Chapter 4

(1) page 88, question 3
   The Moon would have to be twice as large to still eclipse the Sun if it were twice as far.

(2) page 88, question 6
   Stars near the horizon twinkle more than those straight up in the sky. The light from stars near the horizon has to come through a larger amount of the Earth’s atmosphere.

(3) page 88, question 14
   The seasons are caused by Earth’s tilt. During December, the southern hemisphere is tilted toward the sun, so that it is summer over this half of Earth. The two main features that determine the seasons are the directness of the Sun’s light and the length of the day.

(4) Suppose you see a quarter Moon overhead at 6:00 pm. What time did the Moon rise that day?
   The Moon must have risen at 12 o’clock noon.

(5) Draw a diagram of Venus going around the Sun, and place Earth at a fixed position exterior to Venus’ orbit. Describe what phases of Venus are seen from Earth over the course of Venus’ orbit.
   See the course website for this diagram.

(6) The celestial sphere:
   (a) At what location on the Earth is the north celestial pole on the horizon? Explain you answer with a diagram.
      At the equator, the north celestial pole is on the horizon. See the course website for the diagram.
   (b) The galaxy Andromeda passes nearly overhead during the autumn nights in Berkeley. Would you ever be able to see Andromeda from the south celestial pole?
      No. From the south celestial pole you can only see the southern hemisphere, and you cannot see anything north of the equator.

(7) A common misconception is that the seasons are due to the changing distance between the Earth and Sun caused by the Earth’s elliptical orbit. One counter argument to this is that it doesn’t explain why the seasons are reversed in the southern hemisphere. What is another convincing and easily understandable argument for why this is not the correct explanation? In other words, what easily observable effect is not explained by a changing distance?
   The path the Sun takes in the sky over the course of a day changes with the seasons. In the summer, the Sun passes much more overhead, while in the winter it is close to the horizon. This correlation with the seasons, is not explained by a changing distance.

Chapter 5

(8) page 108, question 2
   In the Ptolemaic system, retrograde motion is explained using epicycles that allow the planets to sometimes move backwards in their orbits. In the Copernican system, retrograde motion is just the apparent motion of the planets as Earth passes them in its orbit.

(9) page 108, question 7, Give your answer in units of AU. You may use a calculator if you wish.
From Kepler’s 3rd law, we know that \( P^2 \propto R^3 \). Furthermore, scaling to the values for Earth, we have \( P^2 = R^3 \) if \( P \) is measured in years and \( R \) is measured in AU. Thus

\[
R = P^{2/3} = (250)^{2/3} \approx 40 \text{ AU}
\]

(10) page 108, question 10
We expect Venus to have a larger angular size in the crescent phase rather than the gibbous phase. The reason why is that to appear as a crescent, Venus must be between Earth and the Sun, thus Venus is closer than in the gibbous phase.

(11) page 108, question 17
The Earth’s gravitational force on the Sun is equal to the Sun’s gravitational force on the Earth. This must be true according to Newton’s 3rd law, but also it is apparent from Newton’s law of gravitation because the gravitational force, \( F = Gm_1m_2/d^2 \) does not change if we exchange 1 and 2.

(12) page 109, question 28, Even though it is multiple choice, be sure to show your work
From Kepler’s 3rd law, \( P \propto R^{2/3} \). Thus if Planet Zaphod orbits at 2 times the distance, then its orbital period is \( 2^{3/2} = \sqrt[3]{8} \) times as long. The answer is b.

Chapter 6

(13) page 149, question 3
(a) The tides are caused by differences in the Moon’s gravitational force on different parts of Earth.
(b) If the Moon were farther away, the tides would be less. This is because the relative amount of force on the near and far sides of Earth would be less.

(14) Draw a diagram showing the positions of the Earth, Moon, and Sun when there is the smallest difference between high and low tide.
See page 10 from the Lecture 7 notes.

(15) page 150, question 9
The rocks on the Earth have been recycled many times due to plate tectonics, volcanism, erosion, and the fact that Earth is a constantly changing place. In contrast, many of the rocks on the Moon have been sitting undisturbed for billions of years.

(16) page 150, question 25
Since the Sun mainly gives off light in the infrared, such an atmosphere would block off most of the Sun’s radiation. Furthermore, any light that gets through and heats the planets surface reradiates in the infrared. Since infrared radiation is not at all trapped, it would easily leave the planet’s surface. There would be no greenhouse effect to speak of and the planet would be much colder.

(17) page 150, question 32
There are surface features that look like the erosion from running water. Also scattered rocks are reminiscent of a lake bed, so perhaps such lakes existed in the past. We measure signs of ice water near the polar caps, though the caps are mainly carbon dioxide. Finally, we measure neutrons being emitted from all over Mars, which is usually associated with water. This may mean that there is a thin layer of permafrost just underneath the Martian surface.

Chapter 7

(18) page 179, question 6
Volume goes like the diameter cubed, so the volume of Jupiter is approximately \( 11.2^3 \approx 1400 \) times larger than the Earth.

(19) page 179, question 7
Io is torqued by nearby moons to have a very elliptical orbit (high eccentricity). This causes a lot of variation in tidal forces from Jupiter, which squeezes and heats Io.
(20) page 179, question 11

The Roche limit tells us how far a moon can be from a planet before it is completely torn apart by the planet’s tidal forces. Saturn’s rings are within this Roche limit. This makes sense, because moons could not survive at such a close distance. Also, it may indicate that the rings were formed by a moon that was torn apart when it reached this limit.

(21) page 179, question 14

The rings are kept thin by small satellites (little moons) that gravitationally prevent the ring from spreading. This effect is called “shepherding.”

(22) page 179, question 17

Neptune takes 164 years to orbit the Sun. Neptune was discovered in 1846, which is 163 years ago. It has therefore traversed $\frac{163}{164} \approx 0.99$ or 99% of one complete orbit. Galileo saw Neptune in 1613 (unknownt to him), which was 396 years ago. Neptune has gone $\frac{396}{164} \approx 2.4$ orbits since then.