Freedman Universe 7e Ch 01

Chapter 1, Introduction

1. The quality that, perhaps above all others, makes human beings stand out among all the animals is

- the lack of animosity toward other human beings.
- the driving curiosity and desire to explore their surroundings and understand them.
- the overwhelming desire for self-preservation.

Section 1-1

2. After making makes a series of observations of a certain phenomenon in a laboratory, a scientist develops a theory that explains these results and predicts new values for future observations. Another scientist makes a series of appropriate observations, but his results always contradict the predictions of the theory. What should the first scientist do?

- Attempt to modify his theory to bring it into accord with the new observations and, if he cannot do so, discard his theory.
- Discard the theory immediately.
- Ignore the new results because his theory explains the earlier results satisfactorily.

Section 1-1

3. Which of the following fundamental requirements must be met in order that a theory or idea can be considered a scientific theory?

- It has to explain all known observations.
- It has to be based upon mathematics.
- The theory should predict new observations, even if they prove the theory wrong.

Section 1-1

4. Which of the following statements best represents the overall rationale for scientific investigation?

- Reality is comprehensible, and a limited number of fundamental principles govern the nature and behavior of the universe.
- The universe is a hodgepodge of unrelated things behaving in unpredictable ways. Nevertheless, we must continue to observe it in case this behavior threatens the Earth. An example of such an observation might be the detection of an asteroid bearing down upon Earth.
- The behavior of the whole universe is governed by man's observations of it, in such a way as to hide the fundamental truth.

Figure 1-1

5. The Hubble Space Telescope (HST) represents a very significant advance in astronomy because

- it operates above the Earth's absorbing and distorting atmosphere.
- its large orbit gives it views of objects from different viewpoints, thereby providing measurements of distances to nearby stars, the shapes and sizes of planets, etc.
- it is closer to the objects that it observes, making it capable of seeing things more clearly and in more detail than observatories upon Earth.

Section 1-2

6. What is a solar system?

- A collection of planets and other, smaller objects orbiting around a star (e.g., the Sun).
- A collection of a million to a hundred billion or more suns (stars) in a large system, often containing spiral arms; for example, our own Milky Way Galaxy.
- A collection of two or a few suns (stars) orbiting around each other.

Figure 1-2

7. In our solar system, which of the following statements is true?

- The diameter of Jupiter is smaller than that of Saturn and of its rings.
- The diameter of Jupiter is larger than that of Saturn and of its rings.
- The diameter of Jupiter is larger than that of Saturn but smaller than the diameter of Saturn's rings.

Section 1-3

8. When did the idea of thermonuclear fusion as source of energy first develop, and in what context?

- During World War II, in theoretical studies of nuclear explosives.
- In the late nineteenth century, during experimental studies of radioactivity.
- In the early twentieth century, during theoretical studies of the interiors of stars.

Section 1-4

9. Quasars are among the most exotic of all of the objects that astronomers study. What are some of the characteristics of quasars that make them so mysterious?

- They involve a spectacular detonation with the complete or almost complete destruction of a star and the ejection of enormous amounts of gas into space.
- They are among the most distant objects in the universe and outshine normal galaxies by a factor of a hundred.
- They appear to be dead stars, and we receive energy from them only in brief, highly repetitive bursts.

Box 1-1

10. In a particular total solar eclipse, the Moon was observed from a location upon Earth to cover the Sun exactly, that is, the Moon's angular size was the same as that of the Sun at that time. If the Sun is 1.5×10^8 km away and has a diameter of 1.4×10^6 km, how far away is the Moon if its diameter is 3.5×10^3 km?

- 3.75×10^3 km
- 3.75×10^5 km
- 3.27×10^1km

Section 1-5

11. Stars on the equator appear to move through a full 360 degrees in about 1 day because of the Earth's rotation. How fast are they moving in degrees per minute?

- 4 degrees per minute
- 15 degrees per minute
- 1/4 degree per minute

Box 1-1, Section 1-5

12. An average observatory telescope can resolve objects that subtend about 1 arc second. What would be the angular size of a 2-meter-tall astronaut as seen from this observatory if she were involved in extravehicular activity and sunlit outside the International Space Station as it passed overhead in its orbit 400 km above the Earth? Would you be able to see her on the Space Station?

- 3.9 arc seconds. Yes, you should be able to see the astronaut very easily.
- 1.03 arc second. Yes, you would JUST be able to make out this astronaut.
- 1.03×10^{-3} arc second. You would NOT be able to see the astronaut.

Section 1-5

13. The human eye can just separate two bright lights when they are 1 arc minute apart in angle. A dime, face-on, at a distance of 720 meters, will have an angular diameter of 5 arc seconds. If a line of dimes is placed 720 meters away, how many would fit between 2 lights that appear to be 1 arc minute apart?

- 12
- 720
- 1/12 (or 0.083), a small fraction of 1 dime

Section 1-5, Box 1-1

14. The Crab Nebula shown in Fig. 1-6, Freedman & Kaufmann, *Universe*, 7th Ed., has a diameter of about 10 ly, and is at a distance of 6500 ly. What angle will this supernova remnant subtend in our sky?

- 5.3 arc minutes
- 650 arc seconds
- 1.6×10^{-3} arc seconds

Section 1-6

15. The distance from the Sun to Mars is about 220,000,000 km. What is this distance in scientific notation?

- 2.2×10^9 km
- 2.2×10^7km
- 2.2×10^8 km

Section 1-6

16. The wavelength of red light is about 0.000 000 65 m. What is this wavelength in scientific notation?

- 6.5×10^{-8}m
- 6.5×10^{-7} m
- 6.5×10^{-6}m

Section 1-6

17. Astronomers sometimes observe objects in the sky at an infrared wavelength of 4.4×10^{-6} m. What is the wavelength expressed as a decimal fraction?

- 0.000 004 4 m
- 0.000 000 44 m
- 0.000 044 m

Section 1-7

18. Astronomers use units such as light-years for distance, which are not included in the International System of Units that is used by the rest of the scientific community, because

- astronomy is the oldest science, and astronomers continue to use units that were developed before the present standard system was devised.
- astronomers require special units in order to account for such concepts as the curvature of space, the existence of black holes, and the constancy of the speed of light within the framework of the universe.
- distances are so vast in the observable universe that alternative, and larger, units are more convenient for use in astronomy.

Section 1-7

19. What is a parsec?
- A unit of distance used in astronomy: the distance from which 1AU subtends an angle of 1 arc second.
- A unit of angle used in astronomy: the angle subtended by 1AU at a distance of 1 light-year.
- A unit of time used in astronomy: the time taken for light to travel from the Sun to the Earth.

Section 1-7

20. A new asteroid is discovered at a distance of 3.3 AU from the Sun. What is this distance in kilometers?
- 2.21×10^8 km
- 4.91×10^8 km
- 3.30×10^8 km

Section 1-7

21. What is the definition of the parsec?
- The distance through which light travels in one year.
- The distance at which 2 AU (the diameter of the Earth's orbit) subtends exactly one second of arc.
- The distance at which 1 AU (the radius of the Earth's orbit) subtends an angle of exactly one second of arc.

Section 1-7

22. In which of the following sequences are the distances in the correct order of increasing size?
- 10^8 km, 1 AU, 0.001 ly, 1 pc
- 1 AU, 10^8 km, 0.001 ly, 1 pc
- 10^8 km, 1 AU, 1 pc, 0.001 ly

Section 1-7

23. Suppose that a particular star were 15 light-years (ly) away from the Earth. What would this distance be in parsecs (pc)?
- 48.9 pc
- 0.217 pc
- 4.6 pc

Section 1-7

24. Suppose that a particular cluster of stars were 4.27 kiloparsecs (kpc) away from the Earth. What would this distance be in light-years (ly)?

- 1310 ly
- 13.9 ly
- 13,920 ly

Submit Reset

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Freedman Universe 7e Ch 02

Sections 2-3 and 2-4

1. One feature of the sky that was most probably used by ancient people to define directions and thereby navigate safely across oceans was the fact that
- the Sun rose and set at the same points on the horizon, day by day.
- the Moon rose and set at the same points on the horizon, night by night.
- certain stars rose and set at the same points on the horizon, night by night.

Section 2-1

2. Which of the following positions in the sky was most probably used by ancient people in the Northern Hemisphere in the definition of a calendar and determination of certain key times in their year?
- The date when the brightest planets rise and/or set at their most northerly points on the horizon.
- The date when sunrise occurred at its most northerly point on the horizon.
- The date on which the Moon rose at its most northerly point on the horizon.

Section 2-2

3. What are constellations?
- Occasions when planets pass close to each other as seen from the Earth, as the planets follow their separate orbits around the Sun.
- Groupings of stars that cover various areas of sky from large to small.
- Galaxies, made up of billions of stars orbiting around a common center.

Section 2-3

4. The constellation Cygnus appears overhead to an observer in the state of New York, USA, at midnight on a particular night. In which part of the sky will this constellation appear to an observer at the same latitude in Montana, 30º farther west in longitude, if observed at precisely the same absolute time (Universal Coordinated Time, or UTC) (which will be 10 PM, Montana local time)?
- In the western sky.
- Overhead, of course.
- In the eastern sky.

Section 2-4

5. The celestial sphere is
- an ancient Greek name for the Sun.

- a large imaginary sphere centered on the Earth, on which all objects in the night sky appear to be located.
- he large band of constellations, centered on the Earth, through which the Sun appears to move each year.

Section 2-4 and Box 2-1

6. If the Sun's declination is 0º on March 21 of a particular year, how long will it be before it is at this declination again?
- 26,000 years later
- 6 months later
- 1 year later

Section 2-4 and Box 2-1

7. If the Sun's declination is + 23.5º on June 21 of a particular year, when will it next be this declination?
- 6 months later
- 3 months later
- year later

Section 2-4

8. If one stands on the equator, are there any stars that always remain above the horizon, that is, are circumpolar?
- It depends upon the time of the year or the season. This is because the Earth's axis tilts at different angles to the equator at different times of the year, making some stars circumpolar at certain times of the year.
- Of course. All stars would be visible for 24 hours from this location if it were not for daylight.
- No. From this position, all stars cross the horizon at some time, rising and setting at intervals of 12 hours.

Section 2-5

9. The primary cause of the seasons on the Earth (spring, summer, fall, and winter) is that
- the Earth's axis of rotation tilts in a constant direction relative to the Earth's orbital plane. The motion of the Earth around the Sun then changes the angle of incidence of solar radiation at each point on the Earth's surface through the year.
- the tilt angle of the Earth's axis of rotation changes relative to the Earth's orbital plane. Spring and fall occur when the axis of rotation is perpendicular to the orbital plane, and summer and fall when the axis is tilted toward and away from the Sun, respectively.
- the distance between the Sun and Earth varies because of the elliptical orbit of the Earth. Summer occurs when the Earth is closest to the Sun, and winter when the Earth is farthest from the Sun.

Section 2-5

10. To an astronomer, the vernal equinox is
- the point on the celestial sphere where the Sun crosses the ecliptic moving north.
- the beginning of autumn in the northern hemisphere.
- the point on the celestial sphere where the Sun crosses the celestial equator moving north.

Section 2-5

11. You are standing somewhere on Earth on a bright, sunny day when you notice that a tall, vertical telephone pole has no shadow. From that observation by itself, what do you know about where you might be standing?
- Exactly at the North or South Pole in midsummer (24-hour daylight).
- Anywhere between the Tropic of Cancer and the Tropic of Capricorn.
- Exactly on the equator.

Section 2-5 and Box 2-1

12. The declination of the Sun on the first day of spring is
- 0º.
- 23.5º north.
- variable, depending on the year.

Section 2-5

13. During one full year, the ecliptic plane (i.e., the plane of the Earth's orbit around the Sun)
- is coincident with the celestial equator, by definition.
- varies between +23.5º and -23.5º to the celestial equator, making an angle of 0º to the equator at midsummer and midwinter.
- remains fixed at an angle of 23.5º to the celestial equator.

Section 2-5

14. The Earth is closest to the Sun
- during winter in the southern hemisphere.
- during summer in the southern hemisphere.
- when the Sun is directly overhead at the equator.

Section 2-5

15. It is warmer in summer than in winter because

- the Sun is higher in the sky and the days are longer.
- the Earth is closer to the Sun.
- the Sun is lower in the sky and sunlight passes through a longer path in the atmosphere, thereby heating it more in summer.

Section 2-6

16. The Earth's rotation axis is tilted relative to the Earth's orbital plane, and the direction of this tilt wobbles, or precesses, cyclically with a period of
- one year, causing the seasons spring, summer, autumn, and winter.
- 24 hours, causing the sun to appear to rise, cross the celestial meridian, and set once each day.
- 26,000 years, causing the vernal equinox to change position along the celestial equator.

Section 2-6

17. The cause of the Earth's slow precession is the effect of the gravitational forces from the Sun and the Moon
- on the Earth's north and south poles, which are at different distances from the Sun or the Moon due to the tilt of the Earth's axis of rotation.
- on the equatorial bulge of the rotating Earth.
- on the Earth as a whole, as if all of the forces were applied at the center of the Earth.

Box 2-1

18. In astronomy, what does the term Right Ascension mean?
- The length of time since the object crossed the celestial meridian.
- The position of an astronomical object on the celestial sphere, as measured by lines perpendicular to the celestial equator (similar to lines of longitude on the Earth).
- The position of an astronomical object on the celestial sphere, as measured by lines parallel to the celestial equator (similar to lines of latitude on the Earth).

Section 2-6

19. The Right Ascension of the Sun on the first day of spring is
- 12^{hr}.
- slowly changing from year to year because of the precession of the Earth's rotation axis.
- 0^{hr}.

Section 2-6 and Box 2-1

20. What is the angle, measured in degrees, between two stars, one at Right Ascension = 4^{hr},

declination = 0° and the other at Right Ascension = 6^{hr}, declination = 0°?
- 120°
- 2°
- 30°

Section 2-6

21. As the Moon orbits around the Earth, its path on the celestial sphere
- is very close to the celestial equator.
- is very close to the path followed by the Sun (the ecliptic).
- is very close to a line of right ascension, passing close to each celestial pole once each orbit.

Section 2-7

22. The Sun is not a good timekeeper, and two of the following statements correctly give reasons for this. Which of these statements is NOT a correct reason?
- The Earth's equator is tilted relative to the Earth's orbital plane.
- The Earth's orbit is elliptical, causing the Earth's orbital speed to vary with time during the year.
- The Earth's rate of rotation, which determines the length of the day, varies with time.

Box 2-2

23. How long does it take the Earth to rotate once around its axis, compared to the distant stars?
- 23 hours, 56 minutes, and 4 seconds, measured in Coordinated Universal Time
- Exactly 24 hours, measured in Coordinated Universal Time, by definition
- 365 1/4 days

Section 2-7

24. Suppose that, on a particular night, the star Spica in the constellation Virgo rises at exactly 10:30 p.m., mean solar time. At what time will it rise one night later?
- 10:34 PM
- 10:26 PM
- 10:30 PM

Section 2-7

25. The meridian (or celestial meridian)
- passes directly overhead exactly once each day, for any given observer on the Earth.
- is always directly overhead for each observer, regardless of the time of day or night or the observer's position on the Earth.

- passes directly overhead only for observers on the line of longitude that passes through Greenwich, England.

Box 2-2

26. The difference between 1 second of sidereal time and 1 second of mean solar time is
- a very small but variable interval of time because of the variable motion of the Earth in its orbit.
- a very small but finite and fixed interval of time.
- zero, because they are defined as equal.

Section 2-8

27. What is a tropical year?
- The time for the Earth to orbit around the Sun exactly once, relative to the stars.
- The time from January 1 to the next January 1 (measured at midnight at the start of each January 1), and therefore variable because of leap years.
- The time from the start of one spring (the Sun precisely on the celestial equator, moving north) to the start of the next spring.

Section 2-8

28. If we were to measure the Sun's position in the sky very carefully, we might notice that the center of the Sun gradually shifts along the ecliptic, being exactly in line with a particular star at some point in time. How long will it be until the center of the Sun is exactly in line with this star again?
- One calendar year
- One tropical year
- One sidereal year

Section 2-8

29. Leap years, which contain one extra day, are needed in order to correct for the fact that
- the length of the day has changed since the calendar was devised by ancient Greeks because of the effect of the tides in slowing down the spin of the Earth.
- the Earth speeds up and slows down as it orbits around the Sun.
- 1 year is about 365.25 days long, instead of exactly 365 days.

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Section 3-1

1. The Moon shows different phases because
- it rotates slowly to reveal more or less of its illuminated hemisphere while remaining relatively fixed against the celestial sphere of stars.
- it moves slowly in and out of the Earth's shadow in its orbital motion around the Earth.
- we view the sunlit hemisphere of the Moon from different angles as the Moon orbits the Earth.

Section 3-1

2. At what time in its monthly cycle will the Moon be seen high in the sky in the daytime, from midlatitudes?
- Only when it is full
- Quarter Moon
- The Moon is never visible in the daytime.

Section 3-1

3. On a particular day, the Moon appears more than half illuminated, and on the following night it appears closer to being half-illuminated. What is the phase of the Moon?
- Waxing crescent
- Waxing gibbous
- Waning gibbous

Section 3-1

4. When does the new Moon rise, approximately?
- At midnight
- At sunset
- Close to sunrise

Section 3-1

5. Where in the sky will the full Moon appear at sunset, in the northern hemisphere?
- High in the southern sky
- Low in the eastern sky
- Low in the western sky

Section 3-2

6. If you were an astronaut on the Moon, in what position close to the Moon's equator would you have to stand in order to be in perpetual darkness?
- On the side of the Moon that faces away from the Sun.
- You cannot do this. There is nowhere near to the Moon's equator where you can be in perpetual darkness.
- On the side of the Moon that faces away from the Earth.

Section 3-2

7. Which of the following correctly describes the rotation of the Moon?
- The Moon rotates once per year in order to keep one face pointed toward the Sun, a necessary condition for us to see the Moon phases every month.
- The Moon rotates once per month to keep one face always toward the Earth.
- The Moon does not rotate at all around an axis because it always keeps one face toward the Earth.

Section 3-2

8. As the Moon orbits the Earth and we observe its phases, how fast does the terminator (the dividing line between illuminated and dark parts of the Moon) move across the lunar surface, in terms of angle of lunar longitude?
- The terminator will never move because the Moon does not rotate with respect to the Earth.
- 360 degrees in about 1 year, or about 1 degree per day.
- 360 degrees in about 1 month or about 12 degrees per day.

Section 3-2

9. Synchronous rotation of the Moon refers to the fact that the Moon
- rotates once upon its axis every lunar cycle, or every revolution around the Earth.
- rotates once upon its axis every year, or every revolution of the Earth-Moon system around the Sun.
- never rotates, with respect to the distant stars.

Section 3-2

10. What is the difference between a sidereal month and a synodic month?
- A sidereal month is one rotation of the Moon with respect to the stars, whereas a synodic month is one rotation of the Moon with respect to the Sun.
- A sidereal month is the actual rotation period of the Moon, whereas a synodic month is 1/12 of the length of a standard tropical year.
- A sidereal month is the period of rotation of the Moon as we actually see it (i.e., an "astronomical" month), whereas a synodic month is an average or "mean" month used to determine the dates of certain religious events.

Section 3-2

11. How long will a full lunar "day" last, from midday to midday, at any location on the Moon's equator?
- Infinite. The Sun will not appear to move in the sky, or rise and set, because the Moon does not rotate.
- 27.3 days, the actual period of rotation of the Moon on its axis.
- About 29.5 days because the Moon rotates once per orbit around the Earth.

Section 3-2

12. If you were camped on the Moon, how long would you be in daylight, from sunrise to sunset, during one lunar "day"?
- About 12 hours because the Moon rotates at the same rate as the Earth.
- About 14 days.
- If you were in daylight, then you would ALWAYS be in daylight because the Moon does not rotate with respect to the Sun.

Section 3-2

13. Astronauts have a great view of Earth as they land at a lunar base near the equator. How often will they see the Earth move over their lunar horizon during their stay on the Moon?
- The Earth will move slowly across their sky, completing an orbit in 1 year.
- The Earth will move across their sky with a period of about 1 month, the rotation period of the Moon.
- The Earth will remain stationary in their sky and therefore it will never cross their horizon.

Section 3-2

14. Astronauts at a lunar base near the crater Copernicus note that the Sun is high in their sky on March 1, 2020. When will it next reach this high position in their sky?
- The Sun will remain fixed at this position in the lunar sky because the Moon does not rotate with respect to the Sun.
- March 27, 2020, or 27.3 days after March 1.
- March 29, 2020, or 29.5 days after March 1.

Section 3-3

15. The plane of the ecliptic is
- a flat plane containing the Earth's orbit.
- a flat plane defined by the intersection of the Earth's orbit and the Moon's orbit.
- a flat plane containing the Moon's orbit.

Section 3-3

16. The reason eclipses do not occur at every new Moon and every full Moon is that
- the Moon's orbit is inclined at an angle to the Earth's orbit.
- the Earth's equator is inclined at an angle to the Earth's orbit.
- the Moon's orbit is inclined at an angle to the Earth's equator.

Section 3-3

17. During a particular eclipse, you find that the Sun is blotted out because the Moon comes between you and the Sun. This is an example of
- a lunar eclipse.
- a solar eclipse.
- a penumbral eclipse.

Section 3-4

18. Lunar eclipses occur
- about twice per year, when the Moon goes into the shadow of the Earth.
- every month, when the Moon moves into the Earth's shadow to produce the dark New Moon.
- about twice per year, when a specific part of the Earth is within the shadow of the Moon.

Section 3-4

19. Which of the following statements is true?
- A lunar eclipse occurs only at full Moon phase and can be seen from anywhere on the nighttime hemisphere of Earth.
- A lunar eclipse occurs only at full Moon and can be seen from within a narrow strip on the Earth's surface.
- A lunar eclipse occurs only at new Moon and can be seen from anywhere on the nighttime hemisphere of Earth.

Section 3-4

20. In the picture of a lunar eclipse in Figure 3-9 of Freedman and Kaufmann, *Universe*, 7th Ed., why is the fully eclipsed Moon reddish in color compared to the partly eclipsed Moon?
- Because the true reddish color of the Moon shows up only under this low level of illumination, the sunlight being bright enough at all other times to make the Moon appear white.
- Because the only sunlight that reaches the Moon at this time has passed through the Earth's atmosphere and this sunlight is reddened because the blue component has been scattered from it.
- Because the Moon becomes much colder during a total eclipse and the surface glows with a cooler light at this time.

Section 3-5

21. During a typical total solar eclipse, how big is the shadow of the Moon upon the Earth, from which no part of the solar disk is visible?
- Very small, with a typical diameter less than about 270 km.
- Very large, extending over the whole sunlit Earth, such that everyone on this side of Earth sees an eclipse.
- About as large as the Moon, with a diameter of about 3500 km.

Section 3-5

22. Why are some solar eclipses annular (with all but an annular ring of the Sun obscured) rather than total (the whole Sun obscured)?
- The Moon's orbit is elliptical and occasionally the Moon is too far away for the umbra of its shadow to reach the Earth's surface.
- The Earth is sometimes farther away from the Sun such that the Moon's angular diameter is less than that of the Sun at this time.
- The Moon's shadow passes just north or south of Earth, causing only an annular ring eclipse.

Section 3-6, Box 3-2

23. An "eclipse year" is
- the time between two successive alignments of the Sun, the Moon and line of nodes.
- the time between two solar eclipses, observed from the same location on the Earth.
- the time from when the line of nodes points toward the Sun to the time when the next identical alignment occurs.

Section 3-6

24. Who was the first person in history to measure the size of the Earth?
- The Italian astronomer Galileo.
- The Polish astronomer Copernicus.
- The ancient Greek astronomer Eratosthenes.

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Section 4-1

1. Which of the following concepts of the universe did the ancient Greek philosophers believe was correct?
- Sun-centered, with the Earth, Moon, planets and stars orbiting around a stationary Sun.
- Stationary, with the Sun, Moon, planets, and stars fixed in position, but appearing to move when viewed from a rotating Earth.
- Earth-centered, with the Sun, Moon, planets and stars orbiting around a stationary Earth.

Section 4-1 and Figure 4-2

2. As observed from Earth, the motion of a planet known as direct motion refers to
- a slow westward motion against the background stars.
- the motion directly toward the Earth at certain points of the planet's orbit.
- a slow eastward motion against the background stars.

Section 4-1

3. Of the following planets, which was known in Greek times?
- Uranus
- Mercury
- Neptune

Section 4-1

4. The very successful Ptolemaic model to describe and predict the apparent motions of the planets, assuming them to orbit the Earth, had the planets moving
- in ellipses, with their respective foci at the center of Earth.
- in circles around the Earth, the planes of which were precessing slowly around a direction perpendicular to the ecliptic plane.
- in small circles, the centers of which were moving around the Earth more slowly in larger circles.

Section 4-1

5. In the Greek model of planetary motion, a planet follows a small epicyclic motion as it moves around a circle while the center of this circle moves on a larger circle, the deferent. In what position is it when it appears to be in retrograde motion?
- The planet is exactly on the deferent, and is moving for a short while directly toward the Earth.
- The planet is farthest from the Earth.

- The planet is closest to the Earth.

Section 4-2

6. Who was the first person to propose that the Earth and all other planets orbit the Sun?
- A sixteenth-century Polish astronomer named Copernicus.
- An ancient Greek astronomer named Aristarchus.
- A seventeenth-century German astronomer named Kepler.

Section 4-2 and Figure 4-5

7. In the modern, heliocentric model of the solar system, the retrograde or "backward" westerly motion of a planet against the background stars is a consequence of
- our view of the planet from a rotating object, the Earth.
- our view of a Sun-orbiting object from a constantly moving viewpoint, the orbiting Earth.
- the speedup and slowdown of the planet as it moves in an elliptical orbit around the Sun.

Section 4-2 and Figure 4-6

8. What condition describes the position of greatest elongation for an inferior planet in our solar system?
- The angle between the Earth-Sun line and the planet-Sun line is 90º.
- The angle between the Earth-Sun line and the Earth-planet line is 90º.
- The angle between the Earth-planet line and the planet-Sun line is 90º.

Section 4-2 and Figure 4-6

9. When a planet is at conjunction, it will
- be at the farthest position from the Sun in the sky, as seen from the Earth.
- set at the same time as the Sun.
- rise as the Sun is setting.

Section 4-2 and Figure 4-6

10. When a planet is at superior conjunction,
- the Sun is between the Earth and the planet.
- the Earth is between the Sun and the planet.
- the planet is between the Earth and the Sun.

Section 4-2

11. Which one of the following objects passes through positions of greatest elongation as seen from the Earth?
- Mercury
- Mars
- The Moon

Section 4-2

12. At which position will Jupiter be seen at its highest in our sky at midnight?
- Opposition
- Greatest elongation
- Conjunction

Section 4-2

13. Suppose that on some particular day, the straight line from the Sun to the Earth continues on to pass through Mars and ultimately through some particular star in the sky. One synodic period later, Mars will be
- lined up again with the Earth and the star, but not with the Sun.
- lined up again with the Earth and the Sun, but not with the star.
- lined up again with the star and the Sun, but not with the Earth.

Section 4-2 and Box 4-1

14. The synodic period for a planet is different from its sidereal period because
- the planet's speed varies as it moves around the Sun in its orbit.
- the planet's orbital distance from the Sun is different from that of Earth from the Sun.
- the Earth (and hence the observer) moves.

Section 4-2 and Box 4-1

15. A space probe is placed in a circular orbit around the Sun, orbiting the Sun once every 10 months. Use one of the equations in Box 4-1 of *Universe*, Freedman and Kaufmann, 7th Ed., to calculate how often the probe passes between the Earth and the Sun.
- Once every 0.2 years (2 1/2 months)
- Once every 0.45 years (5 1/2 months)
- Once every 5 years

Section 4-3

16. Tycho Brahe's major contribution to the development of modern astronomy was
- a detailed and successful Earth-based model of the solar system.
- the detailed and precise measurement of the positions of stars and planets in our sky.

- the first telescope observations of the variation of apparent shapes and sizes of planets, particularly Venus and Mercury.

Section 4-4

17. The shape of the Earth's orbit around the Sun is
- elliptical, with the Sun at a point known as a focus of the ellipse.
- circular, as are the orbits of all other planets around the Sun.
- elliptical, with the Sun at the center of the ellipse.

Section 4-4

18. Which of the following methods could one use to demonstrate that the Earth's distance from the Sun varies as a consequence of its elliptical orbit?
- Measure the time between successive passages of a given star through your zenith.
- Measure the variation in the length of the shadow of a vertical pole produced by the Sun at midday throughout the year.
- Measure the angular size of the Sun during the year.

Section 4-4

19. An object orbiting the Sun with an orbital eccentricity of 0.1 has an orbit whose shape is
- slightly elliptical, but almost circular.
- a long, narrow ellipse.
- circular, but with the Sun off-center in the circle.

Section 4-4

20. A planet moving in an ellipse with the Sun at one focus will have a speed which is
- highest when it is farthest from the Sun.
- constant along the orbit, as required by Kepler's law.
- highest when it is closest to the Sun.

Section 4-4 and Figure 4-11

21. If you were to draw a straight line from the Sun to Mars and then watch this line as Mars moves along its orbit around the Sun, what would you see?
- The angle (measured in degrees) swept out by the line in one week would be the same in all parts of Mars's orbit.
- The length of the line (measured in kilometers) would be the same in all parts of Mars's orbit.
- The area swept out by the line in one week would be the same in all parts of Mars's orbit.

Section 4-4

22. Kepler's laws
- apply only to large planets orbiting our Sun, but provide only an approximate description for smaller objects, such as asteroids, etc. and are not applicable at all for other situations such as mutually orbiting binary stars.
- apply for all objects orbiting the Sun, such as planets, comets, asteroids and man-made space probes, but do not hold for objects orbiting any other object in the universe.
- can be shown to apply universally, whenever two objects orbit each other under gravitational attraction.

Section 4-4 and Box 4-2

23. A solar observatory has been put into space, orbiting the Sun in a circular orbit once every 10 months. Use one of the equations in Box 4-2 of *Universe*, Freedman and Kaufmann, 7th Ed., to calculate how far the satellite is from the Sun (i.e., the radius of the satellite's orbit).
- 0.886 AU
- 0.833 AU
- 0.694 AU

Section 4-4

24. According to Kepler's third law, an asteroid orbiting the Sun in a circular orbit at twice the Earth's distance from the Sun would have a sidereal period of
- 2.8 years.
- 4.0 years.
- 8.0 years.

Section 4-5

25. Who was the first person to prove through direct astronomical observations that planets moved around the Sun, rather than around the Earth as the ancient Greeks believed?
- Isaac Newton
- Galileo
- Kepler

Section 4-5

26. Which of the "phases" of Venus first seen by Galileo with his telescope, equivalent to those of the Moon, convinced him that Venus orbited the Sun rather than the Earth?
- New Moon, or dark phase
- Gibbous phase
- Crescent phase

Section 4-5

27. Galileo observed four moons orbiting Jupiter. In which way did this observation contradict Greek dogma about the universe, to incur the wrath of the established church, which believed and taught the Greek idea?
- This observation showed that there were objects that did NOT orbit the Earth, contrary to the Greek model.
- This observation showed that there were objects that did not orbit the Sun, as required by the Greek model.
- This observation showed that planets other than the Earth had a moon or moons, contrary to Greek belief.

Section 4-6

28. Newton's first law of motion, that "a body remains at rest, or moves in a straight line at a constant speed, unless acted upon by a net outside force" appears to be contradicted by everyday experience. Why is this?
- The force of friction almost always acts on any moving object on the Earth, supplying an unbalanced force that slows the object down.
- Gravity always acts on objects on the Earth, supplying an out-of-balance force that slows down any object moving across the Earth's surface.
- The Earth rotates, and this rotational motion significantly affects the motion of objects across the surface of the Earth.

Section 4-6

29. A dog team is pulling a sled northward over the snow at a constant speed. Which one of the following statements about the net force on the sled is correct?
- The net force on the sled is directed forward, through the dogs.
- The net force on the sled is zero.
- The net force on the sled is directed at an angle downward, ahead of the sled, being made up of a forward force by the dogs plus a downward force by gravity.

Section 4-6

30. What is acceleration?
- The change in an object's velocity in one second.
- The change in an object's position in one second.
- The total force on an object.

Section 4-6

31. Which of the following objects is NOT accelerating?
- A person standing on scales, weighing himself.
- The Moon moving around in its orbit.

◯ An apple falling toward the ground in the Earth's gravitational field.

Section 4-6

32. Which of the following three objects or persons is NOT accelerating?
◯ A water skier slowing down while moving in a straight line after letting go of the tow line.
◯ A skydiver falling in a straight line at a constant speed (i.e., at "terminal speed").
◯ A racecar traveling at constant speed around a circular track.

Section 4-6

33. An astronaut exerts a certain force on a satellite to accelerate it away from the Space Shuttle. She then exerts the SAME force on another satellite that has twice the mass of the first satellite. How does the acceleration of the second (more massive) satellite compare to that of the first satellite?
◯ The two satellites have exactly the same acceleration because the forces are the same.
◯ The more massive satellite has half the acceleration of the lighter satellite.
◯ The more massive satellite has twice the acceleration of the lighter satellite.

Section 4-6

34. A person is pushing (and slightly squashing) a basketball against a wall. According to Newton's Third Law, the reaction force for the force that the hand exerts on the basketball is
◯ the force that the basketball exerts on the wall.
◯ the force that the wall exerts on the basketball.
◯ the force that the basketball exerts on the hand.

Section 4-6

35. A moose is standing at rest upon a rock. The weight of the moose is the force of gravity pulling downward on the moose, and the rock is pushing up on the moose with a force that is equal and opposite to this weight. This is an example of
◯ Newton's third law.
◯ None of Newton's laws.
◯ Newton's second law.

Section 4-7

36. In which of the following situations is the gravitational force from the Earth on 1 kg of matter equal to zero?
◯ 1 kg of matter at the center of Earth
◯ A 1 kg mass orbiting in the Space Shuttle
◯ A 1 kg mass at rest on a smooth surface of ice on Earth

Section 4-7

37. If a comet approaches and then recedes from the Sun in a parabolic orbit, it will
◯ return toward the Sun after anything from a few years to millions of years or even never, depending on the size of the orbit.
◯ return toward the Sun only after several thousand years.
◯ never again return toward the Sun.

Section 4-7

38. Which of the following masses would feel the greatest gravitational force from the Earth?
◯ 450 kg, at a distance of 3 Earth radii from the Earth's surface, or 4 radii (25,400 km) from its center.
◯ 150 kg on the surface of Earth, 6400 km from its center.
◯ 300 kg, at a distance of 1 Earth radius above the Earth's surface, or 2 radii (12,800 km) from the center of the Earth.

Section 4-7

39. If there is a force of gravity from the Earth on an artificial satellite of mass 1000 kg, what is the size of the force exerted on the Earth by the satellite?
◯ Essentially zero because the satellite's mass is negligible compared to that of the Earth.
◯ Much larger than that on the satellite because the Earth's mass is so large.
◯ Exactly the same as the force on the satellite.

Section 4-7

40. A wheelbarrow of mass M kg was transported to the Moon during an Apollo mission. Its weight on the Earth was W. Which of the following conditions is found to hold on the surface of the Moon?

◯ Mass and weight of the wheelbarrow are reduced by the same fraction, to 1/6 of their values on Earth.
◯ The mass of the wheelbarrow remains the same, but its weight on the Moon is less.
◯ The mass of the wheelbarrow remains the same while weight is found to be zero because the wheelbarrow is at a large distance from the center of the Earth.

Section 4-7

41. How many forces are acting on the space shuttle when it is in a circular orbit around the Earth? (Ignore forces from very distant objects, such as the Sun and Moon.)
◯ One force, acting outward (away from the Earth) to keep the Shuttle from falling.
◯ Equal and opposite forces acting toward and away from the Earth, so that the shuttle always

remains the same distance above the Earth's surface.
- One force, acting toward the center of the Earth.

Section 4-7

42. Halley's Comet is named after Edmund Halley. Why?
- Edmund Halley discovered the comet on Christmas Day (Isaac Newton's birthday).
- Halley used the comet as a test of Newton's law of gravitation.
- Isaac Newton used the newly discovered comet to illustrate his theory of gravitation, and named it after his friend Edmund Halley.

Section 4-7

43. Which planet was predicted to exist mathematically, using Newton's theory of gravitation combined with careful observations of the motion of another planet, before it was discovered observationally?
- Neptune
- Uranus
- Vulcan

Section 4-8

44. The tides produced in the Earth's oceans by the Moon show which of the following patterns?
- Two high and two low tides per month
- One high and one low tide per day
- Two high and two low tides per day

Section 4-8

45. The Moon is not the only object to exert a tidal force on the Earth. The Sun does so also. How strong is the tidal force exerted on the Earth by the Sun compared to that exerted by the Moon?
- Less than 1/10 as strong because the Sun is so far away.
- Eight times as strong, because the Sun is much more massive than the Moon.
- Half as strong because the Sun's large mass partly compensates for its greater distance from the Earth.

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Section 5-1

1. The first person to prove that light did not travel at infinite speed was
- Galileo Galilei.
- Olaus Rømer.
- Albert Einstein.

Section 5-1

2. In Galileo's attempt to measure the speed of light by timing the passage of flashes of light between adjacent hilltops, what would have been the light travel time between him and his assistant if the hills had been 3 km apart? (His assistant's reaction time would have had to have been much less than this time interval for this experiment to have been successful!)
- 10^{-8} second or 10 ns
- 10^{-5} second or 10 μs
- 10^{-2} second or 10 ms

Section 5-1

3. A flash of light is transmitted simultaneously through two parallel tubes of length 1 km, one evacuated, the other filled with water. Detectors sense the arrival times of the light flash at the ends of these tubes. What will be the relationship between arrival times of these light flashes?
- The flashes of light will arrive simultaneously at the ends of the tubes because light always travels at the same speed.
- The flash will arrive earlier through the water-filled tube.
- The flash will arrive earlier through the evacuated tube.

Section 5-2

4. An electrically charged object moving at a constant speed in a straight line is found to generate
- an oscillating electric field, part of a moving electromagnetic wave.
- a magnetic field.
- a gravitational field.

Section 5-2

5. What limitation is placed upon the possible wavelengths of electromagnetic radiation by Maxwell's equations, which govern the behavior of this type of radiation?
- There are no wavelength limits, either long or short.
- Wavelengths are limited to those shorter than radio waves of about 1 meter in length.

- Wavelengths are limited to those around that of visible light, roughly from ultraviolet to infrared radiation. All other radiations (e.g., X rays, radio) are NOT true electromagnetic radiation.

Section 5-2

6. The frequency associated with blue light compared to that of red light is
- the same because both red and blue are part of the visible light spectrum.
- lower.
- higher.

Section 5-3

7. If an object is a perfect blackbody then
- it emits no energy.
- it emits energy only at certain well-defined wavelengths called spectral lines.
- it emits energy with a continuous distribution that peaks at a certain wavelength dependent upon temperature.

Section 5-3

8. A perfect blackbody is so-called by scientists because
- the shape of the spectrum of energy emitted by it has a fixed shape independent of temperature and only the emitted intensity at each wavelength changes with the black-body's temperature.
- it absorbs all energy falling upon it and emits a characteristic spectrum of radiation whose intensity as a function of wavelength depends only on its temperature.
- it absorbs all energy falling upon it and emits no energy at all, hence its name.

Section 5-3

9. A blacksmith heats a piece of steel until the wavelength of maximum emission of radiation is measured to be 1 μm, in the infrared part of the spectrum. How would he have to change its temperature in order that this peak wavelength would move to 0.5 μm, or 500 nm in the visible spectral range?
- He would have to cool the steel to half its temperature.
- He would have to raise the temperature by a factor of 2^4, or 16.
- He would have to double its temperature.

Section 5-4

10. As an asteroid moves out into deep space after coming close to the Sun, the peak wavelength of its emitted electromagnetic radiation will
- move from infrared toward visible wavelengths as the asteroid cools.

- increase, from infrared toward microwave wavelengths.
- not change at all: intensity of radiation at all wavelengths will decrease with no change in the peak wavelength because the asteroid behaves like a black body.

Section 5-4

11. The energy emitted per second by the Sun is greatest at a wavelength of about 500 nm. The energy emitted per second by a star having half the temperature of the Sun would be greatest at a wavelength of about

- 1000 nm, in the infrared.
- 250 nm, in the near UV.
- 8000 nm, in the infrared range, (16 times 500 nm).

Section 5-4

12. Suppose the Sun had a temperature of 17,400 K (three times its present temperature), but had the same size that it has now. How much more energy would the Sun emit per second?

- 81 times more
- 9 times more
- 3 times more

Section 5-5

13. Suppose a light source is emitting red light at a wavelength of 700 nm and another light source is emitting ultraviolet light at a wavelength of 350 nm. Each photon of the ultraviolet light has

- either more OR less energy than each photon of the red light, depending on the intensities of the two light sources.
- half the energy of each photon of the red light.
- twice the energy of each photon of the red light.

Section 5-5

14. The ratio of the energy of a photon of X rays of wavelength 0.05 nm to that of a photon of visible light of wavelength 500 nm is

- 1. Photons of electromagnetic radiation all have the same energy, but more photons per second are emitted by an X-ray source than by a visible light source.
- 10,000.
- 1/10,000.

Section 5-5

15. The photoelectric effect is

- the change in the direction of a beam of electromagnetic radiation as it enters a transparent medium, such as glass.
- the emission of electrons from a metal surface when it is illuminated by light.
- the darkening of certain types of glass when exposed to sunlight.

Section 5-5

16. The first person to show that light traveled in wave packets, or photons, in which the energy of a photon depends on its wavelength, was

- Thomas Young.
- James Clerk Maxwell.
- Albert Einstein.

Section 5-5

17. In a beam of radiation from a blackbody, the amounts of energy per second at an ultraviolet wavelength of 300 nm and at an infrared wavelength of 800 nm are found to be equal. In this beam, how do the numbers of photons per second at each of these wavelengths compare?

- There will be equal numbers of photons at each of these wavelengths.
- There will be more IR photons than UV photons.
- There will be more UV photons than IR photons.

Section 5-6

18. Spectral lines were first discovered

- by Balmer, by passing an electric current through rarified hydrogen gas and splitting the resulting light into colors using a prism.
- by Fraunhofer, by a close examination of the spectrum of the Sun using a prism to spread out this spectrum.
- by Kirchhoff, by dropping chemicals in the form of powder into a very hot flame and looking at the resulting light through a prism.

Section 5-6

19. The presence of dark lines in the solar spectrum, the so-called Fraunhofer lines, means that

- interplanetary gases have absorbed light at specific wavelengths.
- a cooler layer of gas overlies the deeper, hotter layers of the solar atmosphere.
- a hotter layer of gas overlies the cooler layers of the solar atmosphere.

Section 5-6

20. A hot, dense gas produces

- a continuous spectrum, with energy emitted at every wavelength.

- an emission-line spectrum, with bright lines against a dark background.
- an absorption-line spectrum, with dark lines against a bright background.

Section 5-6

21. When heated in a flame, small quantities of different chemical elements emit light only at specific wavelengths called "spectral line" emissions. The pattern of these emission lines as a function of wavelength is

- the same for all elements except that one line, a different line for each element, is missing from the sequence
- characteristic for each element, but differs from element to element.
- the same for all elements, but with different relative line intensities for different elements.

Section 5-7

22. The person who first showed that most of the mass of an atom is concentrated in a very small volume at the center of the atom was

- Kirchhoff.
- Bohr.
- Rutherford.

Section 5-7, Box 5-5

23. Elements that have similar chemical properties in the periodic table of elements

- occupy a small block of adjacent rows and columns.
- are in a single vertical column.
- are in a single horizontal row.

Section 5-7, Box 5-5

24. Two isotopes of an element differ from one another because

- they have the same number of protons but different numbers of neutrons in their nuclei.
- the sum of neutrons and protons in their nuclei is the same but one isotope has one extra neutron and one less proton while the second isotope has one more neutron and one less proton.
- they have the same number of neutrons but different numbers of protons in their nuclei.

Sections 5-7 and 5-8

25. An atom of singly ionized magnesium has 12 protons in its nucleus. How many electrons surround this nucleus?

- 13
- 11
- 12

Section 5-7

26. An electron is added to a completely ionized hydrogen atom to make it electrically neutral. How much extra mass is added to the atom in this process, expressed as a fraction of the final mass?

- 5%
- 0.05%
- 1%

Section 5-7, Box 5-5

27. A neutron is combined in a nuclear reaction with a proton to make a heavy hydrogen nucleus. This nucleus then acquires sufficient electrons to become electrically neutral. How many electrons will this heavy hydrogen atom contain?

- 2
- 1
- None. Because the neutron-proton combination is already neutral.

Section 5-7, Box 5-5

28. Tritium is a radioactive form of hydrogen in which the nucleus contains one proton and two neutrons. How much more massive is this nucleus than that of ordinary hydrogen?

- The same mass because this is still a hydrogen nucleus
- Three times as massive
- Twice as massive

Section 5-7, Box 5-5

29. The metal, nickel (Ni) occupies position number 28 in the periodic table. How many electrons will need to be removed from a neutral nickel atom to completely ionize it, leaving only a nucleus?

- 1
- 27
- 28

Section 5-8

30. In order to produce the primary H-alpha (H_α) Balmer spectral line in emission, an electron must jump between which two energy levels in the hydrogen atom?

- From n = 2 to n = 1, the ground state
- From n = 3 to n = 2
- From n = 3 to n = 1, the ground state

Section 5-8

31. In a hydrogen atom, if an electron jumps from the n = 3 energy level to the n = 5 energy level, the result will be

- an absorption line in the infrared.
- an emission line in the ultraviolet.
- an absorption line in the visible part of the spectrum.

Section 5-9

32. When a source of light is moving away from the observer, the wavelength of the detected light is shifted with respect to the emitted or rest wavelength. The size of this shift in wavelength is described by the Doppler Effect, and is equal to

- the ratio of the speed of the source to the speed of light.
- the product of the rest wavelength times the speed of the source.
- the value of the rest wavelength times the ratio of the source speed to the speed of light.

Section 5-9

33. A star is found to be moving across our sky at a small fraction of the speed of light, in a direction at right angles to the line from the star to the Earth. The Doppler shift of the spectrum of the light from this star is

- zero for all wavelengths because the star is moving perpendicular to the line of sight.
- small because the star's speed is small, but it is not zero. The shift is greater for red light than for blue light.
- small, but not zero, and greater for the more energetic blue photons than for the less energetic red photons.

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