zenith and the north and south celestial poles.
    d. zenith and east and west directions.
    e. celestial equator and summer solstice.

    ANS: C DIF: Medium REF: Section 2.1
    MSC: Remembering
    OBJ: Identify the locations of the north celestial pole, south celestial pole, celestial equator, zenith, meridian, and horizon on the celestial sphere.

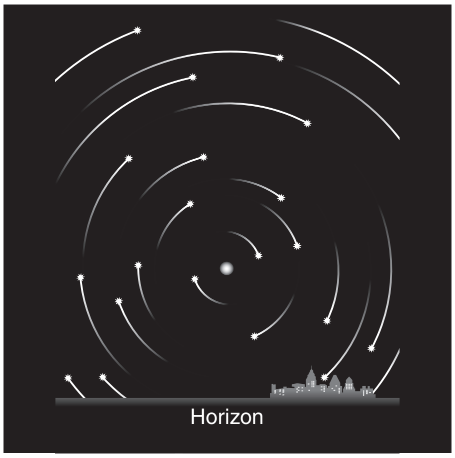
15. A friend takes a time-lapse picture of the sky, as shown in the figure below. What direction must your friend have been facing when the picture was taken?



    a. north
    b. east
    c. south
    d. west
    e. directly overhead

    ANS: A DIF: Medium REF: Section 2.1
    MSC: Applying
    OBJ: Show the path that a star follows on the sky, from the time it rises until it sets.

16. A friend takes a time-lapse picture of the sky, as shown in the figure below. What direction must your friend have been facing when the picture was taken?



a. north
b. east
c. south
d. west
e. directly overhead

ANS: C DIF: Medium REF: Section 2.1
MSC: Applying
OBJ: Show the path that a star follows on the sky, from the time it rises until it sets.

17. How far away on average is Earth from the Sun?
a. 1 light-second
b. 1 light-minute
c. 1 astronomical unit
d. 1 light-hour
e. 1 light-year

ANS: C DIF: Easy REF: Section 2.2
MSC: Remembering
OBJ: Identify the path of the ecliptic, the solstices, and the equinoxes on the celestial sphere.

18. If you go out at exactly 9 P.M. each evening over the course of 1 month, the position of a given star will move westward by tens of degrees. What causes this motion?
a. Earth's rotation on its axis
b. the revolution of Earth around the Sun
c. the revolution of the Moon around Earth
d. the revolution of the Sun around Earth
e. the speed of the star through space

ANS: B DIF: Easy REF: Section 2.2
MSC: Applying
OBJ: Relate Earth's position around the Sun to the zodiacal constellations we observe in the night-time sky.

19. The ecliptic is defined by the motion of _________ in the sky.
a. the Moon
b. the Sun
c. the planets
d. Polaris
e. the stars

ANS: B DIF: Easy REF: Section 2.2
MSC: Remembering
OBJ: Identify the path of the ecliptic, the solstices, and the equinoxes on the celestial sphere.

20. When the northern hemisphere experiences fall, the southern hemisphere experiences
a. spring.
b. summer.
c. fall.
d. winter.

ANS: A DIF: Easy REF: Section 2.2
MSC: Applying
OBJ: Explain why Earth's axial tilt causes seasons.

21. When the northern hemisphere experiences summer, the southern hemisphere experiences
a. spring.
b. summer.
c. fall.
d. winter.

ANS: D DIF: Easy REF: Section 2.2
MSC: Applying
OBJ: Explain why Earth's axial tilt causes seasons.

22. The day with the smallest number of daylight hours over the course of the year for a person living in the *northern* hemisphere is the
a. summer solstice (June 1)
b. vernal equinox (March 21)
c. winter solstice (Dec. 22)
d. autumnal equinox (Sept. 23)
e. The number of daylight hours is always the same.

ANS: C DIF: Easy REF: Section 2.2
MSC: Applying
OBJ: Illustrate how the height of the Sun and the length of a day vary with the season and your latitude.

23. On which day of the year does the Sun reach its northernmost point in the sky?
  a. vernal equinox
  b. summer solstice
  c. autumnal equinox
  d. winter solstice
  e. The sun always reaches the same altitude.

ANS: B DIF: Easy REF: Section 2.2
MSC: Remembering
OBJ: Illustrate how the height of the Sun and the length of a day vary with the season and your latitude.

24. Earth's rotational axis precesses in space and completes one revolution every
  a. 200 years.
  b. 1,800 years.
  c. 7,300 years.
  d. 26,000 years.
  e. 51,000 years.

ANS: D DIF: Easy REF: Section 2.2
MSC: Remembering
OBJ: Explain why Earth's axial tilt causes seasons.

25. Which of the following stars will be the North Star in 12,000 years?
  a. Polaris
  b. Deneb
  c. Vega
  d. Thuban
  e. Sirius

ANS: C DIF: Medium REF: Section 2.2
MSC: Remembering
OBJ: Explain why Earth's axial tilt causes seasons.

26. The latitude of the Antarctic Circle is
  a. 23.5° N.
  b. 66.5° N.
  c. 23.5° S.
  d. 66.5° S.
  e. 90° S.

ANS: D DIF: Medium REF: Section 2.2
MSC: Remembering
OBJ: Define the bold-faced vocabulary terms within the chapter.

27. During summer above the Arctic circle
  a. the Moon cannot be seen.
  b. the Sun can always be seen.
  c. the Sun cannot be seen.
  d. the Sun is always in the southern part of the sky.
  e. the Sun is always directly overhead.

ANS: B DIF: Medium REF: Section 2.2
MSC: Understanding
OBJ: Illustrate how the height of the Sun and the length of a day vary with the season and your latitude.

28. The day with the smallest number of daylight hours over the course of the year for a person living in the *southern* hemisphere is the
  a. summer solstice (June 1)
  b. vernal equinox (March 21)
  c. winter solstice (Dec. 22)
  d. autumnal equinox (Sept. 23)
  e. The number of daylight hours is always the same.

ANS: A DIF: Medium REF: Section 2.2
MSC: Applying
OBJ: Illustrate how the height of the Sun and the length of a day vary with the season and your latitude.

29. If Earth's axis were tilted by 5° instead of its actual tilt, how would the seasons be different than they are currently?
  a. The seasons would remain the same.
  b. Summers would be warmer.
  c. Winters would last longer.
  d. Winters would be warmer.
  e. Summers would last longer.

ANS: D DIF: Medium REF: Section 2.2
MSC: Remembering
OBJ: Explain why Earth's axial tilt causes seasons.

30. If Earth's axis were tilted by 35° instead of its actual tilt, how would the seasons be different than they are currently?
  a. The seasons would remain the same.
  b. Summers would be colder.
  c. Winters would be shorter.
  d. Winters would be colder.
  e. Summers would be shorter.

ANS: D DIF: Medium REF: Section 2.2
MSC: Understanding
OBJ: Explain why Earth's axial tilt causes seasons.

31. We experience seasons because
   a. Earth's equator is tilted relative to the plane of the solar system.
   b. Earth is closer to the Sun in summer and farther from the Sun in the winter.
   c. the length of the day is longer in the summer and shorter in the winter.
   d. Earth moves with a slower speed in its orbit during summer and faster during winter.
   e. one hemisphere of Earth is closer to the Sun than the other hemisphere during the summer.

   ANS: A DIF: Medium REF: Section 2.2
   MSC: Applying
   OBJ: Explain why Earth's axial tilt causes seasons.

32. During which season (in the Northern Hemisphere) could you see the Sun rising from the furthest north?
   a. winter
   b. spring
   c. summer
   d. fall
   e. The Sun always rises directly in the east.

   ANS: C DIF: Medium REF: Section 2.2
   MSC: Applying
   OBJ: Illustrate how the height of the Sun and the length of a day vary with the season and our latitude.

33. For a person who lives at a latitude of $+40°$, when is the Sun directly overhead at noon?
   a. only on the summer solstice
   b. only on the winter solstice
   c. only on the vernal and autumnal equinoxes
   d. never
   e. always

   ANS: D DIF: Medium REF: Section 2.2
   MSC: Applying
   OBJ: Illustrate how the motion and visibility of stars change with the one's location on Earth.

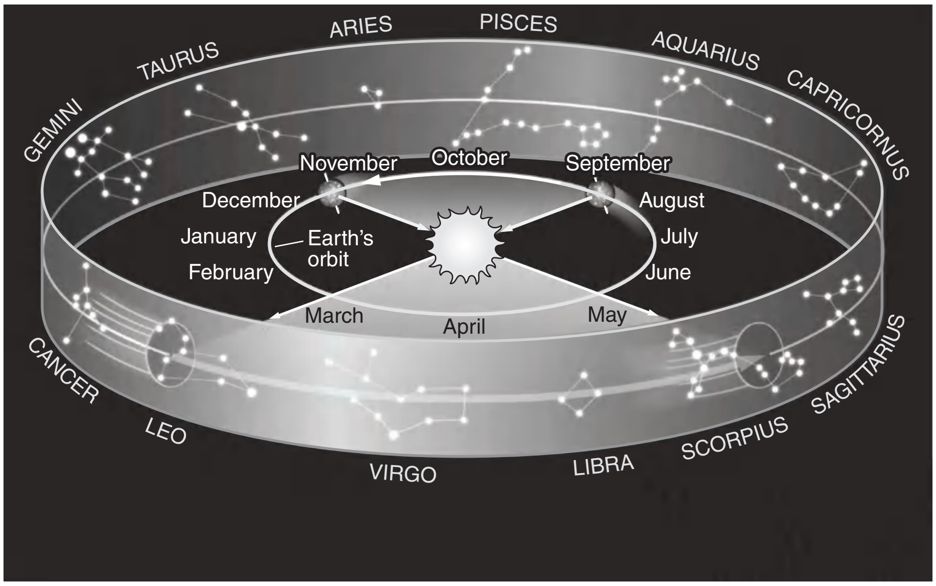
34. For a person living in Vancouver, Canada, at latitude of $+49°$, the maximum altitude of the Sun above the southern horizon on the day of the Winter Solstice is:
   a. 41.0°.
   b. 17.5°.
   c. 25.5°.
   d. 37.0°.
   e. 64.5°.

   ANS: B DIF: Difficult REF: Section 2.2
   MSC: Applying
   OBJ: Illustrate how the motion and visibility of stars change with the one's location on Earth.

35. Earth is closest to the Sun when the Northern Hemisphere experiences
   a. spring.
   b. summer.
   c. fall.
   d. winter.

   ANS: D DIF: Difficult REF: Section 2.2
   MSC: Remembering
   OBJ: Explain why Earth's axial tilt causes seasons.

36. Assume you are observing the night sky from a typical city in the United States with a latitude of +40°. Using the figure below, which constellation of the zodiac would be nearest to the meridian at midnight in mid-September?



a. Scorpius
b. Taurus
c. Pisces
d. Aquarius
e. Leo

ANS: D DIF: Medium REF: Section 2.2
MSC: Applying
OBJ: Relate Earth's position around the Sun to the zodiacal constellations we observe in the night-time sky.

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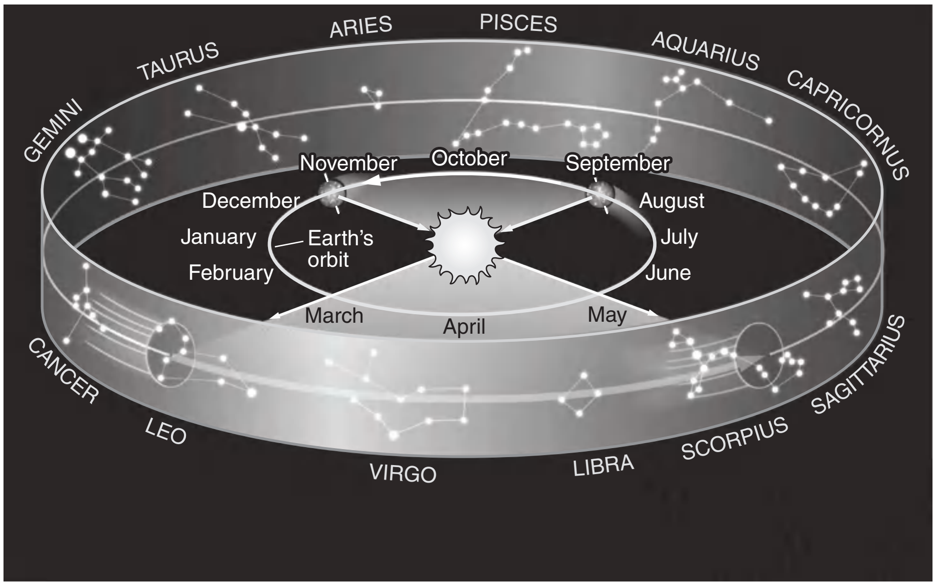
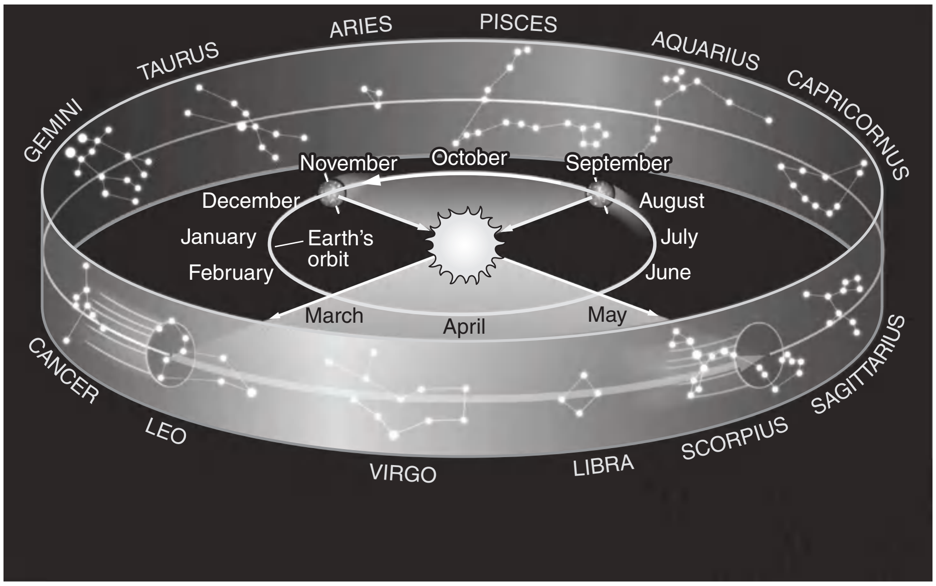
37. Assume you are observing the night sky from a typical city in the United States with a latitude of +40°. Using the figure below, which constellation of the zodiac would be nearest to the meridian at 6 P.M. in mid-September?



a. Scorpius
b. Taurus
c. Pisces
d. Aquarius
e. Leo

ANS: A DIF: Difficult REF: Section 2.2
MSC: Applying
OBJ: Relate Earth's position around the Sun to the zodiacal constellations we observe in the night-time sky.

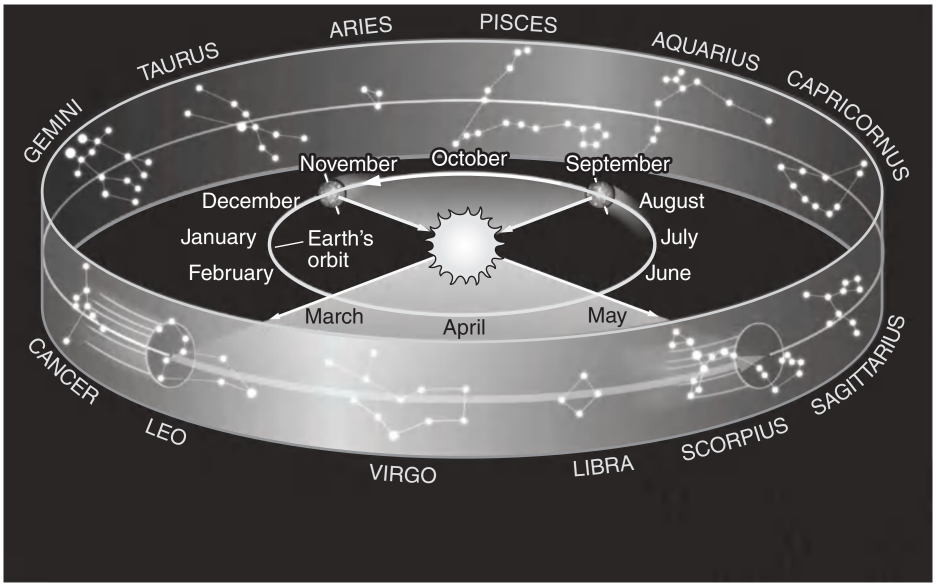
38. Assume you are observing the night sky from a typical city in the United States with a latitude of +40°. Using the figure below, which constellation of the zodiac would be nearest to the meridian at 10 P.M. in mid-May?



a. Scorpius
b. Taurus
c. Pisces
d. Aquarius
e. Leo

ANS: A DIF: Difficult REF: Section 2.2
MSC: Applying
OBJ: Relate Earth's position around the Sun to the zodiacal constellations we observe in the night-time sky.

39. Using the figure below, what time of the day or night will the zodiac constellation Gemini rise in March?



a. 2 P.M.
b. 8 P.M.
c. 2 A.M.
d. 8 A.M.
e. noon

ANS: A DIF: Difficult REF: Section 2.2
MSC: Applying
OBJ: Relate Earth's position around the Sun to the zodiacal constellations we observe in the night-time sky.

40. You and a friend go outside to view the stars at midnight tonight. Six months later, you go outside to find the stars in exactly the same position in the sky as when you and your friend viewed them. What time is it? Assume you can see the stars at any time, day or night.
a. 6 A.M.
b. noon
c. 6 P.M.
d. midnight
e. This can never happen.

ANS: B DIF: Difficult REF: Section 2.2
MSC: Applying
OBJ: Relate Earth's position around the Sun to the zodiacal constellations we observe in the night-time sky.

41. The brightest star in the constellation Canis Major can be referred to as
a. Alpha Canis Majoris
b. Beta Canis Majoris
c. Beta Canis
d. Alpha Majoris
e. Alpha Canis

ANS: A DIF: Difficult REF: Section 2.2
MSC: Remembering
OBJ: Relate Earth's position around the Sun to the zodiacal constellations we observe in the night-time sky.

42. At which of the following latitudes is it possible for the Sun's rays to hit the ground perpendicular to the ground at some point during the year?
a. 87°
b. 55°
c. 42°
d. 33°
e. 20°

ANS: E DIF: Difficult REF: Section 2.2
MSC: Applying
OBJ: Explain why Earth's axial tilt causes seasons.

43. At approximately what time does a full Moon rise?
   a. 12 midnight
   b. 12 noon
   c. 6 A.M.
   d. 6 P.M.
   e. 3 P.M.

ANS: D DIF: Easy REF: Section 2.3
MSC: Applying
OBJ: Illustrate the Sun-Moon-Earth geometry needed to produce each Moon phase.

44. In regard to the phase of the Moon, the term *waxing* means
   a. less than half-illuminated.
   b. more than half–illuminated.
   c. becoming smaller.
   d. illuminated area increasing.
   e. illuminated area decreasing.

ANS: D DIF: Easy REF: Section 2.3
MSC: Remembering
OBJ: Define the bold-faced vocabulary terms within the chapter.

45. If tonight the Moon is in the waxing gibbous phase, in 3 days what is the most likely phase of the Moon?
   a. new phase.
   b. full phase.
   c. third quarter phase.
   d. first quarter phase.
   e. waxing crescent phase.

ANS: B DIF: Easy REF: Section 2.3
MSC: Applying
OBJ: Define the phases of the moon.

46. If there is a full Moon out tonight, approximately how long from now will it be in the third quarter phase?
   a. 3 to 4 days
   b. 1 week
   c. 2 weeks
   d. 3 weeks
   e. 1 month

ANS: B DIF: Easy REF: Section 2.3
MSC: Applying
OBJ: Illustrate the Sun-Moon-Earth geometry needed to produce each Moon phase.

47. Which of the following is *false*?
   a. Everyone on Earth observes the same phase of the Moon on a given night.
   b. The phases of the Moon cycle with a period that is longer than its sidereal period.
   c. In some phases, the Moon can be observed during the day.
   d. The observed phase of the Moon changes over the course of one night.
   e. A full Moon can be seen on the eastern horizon at sunset.

ANS: D DIF: Easy REF: Section 2.3
MSC: Applying
OBJ: Explain what causes us to observe moon phases.

48. If you see a full Moon tonight, approximately how long would you have to wait to see the next full Moon?
   a. 1 week
   b. 2 weeks
   c. 3 weeks
   d. 4 weeks
   e. 5 weeks

ANS: D DIF: Easy REF: Section 2.3
MSC: Remembering
OBJ: Explain what causes us to observe moon phases.

49. The Moon undergoes synchronous rotation, and as a consequence the
   a. rotational period of the Moon equals the orbital period of the Moon around Earth
   b. rotational period of the Moon equals the rotational period of Earth
   c. rotational period of the Moon equals the orbital period of Earth around the Sun
   d. orbital period of the Moon around Earth equals the rotational period of Earth
   e. Moon does not rotate as it orbits Earth

ANS: A DIF: Easy REF: Section 2.3
MSC: Understanding
OBJ: Explain what causes us to observe moon phases.

50. The sidereal period of the moon is
   a. 1 month.
   b. 27.32 days.
   c. 28 days.
   d. 29.53 days.
   e. 30 days.

ANS: B DIF: Medium REF: Section 2.3
MSC: Remembering
OBJ: Define the bold-faced vocabulary terms within the chapter.

51. What time does a third quarter Moon rise?
    a. 12 midnight
    b. 12 noon
    c. 3 P.M.
    d. 6 A.M.
    e. 6 P.M.

    ANS: A DIF: Medium REF: Section 2.3
    MSC: Applying
    OBJ: Illustrate the Sun-Moon-Earth geometry needed to produce each Moon phase.

52. The Moon's sidereal period is 2.2 days shorter than the period during which the Moon's phases change because
    a. the Moon always keeps the same side turned toward Earth.
    b. Earth must rotate so an observer can see the Moon.
    c. the Moon's orbit is tilted with respect to Earth's rotational axis.
    d. Earth moves significantly in its orbit around the Sun during that time.
    e. the Moon's orbital speed varies.

    ANS: D DIF: Medium REF: Section 2.3
    MSC: Understanding
    OBJ: Explain what causes us to observe moon phases.

53. At which of the possible times below could the waxing gibbous moon be seen rising?
    a. 3 P.M.
    b. 9 A.M.
    c. 11 P.M.
    d. 5 A.M.
    e. 8 P.M.

    ANS: A DIF: Difficult REF: Section 2.3
    MSC: Applying
    OBJ: Illustrate the Sun-Moon-Earth geometry needed to produce each Moon phase.

54. If a person on Earth currently views the Moon in a waxing crescent phase, in what phase would Earth appear to a person on the Moon?
    a. waxing crescent
    b. waxing gibbous
    c. waning gibbous
    d. waning crescent
    e. New

    ANS: C DIF: Difficult REF: Section 2.3
    MSC: Applying
    OBJ: Illustrate the Sun-Moon-Earth geometry needed to produce each Moon phase.

55. Leap years occur because
    a. Earth's orbital period around the Sun is decreasing.
    b. Earth's orbital period is 365.24 days.
    c. the Gregorian calendar contains only 11 months.
    d. Earth speeds up in its orbit when it comes closest to the Sun.
    e. a calendar month is not the same as a lunar month.

    ANS: B DIF: Easy REF: Section 2.4
    MSC: Understanding
    OBJ: Illustrate the need for our current pattern of leap years.

56. How often do leap years occur?
    a. almost every 3 years
    b. almost every 4 years
    c. almost every 5 years
    d. almost every 8 years
    e. almost every 10 years

    ANS: B DIF: Easy REF: Section 2.4
    MSC: Remembering
    OBJ: Illustrate the need for our current pattern of leap years.

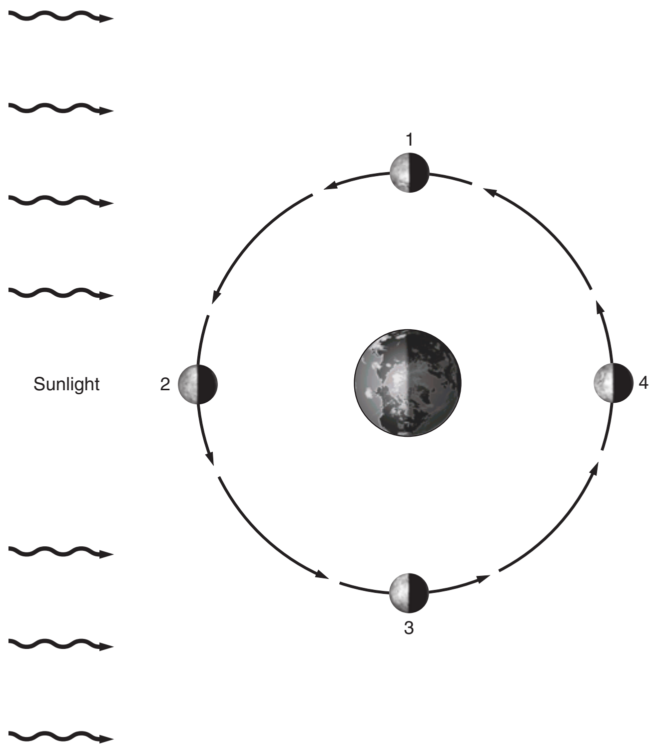
57. How often would we have leap years if Earth's orbital period were 365.1 days?
    a. every year
    b. every 2 years
    c. every 4 years
    d. every 10 years
    e. We would not need to have leap years.

    ANS: D DIF: Medium REF: Section 2.4
    MSC: Applying
    OBJ: Illustrate the need for our current pattern of leap years.

58. A purely lunar calendar is not ideal for our modern world because
    a. leap years are more frequent.
    b. the months line up with the phases of the moon.
    c. the seasons don't occur in the same month every year.
    d. high and low tides occur at different times.
    e. leap year are less frequent.

    ANS: C DIF: Difficult REF: Section 2.4
    MSC: Applying
    OBJ: Compare and contrast solar and lunar calendars.

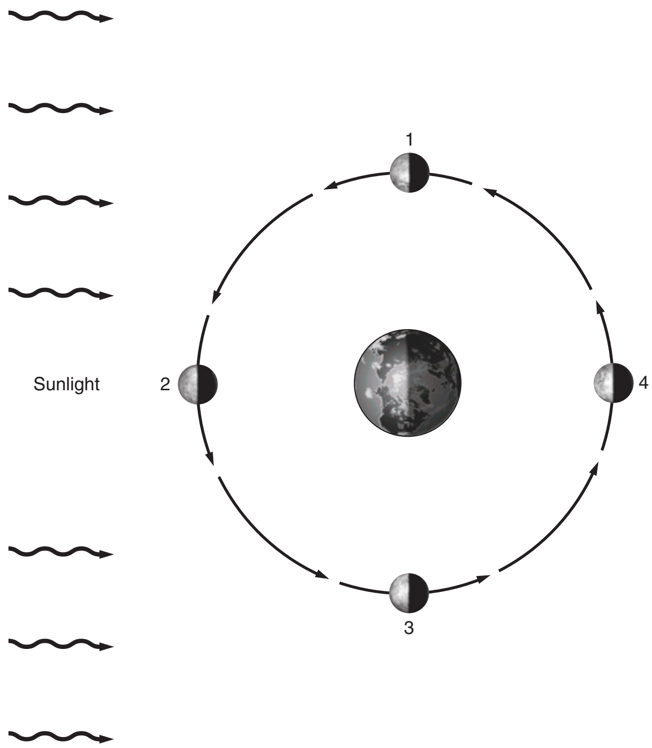
59. In the figure below, at which position must the Moon be located in order for a lunar eclipse to occur?



a. 1
b. 2
c. 3
d. 4

ANS: D DIF: Easy REF: Section 2.5
MSC: Understanding
OBJ: Illustrate the Sun-Moon-Earth geometries needed to produce solar and lunar eclipses.

60. In the figure below, at which position must the Moon be located in order for a solar eclipse to occur?



a. 1
b. 2
c. 3
d. 4

ANS: B DIF: Easy REF: Section 2.5
MSC: Understanding
OBJ: Illustrate the Sun-Moon-Earth geometries needed to produce solar and lunar eclipses.

61. During which lunar phase do solar eclipses occur?
a. new
b. first quarter
c. full
d. third quarter

ANS: A DIF: Easy REF: Section 2.5
MSC: Remembering
OBJ: Illustrate the Sun-Moon-Earth geometries needed to produce solar and lunar eclipses.

62. A partial lunar eclipse occurs when
   a. the Sun appears to go behind the Moon.
   b. the Moon passes through part of the Earth's shadow.
   c. the Moon shadows part of the Sun.
   d. The Earth passes through part of the Moon's shadow.
   e. the Moon passes through part of the Sun's shadow.

   ANS: B DIF: Easy REF: Section 2.5
   MSC: Remembering
   OBJ: Illustrate the Sun-Moon-Earth geometries needed to produce solar and lunar eclipses.

63. If you are lucky enough to see a total solar eclipse, you must be standing in the
   a. Moon's umbra.
   b. Moon's penumbra.
   c. Earth's umbra.
   d. Earth's penumbra.
   e. Sun's umbra.

   ANS: A DIF: Medium REF: Section 2.5
   MSC: Applying
   OBJ: Relate the geometry of solar and lunar eclipses to their visibility across Earth.

64. The darkest part of the Moon's shadow is the
   a. partial shadow.
   b. penumbra.
   c. umbra.
   d. annular.

   ANS: C DIF: Easy REF: Section 2.5
   MSC: Remembering
   OBJ: Define the bold-faced vocabulary terms within the chapter.

65. During a lunar eclipse the Moon can appear red. This is caused by
   a. the moon glowing red.
   b. oxidation of the lunar crust.
   c. solar flares.
   d. light traveling through Earth's atmosphere.

   ANS: D DIF: Medium REF: Section 2.5
   MSC: Remembering
   OBJ: Relate the geometry of solar and lunar eclipses to their visibility across Earth.

66. If you are observing a partial solar eclipse, you must be standing in the
   a. Moon's umbra.
   b. Moon's penumbra.
   c. Earth's umbra.
   d. Earth's penumbra.
   e. Sun's umbra.

   ANS: B DIF: Medium REF: Section 2.5
   MSC: Applying
   OBJ: Relate the geometry of solar and lunar eclipses to their visibility across Earth.

67. A solar-powered spacecraft is traveling through the Moon's shadow. Which part(s), if any, of the Moon's shadow will cause the spacecraft to completely lose power?
   a. umbra
   b. penumbra
   c. annulus
   d. both umbra and penumbra
   e. The spacecraft will never lose power.

   ANS: A DIF: Medium REF: Section 2.5
   MSC: Applying
   OBJ: Relate the geometry of solar and lunar eclipses to their visibility across Earth.

68. Solar and lunar eclipses are rare because
   a. the Moon's orbital plane is tipped by 5.2° relative to the plane defined by Earth's equator.
   b. the Moon's orbital plane is tipped by 5.2° relative to Earth's orbital plane.
   c. the Moon's orbital plane is tipped by 23.5° relative to the plane defined by Earth's equator.
   d. the Moon's orbital plane is tipped by 23.5° relative to Earth's orbital plane.
   e. the Moon's orbital plane is tipped by 5.2° relative to the galactic plane.

   ANS: B DIF: Medium REF: Section 2.5
   MSC: Understanding
   OBJ: Illustrate the Sun-Moon-Earth geometries needed to produce solar and lunar eclipses.

69. A type of eclipse in which the Sun appears as a bright ring is called a
   a. total solar eclipse.
   b. partial solar eclipse.
   c. annular solar eclipse.
   d. lunar eclipse.
   e. umbral eclipse.

   ANS: C DIF: Medium REF: Section 2.5
   MSC: Remembering
   OBJ: Define the bold-faced vocabulary terms within the chapter.

70. Approximately how often do lunar eclipses occur?
    a. twice every year
    b. three times every year
    c. once per month
    d. twice every 11 months
    e. once every 11 years

    ANS: D DIF: Difficult REF: Section 2.5
    MSC: Remembering
    OBJ: Illustrate the Sun-Moon-Earth geometries needed to produce solar and lunar eclipses.

SHORT ANSWER

1. Consider an observer located on the equator. If the observer sees a star directly overhead at 10 P.M., where will that star be located in the night sky at 3 A.M.?

   ANS: The star will be visible low on the western horizon.
   DIF: Easy REF: Section 2.1 MSC: Applying
   OBJ: Show the path that a star follows on the sky, from the time it rises until it sets.

2. Consider an observer located on the equator. If the observer sees a star directly overhead at 8 P.M., where will that star be located in the night sky at midnight? How far above the horizon will it be or will it have set?

   ANS: The star will move westward by an amount that is equal to (12 hours − 8 hours) × 360°/24 hours = 60°, and the star will be 90° − 60° = 30° above the western horizon.
   DIF: Medium REF: Section 2.1 MSC: Applying
   OBJ: Illustrate how the motion and visibility of stars change with the one's location on Earth.

3. On what place(s) on Earth can you stand and have the celestial equator be at the same altitude for all 360 degrees of its circumference?

   ANS: You can stand at either the North Pole or the South Pole.
   DIF: Medium REF: Section 2.1 MSC: Applying
   OBJ: Identify the locations of the north celestial pole, south celestial pole, celestial equator, zenith, meridian, and horizon on the celestial sphere.

4. Draw a dome representing the visible sky. Label the horizon, meridian, zenith, and each of the four cardinal directions (north, east, south, and west).

   ANS: The drawing should look like a dome, with the ground portion labeled as the horizon, the topmost part of the dome labeled as the zenith, and the cardinal directions labeled on the horizon with north, east, south, and west at 90 degrees from each other, clockwise. Finally, the meridian should be a line drawn from the north, through the zenith, to the south.
   DIF: Medium REF: Section 2.1
   MSC: Understanding
   OBJ: Identify the locations of the north celestial pole, south celestial pole, celestial equator, zenith, meridian, and horizon on the celestial sphere.

5. The center of the Milky Way lies approximately 30° south of the celestial equator. From what latitudes on Earth is it impossible to view the center of our galaxy?

   ANS: At latitudes greater than 90° − 30° = 60°, it would be impossible to see the center of our galaxy because it would lie below the horizon.
   DIF: Medium REF: Section 2.1 MSC: Applying
   OBJ: Illustrate how the motion and visibility of stars change with the one's location on Earth.

6. How is the observed height of Polaris above the horizon related to an observer's latitude? (Hint: Consider three cases of observers located at the equator, the North Pole, and latitude = +45°.)

   ANS: The observed height of Polaris above the horizon is equal to an observer's latitude. For an observer at the equator (latitude = 0°), Polaris is on the horizon. For an observer at the North Pole (latitude = +90°), Polaris is at the zenith or 90° above the horizon. For an observer at latitude = +45°, Polaris is 45° above the horizon.
   DIF: Medium REF: Section 2.1 MSC: Applying
   OBJ: Demonstrate how knowledge of the sky permits one to know latitude and direction on Earth.

7. What latitude on Earth would be the best for observing as much of the celestial sphere as possible over the course of a year?

   ANS: The equator, 0° latitude, is best because over the course of the year you would be able to see all of the northern and southern hemispheres of the celestial sphere.
   DIF: Medium REF: Section 2.1 MSC: Applying
   OBJ: Illustrate how the motion and visibility of stars change with the one's location on Earth.

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8. If you are standing on the equator and shoot a cannonball directly north, where would you expect it to land?

ANS: The cannonball would land to the northeast of your position. Because you are standing on the equator, you have the fastest ground speed of any location on Earth. Once the cannonball is fired, it is given a velocity in the northern direction. However, the cannonball retains the ground speed of the equator also. Because the ground speed of the northern latitudes is lower than that of the equator, the cannonball will appear to travel northeast instead of straight north!
DIF: Difficult REF: Section 2.1
MSC: Understanding
OBJ: Illustrate how one event will look in two different frames of reference.

9. What would be the effect on the seasons if the tilt of Earth's axis were 10° rather than 23.5°?

ANS: If the tilt of Earth's axis were smaller, there would be a less dramatic temperature shift between the seasons because the angle of the Sun's rays would vary less and the length of day/night would be more equal throughout the year.
DIF: Easy REF: Section 2.2 MSC: Applying
OBJ: Explain why Earth's axial tilt causes seasons.

10. What is the point on the celestial sphere where the ecliptic crosses from below to above the celestial equator called?

ANS: The vernal or spring equinox.
DIF: Medium REF: Section 2.2
MSC: Remembering
OBJ: Identify the path of the ecliptic, the solstices, and the equinoxes on the celestial sphere.

11. What makes the equinoxes and solstices special?

ANS: The equinoxes occur when the Sun is directly above the equator; the entire world experiences a 12-hour day and a 12-hour night. The solstices occur when the Sun is farthest from the equator (north or south). On these days, one hemisphere experiences its longest day and shortest night, while the other hemisphere experiences its shortest day and longest night.
DIF: Medium REF: Section 2.2
MSC: Understanding
OBJ: Identify the path of the ecliptic, the solstices, and the equinoxes on the celestial sphere.

12. On what day(s) of the year does the Sun set due west?

ANS: The Sun will set due west on the vernal and autumnal equinoxes.
DIF: Medium REF: Section 2.2 MSC: Applying
OBJ: Identify the path of the ecliptic, the solstices, and the equinoxes on the celestial sphere.

13. Earth experiences seasons due to the tilt of its axis. What are two consequences of this tilt that contribute to the seasons?

ANS: (1) Variation in the length of daylight, and (2) variation in the directness of the Sun's rays.
DIF: Medium REF: Section 2.2 MSC: Applying
OBJ: Explain why Earth's axial tilt causes seasons.

14. For an observer in Seattle, Washington, which is located at latitude $= +47°$, what is the lowest possible altitude one might see the Sun on the meridian over the course of the year? Approximately what time of the day and year will this occur?

ANS: For an observer in Seattle, Washington, the celestial equator will be at an altitude of $90° - 47° = 43°$ above the southern horizon. The Sun will be located at its southernmost position on the celestial sphere on the winter solstice, which is 23.5° south from the celestial equator. Therefore, the Sun will be on the meridian at noon on the winter solstice with an altitude of $43° - 23.5° = 19.5°$ above the southern horizon.
DIF: Difficult REF: Section 2.2 MSC: Applying
OBJ: Illustrate how the height of the Sun and the length of a day vary with the season and your latitude.

15. The position of the autumnal equinox lies at the intersection of which two great celestial circles on the celestial sphere?

ANS: The autumnal equinox lies at the intersection of the celestial equator and the ecliptic.
DIF: Difficult REF: Section 2.2
MSC: Remembering
OBJ: Identify the path of the ecliptic, the solstices, and the equinoxes on the celestial sphere.

16. Why does the Moon always show the same face to Earth?

ANS: The Moon's rotation and orbital period (revolution) are the same. The Moon experiences synchronous rotation.
DIF: Easy REF: Section 2.3
MSC: Remembering
OBJ: Define the bold-faced vocabulary terms within the chapter.

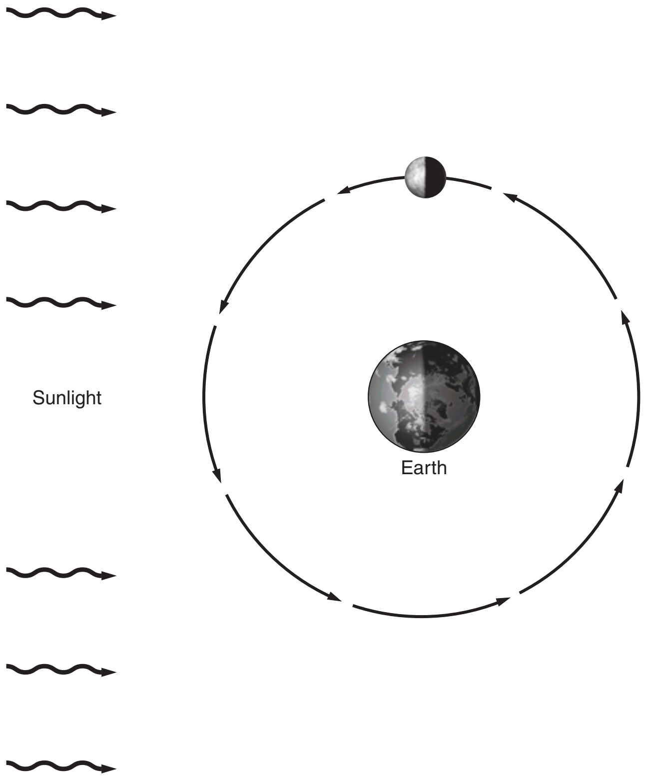
17. Explain why we always see the same side of the Moon from Earth.

ANS: The amount of time it takes for the Moon to rotate once about its axis is exactly equal to the amount of time it takes to orbit once around Earth.
DIF: Easy REF: Section 2.3 MSC: Understanding
OBJ: Explain what causes us to observe moon phases.

18. If the Moon was full 3 days ago, what phase will it be in tonight, and when will it rise and set?

ANS: The Moon's phase cycles on a 29.5-day period. Therefore, the Moon tonight will be approximately halfway between the full and third quarter phases, and thus it will be in the waning gibbous phase. It will be on an observer's eastern horizon and rising halfway between 6 P.M. and midnight, which is 9 P.M. It will set 12 hours later at 9 A.M.
DIF: Medium REF: Section 2.3 MSC: Applying
OBJ: Define the phases of the moon.

19. Based on the location of the Moon shown in the figure below, draw a picture of how the moon would appear to an observer located on Earth.

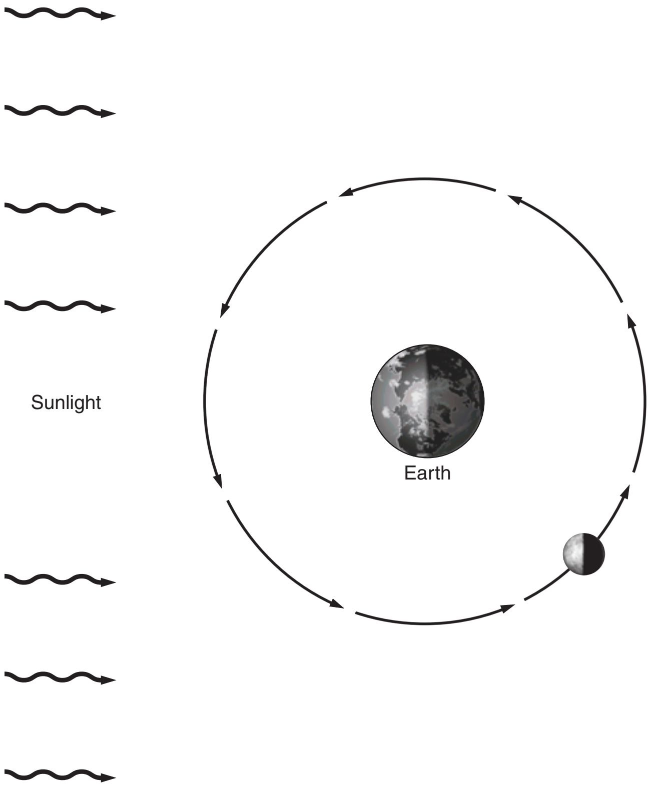


ANS: The drawing should show a third quarter moon, where the left half of the Moon's face will be lit up and the right half will be in darkness.
DIF: Medium REF: Section 2.3
MSC: Understanding
OBJ: Illustrate the Sun-Moon-Earth geometry needed to produce each Moon phase.

20. As the month passes, the Moon appears to rise later in the day or night when compared to the previous day. Explain why this happens.

ANS: In general, objects appear to rise and set due to Earth's rotation. Whereas Earth rotates once every 24 hours, the Moon also orbits around Earth roughly once a month in the same direction as Earth's rotation. Therefore, over 24 hours, the Moon has moved slightly from its original position, and Earth has to rotate a little more before the Moon appears to rise again the next day.
DIF: Medium REF: Section 2.3 MSC: Applying
OBJ: Explain what causes us to observe moon phases.

21. Based on the location of the Moon shown in the figure below, draw a picture of how the Moon would appear to an observer located on Earth.



ANS: The drawing should show a waxing gibbous moon, where more than half of the Moon's right face will be lit up and less than half of the left face will be in darkness. DIF: Difficult REF: Section 2.3
MSC: Understanding
OBJ: Illustrate the Sun-Moon-Earth geometry needed to produce each Moon phase.

22. What is the difference between the terms solar day and sidereal day?

ANS: A solar day is the time it takes for the Sun to come back to the same local meridian. A solar day is 24 hours long. A sidereal day is the time it takes for Earth to complete one full rotation relative to the distant stars; this takes 23 hours 56 minutes.
DIF: Easy REF: Section 2.4
MSC: Remembering
OBJ: Define the bold-faced vocabulary terms within the chapter.

23. How does today's Gregorian calendar differ from the calendars of more ancient civilizations, such as the Chinese, the Egyptians, and the Babylonians?

ANS: The Gregorian calendar is based on the tropical year, based on the motion of Earth around the Sun. The others are lunar calendars based on the motion of the Moon around Earth. The Gregorian calendar also includes leap years to avoid the shifting of the seasons due to the fact that Earth orbits the Sun in 365.24 days.
DIF: Medium REF: Section 2.4
MSC: Remembering
OBJ: Compare and contrast solar and lunar calendars.

24. Why do some years in certain lunar calendars have 13 months?

ANS: A lunar calendar can have 13 months, which act to keep the lunar calendar in sync with the seasons. These are like leap years, but not every year will have 13 months.
DIF: Difficult REF: Section 2.4
MSC: Understanding
OBJ: Compare and contrast solar and lunar calendars.

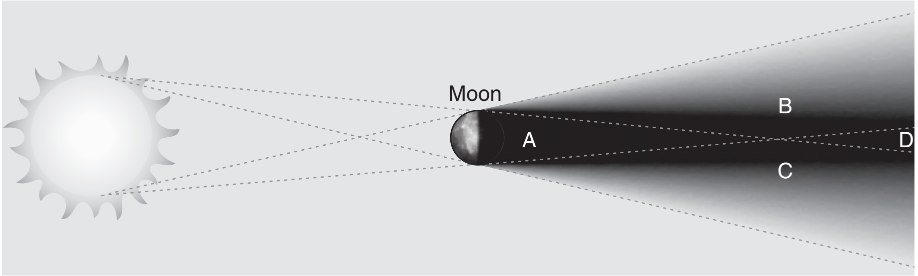
25. Draw a picture below showing the Moon's location relative to Earth and the Sun during a lunar eclipse.

ANS: The Moon, Earth, and Sun should all be drawn in a straight line with Earth in between the Moon and the Sun.
DIF: Medium REF: Section 2.5 MSC: Applying
OBJ: Illustrate the Sun-Moon-Earth geometries needed to produce solar and lunar eclipses.

26. Draw a picture below showing the Moon's location relative to Earth and the Sun during a solar eclipse.

ANS: The Moon, Earth, and Sun should all be drawn in a straight line with the Moon in between Earth and the Sun.
DIF: Medium REF: Section 2.5 MSC: Applying
OBJ: Illustrate the Sun-Moon-Earth geometries needed to produce solar and lunar eclipses.

27. Explain the type of solar eclipse that would be observed by an observer on Earth if they were in each respective part (A, B, C, and D) of the shadow of the moon, shown in the figure below.



ANS: An observer in part A would observe a total solar eclipse. An observer in parts B and C would observer a partial solar eclipse. An observer in part D would observe an annular eclipse.
DIF: Medium REF: Section 2.5 MSC: Applying
OBJ: Relate the geometry of solar and lunar eclipses to their visibility across Earth.

28. Explain why the eclipse seasons occur roughly twice every 11 months, rather than twice per year.

ANS: This happens because the plane of the Moon's orbit slowly wobbles, completing one full "wobble" every 18.6 years. Because the wobble is in the opposite direction from the Moon's orbit, the eclipse seasons occur less than 6 months apart.
DIF: Difficult REF: Section 2.5 MSC: Applying
OBJ: Illustrate the Sun-Moon-Earth geometries needed to produce solar and lunar eclipses.

29. Approximately how large is the umbra on the surface of Earth?

ANS: The largest it can be is when Earth and the Moon are closest together, which makes the umbra approximately 270 km wide. The shadow is on the order of hundreds of kilometers.
DIF: Difficult REF: Section 2.5
MSC: Understanding
OBJ: Relate the geometry of solar and lunar eclipses to their visibility across Earth.

30. Earth has an average radius of approximately 6.4×10^3 km. What is the average speed, in units of km/s, of the ground at Earth's equator due to the daily rotation of Earth if there are 8.64×10^4 seconds per day?

ANS: Here the students need to convert the radius of Earth to its circumference: $C = 2\pi r = 2 \times 3.14159 \times 6.4 \times 10^3 = 4.02 \times 10^4$ km. Divide this distance by 8.64×10^4 s, and we get a speed of 0.465 km/s = 1,676 km/h.
DIF: Difficult REF: Working It Out 2.1
MSC: Applying
OBJ: Use proportional reasoning to estimate a characteristic of the whole based on measurement of a part.