1. Two stars that are in the same constellation
   - A. must both be part of the same cluster of stars in space.
   - B. must both have been discovered at about the same time.
   - C. may actually be very far away from each other.

2. The north celestial pole is 35° above your northern horizon. This tells you that
   - A. you are at latitude 35°N.
   - B. you are at longitude 35°E.
   - C. you are at latitude 35°S.

3. Beijing and Philadelphia have about the same latitude but very different longitudes. Therefore, tonight’s night sky in these two places
   - A. will look about the same.
   - B. will have completely different sets of constellations.
   - C. will have partially different sets of constellations.

4. In winter, Earth’s axis points toward the star Polaris. In spring,
   - A. the axis also points toward Polaris.
   - B. the axis points toward Vega.
   - C. the axis points toward the Sun.

5. When it is summer in Australia, the season in the United States is
   - A. winter.
   - B. summer.
   - C. spring.

6. If the Sun rises precisely due east,
   - A. you must be located at Earth’s equator.
   - B. it must be the day of either the spring or fall equinox.
   - C. it must be the day of the summer solstice.

7. A week after full moon, the Moon’s phase is
   - A. first quarter.
   - B. third quarter.
   - C. new.

8. Some type of lunar or solar eclipse (not necessarily a total eclipse) occurs
   - A. about once every 18 years.
   - B. about once a month.
   - C. at least four times a year.

9. If there is going to be a total lunar eclipse tonight, then you know that
   - A. the Moon’s phase is full.
   - B. the Moon’s phase is new.
C. the Moon is unusually close to Earth.

10. When we see Saturn going through a period of apparent retrograde motion, it means
   A. Saturn is temporarily moving backward in its orbit of the Sun.
   B. Earth is passing Saturn in its orbit, with both planets on the same side of the Sun.
   C. Saturn and Earth must be on opposite sides of the Sun.

Figure 1: The figure above is a typical diagram used to describe Earth’s seasons. Use this figure to answer questions 11–15.

11. Which of the four labeled points (A through D) in Figure 1 represents the beginning of summer for the Northern Hemisphere?
   **Solution:** B

12. Which of the four labeled points in Figure 1 represents the beginning of summer for the Southern Hemisphere?
   **Solution:** D

13. Which of the four labeled points in Figure 1 represents the beginning of spring for the Northern Hemisphere?
   **Solution:** A

14. Which of the four labeled points in Figure 1 represents the beginning of spring for the Southern Hemisphere?
   **Solution:** C

15. Diagrams like Figure 1 are useful for representing seasons, but they can also be misleading because they exaggerate the sizes of Earth and the Sun relative to the orbit. If Earth were correctly scaled relative to the orbit in the figure, how big would it be?
   A. about half the size shown
   B. about 2 millimeters across
   C. about 0.1 millimeter across
   D. microscopic
For the following questions, show your work in the space provided below each question.

16. Arcminutes and Arcseconds. There are $360^{\circ}$ in a full circle.
   (a) How many arcminutes are in a full circle?
   Solution: There are $360 \times 60 = 21600$ arcminutes in a full circle.
   
   (b) How many arcseconds are in a full circle?
   Solution: There are $360 \times 60 \times 60 = 1296000$ arcseconds in a full circle.
   
   (c) The Moon’s angular size is about $0.5^{\circ}$. What is this in arcminutes? In arcseconds?
   Solution: The Moon’s angular size of $0.5^{\circ}$ is equivalent to $30$ arcminutes or $30 \times 60 = 1800$ arcseconds.

17. Latitude Distance. Earth’s radius is approximately $6370$ km.
   (a) What is the Earth’s circumference?
   Solution: Circumference = $2\pi r = 2\pi (6371 \text{ km}) = 40000 \text{ km}$
   
   (b) What distance is represented by each degree of latitude??
   Solution: equator to pole distance = $\frac{\text{Circumference}}{4} = \frac{40000 \text{ km}}{4} = 10000 \text{ km}$
   Thus, $1^{\circ} = \frac{10000 \text{ km}}{90^{\circ}} = 111 \text{ km}$
   
   (c) What distance is represented by each arcminute of latitude??
   Solution: Each arcminute of latitude represents $1.85$ kilometers.
   
   (d) Can you give similar answers for the distances represented by a degree or arc minute of longitude? Why or why not?
   Solution: We cannot provide similar answers for longitude, because lines of longitude get closer together as we near the poles, eventually meeting at the poles themselves. So there is no single distance that can represent $1^{\circ}$ of longitude everywhere on Earth.

18. Angular Conversions I. The following angles are given in degrees and fractions of degrees. Rewrite them in degrees, arcminutes, and arcseconds.
   (a) $24.3^{\circ}$
   Solution: We start by recognizing that there are 24 whole degrees in this number. So we just need to convert the $0.3^{\circ}$ into arcminutes and arcseconds. So first converting to arcminutes:
   \[
   0.3^{\circ} = \frac{60 \text{ arcminutes}}{1^{\circ}} = 18 \text{ arcminutes}
   \]
   Since there is no fractional part left to convert into arcseconds, we are done. So $24.3^{\circ}$ is the same as $24^{\circ}18'$.
   
   (b) $1.59^{\circ}$
19. Angular Conversions II. The following angles are given in degrees, arcminutes, and arcseconds. Rewrite them in degrees and fractions of degrees.

(a) 7°38'42"
Solution: 7.645°

(b) 12'54"
Solution: 0.215°

(c) 1°59'59"
Solution: 1.9997°

(d) 1'
Solution: 0.017°

(e) 1"
Solution: \((2.78 \times 10^{-4})°\)

20. Moon Speed. The Moon takes about 27.3 days to complete each orbit of Earth. About how fast is the Moon going as it orbits Earth? Give your answer in km/hr.

Solution: From the textbook’s Appendix E, the Moon’s orbit has a radius of 384,400 kilometers. The distance that the Moon travels in one orbit is the circumference of the orbit:

\[
\text{distance traveled} = 2\pi r = 2\pi (384400 \text{ km}) = 2.415 \times 10^6 \text{ km}
\]

To find the Moon’s speed in kilometers per hour, we also need to find how many hours are in the Moon’s 27.3–day orbit:

\[
27.3 \text{ days} \times \frac{24 \text{ hr}}{1 \text{ day}} \approx 656 \text{ hr}
\]

The speed is the distance over the time,

\[
\text{speed} = \frac{\text{distance}}{\text{time}} = \frac{2.415 \times 10^6 \text{ km}}{656 \text{ hr}} \approx 3680 \text{ km/hr}
\]

The Moon orbits Earth at a speed of 3680 kilometers per hour.
21. **Scale of the Moon.** The Moon’s diameter is about 3500 km and its average distance from Earth is about 380,000 km. How big and how far from Earth is the Moon on the 1-to-10-billion scale used in Chapter 1? Compare the size of the Moon’s orbit to the size of the Sun on this scale.

**Solution:** Starting with the size of the Moon, we convert to the scale model distance by dividing by 10 billion:

\[
\frac{3500 \text{ km}}{10^{10}} = 3.5 \times 10^{-7} \text{ km}
\]

This number is pretty hard to understand, so we should convert it to something more useful. Judging by the sizes of other objects in the model, let’s convert from kilometers to millimeters:

\[
3.5 \times 10^{-7} \text{ km} \times \frac{1000 \text{ mm}}{1 \text{ km}} = 0.35 \text{ mm}
\]

The Moon’s size on this scale is 0.35 millimeter.

We perform the same conversion to get the Moon’s scale distance:

\[
\frac{3.8 \times 10^5 \text{ km}}{10^{10}} = 3.8 \times 10^{-5} \text{ km}
\]

Just as above, this number is hard to understand. We’ll also convert it to millimeters:

\[
3.8 \times 10^{-5} \text{ km} \times \frac{1000 \text{ mm}}{1 \text{ km}} = 38 \text{ mm}
\]

The distance to the Moon on this scale is 38 millimeters. Since there are 10 millimeters to 1 centimeter, we can convert this to centimeters:

\[
38 \text{ mm} \times \frac{1 \text{ cm}}{10 \text{ mm}} = 3.8 \text{ cm}
\]

The Moon’s scaled distance is 3.8 centimeters, which is less than 2 inches. It also means that the Moon’s orbit is about half the size of the ball of the Sun. The ball of the Sun was the size of a grapefruit in this scale model, so sticking with fruit, we could say that the Moon’s orbit has the diameter of a medium-size orange or an apple.

22. **Find the Sun’s Diameter.** The Sun has an angular diameter of about 0.5° and an average distance from Earth of about 150 million km. What is the Sun’s approximate physical diameter? Compare your answer to the actual value of 1,390,000 km.

**Solution:** To solve this problem, use the equation given on page 30 in the textbook, where we learn that the physical size of an object, its distance, and its angular size are related by the equation:

\[
\text{physical size} = \frac{2\pi \times \text{distance} \times \text{angular size}}{360^\circ}
\]

We are told that the Sun is 0.5° in angular diameter and is about \(1.5 \times 10^8\) kilometers away. So we put those values in:

\[
\text{physical size} = \frac{2\pi \times (1.5 \times 10^8 \text{ km}) \times (0.5^\circ)}{360^\circ} = 1.31 \times 10^6 \text{ km}
\]

For the values given, we estimate the size to be about \(1.31 \times 10^6\) km. We are told that the actual value is about \(1.39 \times 10^6\) km. The two values are pretty close and the difference can probably be explained by the Sun’s actual diameter not being exactly 0.5° and the distance to the Sun not being exactly \(1.5 \times 10^8\) km.