CHAPTER 1

Why Learn Astronomy?

CONCEPT MAP

Sec 1.1

1. Astronomy
    I. Definition
        i. *Astronomy* loosely translated means “patterns among the stars” (MC: 1)
    II. Your Place in the Universe
        i. Your address: street, city, town, country, Earth, Sun, Milky Way, Local Group, Virgo Supercluster, universe (MC: 3, SA: 1)
        ii. Solar System: classical versus dwarf planets (TF: 1, 2, MC: 1–4, 7, SA: 2)
        iii. Milky Way: contains 200 to 400 billion stars (MC: 3, 5–7)
        iv. Local Group (MC: 3, 8)
        v. Virgo Supercluster (TF: 3, MC: 3)
        vi. Universe: contains hundreds of billions of galaxies, roughly as many stars as in the Milky Way (TF: 4)
        vii. Much of the universe is made of dark matter, and all of space is permeated by dark energy (TF: 5, MC: 9, 10)
    III. Scale of the Universe
        i. Speed of light, $c \approx 3 \times 10^8$ m/s (MC: 11)
        ii. $d = v \times t$ (TF: 2, MC: 12–17)
        iii. Light year is a measure of distance (TF: 6, MC: 12, SA: 3)
        iv. Distance versus time comparison: circumference of the Earth versus snapping your fingers (MC: 19, 20, SA: 4–6)
    IV. Origin and Evolution of Universe
        i. Age of universe: 13.7 billion years (MC: 21)
        ii. Big Bang created the initial chemical elements: H, He, Li, Be, B (TF: 7, MC: 22, 23)

iii. Stars manufactured the other chemical elements from nuclear burning and explosions (TF: 7, 8, MC: 24, 25, SA: 7)
iv. Solar System formed
v. Life evolved on Earth

Sec 1.2

2. Science Involves Exploration and Discovery

I. Evolution of Astronomy from New Technology

i. Satellites, e.g., Sputnik, lunar exploration, Solar System exploration (TF: 10, MC: 26, SA: 8, 9)
ii. Space-based astronomy used for high spatial resolution and access to wavelengths blocked by the atmosphere (TF: 10, MC: 27, SA: 9, 10)
iii. Cross disciplines: astronomy, physics, chemistry, geology, planetary science
iv. Computers: a new important tool for astronomers (SA: 9)

Sec 1.3

3. Science Is a Way of Viewing the World

I. Scientific Method

i. Scientific method (MC: 28, 29, SA: 11)
ii. Rational inquiry
iii. Facts
iv. Hypothesis (MC: 28, 30, SA: 11)
v. Theory (MC: 28, 30, SA: 12)
vi. Testable predictions/falsifiable (TF: 10, 11, MC: 28, SA: 11)
vii. Physical laws
viii. Scientific principle
ix. Occam's razor (MC: 31, 32)
x. Cosmological principle (TF: 12, MC: 33, 34, SA: 13, 14)

II. Scientific Knowledge Changes and Evolves

i. Scientific knowledge continually evolves, usually slowly and gradually, because of new information (MC: 28)
ii. Even when a theory is accepted as true, it may need revision later when new data comes along (TF: 14, MC: 28, 35, SA; 12)
iii. *Scientific revolutions*: e.g. Newton/gravity, Einstein/special and general relativity, and quantum mechanics (MC: 36, SA: 15)

iv. “Modern Physics,” post-quantum mechanics

III. Challenges to Science

i. Cultural/philosophical/religious influences

ii. Scientific facts and theories need to be judged based on their predictions and observations alone

iii. Scientists never ignore data just because it doesn’t fit their theory

Sec 1.4

4. Patterns Make Our Lives and Science Possible

I. Patterns Point Out Underlying Scientific Principles

i. Patterns point out underlying scientific principles (TF: 15, MC: 37, SA: 16, 17)

ii. Examples of patterns: rise/setting of Sun, seasons (MC: 38, SA: 16, 17)

II. Mathematical Tools

i. Mathematics is the “language of science,” a tool to quantify and compare patterns (MC: 39, SA: 18)

ii. Scientific notation (MC: 40–43)

iii. Ratios and proportionalities (MC: 44–49)

iv. Units (MC: 50, 51)

v. Reading a graph (MC: 52)

vi. Slope of a line (MC: 53)

Sec 1.5

5. Thinking Like an Astronomer

I. What Is a Planet?

i. Pluto was reclassified as a dwarf planet in 2006 (TF: 2, MC: 54–56, SA: 19)

Sec 1.6

6. Origins: An Introduction

I. Astrobiology

i. Astrobiology: study of whether there is life elsewhere in the Solar System and the universe (MC: 57, SA: 20)

TRUE/FALSE

1. Our Sun is one of the most massive and luminous stars in the Milky Way.

ANS: F DIF: Easy REF: Section 1.1 MSC: Factual TOP: 1IIii

2. Pluto is the only dwarf planet in our Solar System.

   ANS: F DIF: Easy REF: Section 1.1 MSC: Factual TOP: 1IIii | 5Ii

3. The Local Group is a member of the Virgo Supercluster.

   ANS: T DIF: Medium REF: Section 1.1 MSC: Factual TOP: 1IIiv | 1IIv

4. There are nearly 1,000 times more galaxies in the observable universe as there are stars in the Milky Way.

   ANS: F DIF: Medium REF: Section 1.1 MSC: Factual TOP: 1IIvi

5. A great majority of the matter in our universe is not visible.

   ANS: T DIF: Easy REF: Section 1.1 MSC: Factual TOP: 1IIvii

6. A light-year is a unit commonly used in astronomy as a measure of time.

   ANS: F DIF: Easy REF: Section 1.1 MSC: Factual TOP: 1IIIiii

7. Human beings are composed almost entirely of elements that were created in the Big Bang.

   ANS: F DIF: Medium REF: Section 1.1 MSC: Applied TOP: 1IVii | 1IViii

8. The heavy elements that make up most of Earth were formed via nuclear fusion in the center of the Sun.

   ANS: F DIF: Easy REF: Section 1.1 MSC: Factual TOP: 1IViii

9. The invention of satellites advanced astronomy because telescopes on satellites can observe wavelengths of electromagnetic radiation, such as X-rays, that cannot penetrate the Earth’s atmosphere.

   ANS: T DIF: Easy REF: Section 1.2 MSC: Factual TOP: 2Iii | 2Iiii

10. If a scientific theory cannot be tested, it is assumed to be true.

    ANS: F DIF: Easy REF: Section 1.3 MSC: Conceptual TOP: 3Ivi

11. A crucial component of a scientific theory is that it is able to be tested by observations and thus proven true or false.

    ANS: T DIF: Easy REF: Section 1.3 MSC: Conceptual TOP: 3Ivi

12. The Copernican principle states that there is nothing special about our local region of the universe.

    ANS: T DIF: Easy REF: Section 1.3 MSC: Conceptual TOP: 3Ix

13. One consequence of the principle of universality is that gravity works the same here on Earth as it does on the planet Jupiter.

    ANS: T DIF: Medium REF: Section 1.3 MSC: Conceptual TOP: 3Ix

14. Once a scientific theory is declared to be true, it is believed from that time onward.

    ANS: F DIF: Medium REF: Section 1.3 MSC: Conceptual TOP: 3IIii

15. Science proceeds by presuming that observed patterns in nature can be attributed to an underlying physical explanation.

    ANS: T DIF: Easy REF: Section 1.4 MSC: Factual TOP: 4Ii

MULTIPLE CHOICE

1. The word *astronomy* means:
   a. “patterns among the stars”
   b. “to study the stars”
   c. “discovering the universe”
   d. “the movement of the stars”
   e. “personality traits set by the stars”

   ANS: A DIF: Easy REF: Section 1.1 MSC: Factual TOP: 1Ii

2. According to the figure below, if you were to specify your address in the universe, listing your membership from the smallest to largest physical structures, it would be:

a. Earth, Local Group, Solar System, Andromeda, the universe
b. Earth, Solar System, Local Group, Milky Way, the universe
c. Earth, Solar System, Milky Way, Local Group, Virgo Supercluster, the universe
d. Earth, Solar System, Milky Way, Fornax Supercluster, the universe
e. Earth, Fornax Supercluster, Milky Way, Solar System, the universe

ANS: C DIF: Difficult REF: Section 1.1 MSC: Factual TOP: 1IIi | 1IIv

3. Which of the following is FALSE?
   a. The Local Group is a member of the Virgo Supercluster, which contains thousands of galaxies.
   b. The Local Group contains two large spiral galaxies and a few dozen dwarf galaxies.
   c. Our Solar System has eight classical planets.
   d. The Milky Way galaxy contains approximately 100 million stars.
   e. The Virgo Supercluster is one of many superclusters in the universe

   ANS: D DIF: Difficult REF: Section 1.1 MSC: Factual TOP: 1IIii | 1IIiii | 1IIiv | 1IIv

4. The number of classical planets in our Solar System is:
   a. eight
   b. nine
   c. twelve
   d. six
   e. four

   ANS: A DIF: Easy REF: Section 1.1 MSC: Factual TOP: 1IIii

5. According to the figure below, the Earth is located approximately:

   a. at the center of the Milky Way
   b. near the center of the Milky Way
   c. about halfway out from the center of the Milky Way
   d. at the farthest outskirts of the Milky Way
   e. outside the Milky Way, which is why we can see it as a band across the night sky

   ANS: C DIF: Easy REF: Section 1.1 MSC: Applied TOP: 1IIiii

6. What is the approximate number of stars in the Milky Way?
   a. 10 million
   b. 300 million
   c. 10 billion
   d. 300 billion
   e. 1 trillion

   ANS: D DIF: Medium REF: Section 1.1 MSC: Factual TOP: 1IIiii

7. If the diameter of the Milky Way is approximately 100,000 light-years, then our galaxy is _____ times larger than our Solar System. For reference, Pluto's orbit has an approximate diameter of 80 AU.
   a. 100
   b. 1,000
   c. 10,000
   d. 10^6
   e. 10^8

   ANS: E DIF: Difficult REF: Section 1.1 MSC: Applied TOP: 1IIiii

8. The Local Group is the environment around:
   a. the Earth-Moon system
   b. the Sun that contains about a dozen stars
   c. the Sun that contains over a million stars
   d. the Milky Way that contains a few dozen galaxies
   e. the Milky Way that contains a few thousand galaxies

   ANS: D DIF: Medium REF: Section 1.1 MSC: Factual TOP: 1IIiv

9. The majority of the mass in our universe is made up of:
   a. planets
   b. stars
   c. galaxies
   d. dust
   e. dark matter

   ANS: E DIF: Medium REF: Section 1.1 MSC: Factual TOP: 1IIvii

10. The majority of the energy in our universe is:
    a. radiated by stars from the nuclear fusion going on in their cores
    b. the kinetic energy found in the collisions of galaxies
    c. the gravitational potential energy of superclusters
    d. emitted in radioactive decays of unstable elements
    e. made up of dark energy that permeates space

    ANS: E DIF: Difficult REF: Section 1.1 MSC: Factual TOP: 1IIvii

11. The speed of light is approximately:
    a. 3,000 km/s
    b. 30,000 km/s
    c. 300,000 km/s
    d. 3 million km/s
    e. 3 billion km/s

    ANS: C DIF: Medium REF: Section 1.1 MSC: Factual TOP: 1IIIi

12. The average distance between the Earth and Sun is 1.5 □ 10^{11} m, and light from the Sun takes approximately _____ to reach Earth.
    a. 8 seconds
    b. 8 minutes
    c. 8 hours
    d. 8 days
    e. 8 years

    ANS: B DIF: Easy REF: Section 1.1 MSC: Applied TOP: 1IIIii

13. If an event were to take place on the Sun, how long would it take for the light it generates to reach us?
    a. 8 minutes
    b. 11 hours
    c. 1 second
    d. 1 day
    e. It would reach us instantaneously.

    ANS: A DIF: Medium REF: Section 1.1 MSC: Applied TOP: 1IIIii

14. After the Sun, the next nearest star to us is approximately _____ away.
    a. 8 light-seconds
    b. 80 light-minutes
    c. 40 light-hours
    d. 4 light-years
    e. 200 light-years

    ANS: D DIF: Difficult REF: Section 1.1 MSC: Factual TOP: 1IIIii

15. One of the nearest stars is Alpha Centauri, whose distance is 4.2×10^{16} m. How long does it take light to travel from Alpha Centauri to us?
    a. 1.25 seconds
    b. 8.3 minutes
    c. 4.4 years
    d. 560 years
    e. 6,200 years

    ANS: C DIF: Medium REF: Section: 1.1 MSC: Applied TOP: 1IIIii

16. The distance to the nearest large spiral galaxy, the Andromeda galaxy, is 2.4×10^{22} m. How long does it take light to travel from Andromeda to us?
    a. 4.4 years
    b. 360 years
    c. 1.2 thousand years
    d. 2.5 million years
    e. 4.5 billion years

    ANS: D DIF: Medium REF: Section 1.1 MSC: Applied TOP: 1IIIii

17. The distance to the center of the Virgo cluster of galaxies is 5×10^{23} m. How long does it take light to travel from these galaxies to us?
    a. 7,000 years
    b. 54,000 years
    c. 120,000 years
    d. 12 million years
    e. 54 million years

    ANS: E DIF: Medium REF: Section 1.1 MSC: Applied TOP: 1IIIii

18. A light-year is a unit commonly used in astronomy as a measure of:
    a. time
    b. speed
    c. mass
    d. distance
    e. acceleration

    ANS: D DIF: Medium REF: Section 1.1 MSC: Factual TOP: 1IIIiii

19. The figure below measures distances in the amount of time it takes light to travel. If the circumference of Earth is a snap of your fingers (1/7 sec), the diameter of the Solar System is approximately equal to:

    a. the length of a quick lunch
    b. the time to turn a page in a book
    c. the length of the work day
    d. the time you spent in high school
    e. a human lifetime

    ANS: C DIF: Difficult REF: Section 1.1 MSC: Applied TOP: 1IIIiv

20. If you compared the diameter of the Earth, which is 13,000 km, to 1 second, then what unit of time would be equivalent to the size of the Milky Way, whose diameter is 10^{21} m, and what significant milestone would this time correspond to in our evolution?
    a. 2 million years, the length of time humans have existed on Earth
    b. 30,000 years, the length of time humans have lived in North America
    c. 400 years, the length of time humans have been exploring the skies with telescopes
    d. 4 billion years, the age of the Solar System
    e. 14 billion years, the age of the universe

    ANS: A DIF: Difficult REF: Section 1.1 MSC: Applied TOP: 1IIIiv

21. Our universe is approximately 13.7 _____ years old.
    a. million
    b. billion
    c. trillion
    d. thousand
    e. hundred

    ANS: B DIF: Easy REF: Section 1.1 MSC: Factual TOP: 1IVi

22. The early universe was composed mainly of which two elements?
    a. hydrogen and helium
    b. carbon and oxygen
    c. hydrogen and oxygen
    d. carbon and iron
    e. nitrogen and oxygen

    ANS: A DIF: Easy REF: Section 1.1 MSC: Factual TOP: 1IVii

23. Which presently observed element or isotope was NOT produced in appreciable amounts in the very early universe shortly after the Big Bang?
    a. hydrogen
    b. helium-4
    c. deuterium
    d. carbon
    e. helium-3

    ANS: D DIF: Medium REF: Section 1.1 MSC: Factual TOP: 1IVii

24. Which is an important element in the composition of your body that was produced by nuclear fusion inside a star or an explosion of a star?
    a. iron
    b. calcium
    c. oxygen
    d. carbon
    e. all of the above

    ANS: E DIF: Easy REF: Section 1.1 MSC: Factual TOP: 1IViii

25. The most massive elements such as those that make up terrestrial planets like Earth were formed:
    a. in the early universe
    b. inside stars and supernovae
    c. through meteor collisions
    d. in the core of Earth
    e. during the formation of the Solar System

    ANS: B DIF: Medium REF: Section 1.1 MSC: Factual TOP: 1IViii

26. An unmanned robotic spacecraft has NOT landed on:
    a. an asteroid
    b. Mars
    c. Venus
    d. Pluto
    e. Titan, Saturn's largest moon

    ANS: D DIF: Medium REF: Section 1.2 MSC: Factual TOP: 2Ii

27. Which is NOT an advantage of placing telescopes in space? From space, a telescope:
    a. has better access to high energy radiation such as ultraviolet light and X-rays
    b. has better access to low energy radiation such as infrared and microwave radiation
    c. avoids the blurring of images caused by the Earth's atmosphere
    d. avoids light pollution from big cities
    e. is closer to the objects being observed

    ANS: E DIF: Easy REF: Section 1.2 MSC: Applied TOP: 2Iii

28. Which of the following is FALSE?
    a. A scientific theory is an undisputed fact.
    b. If continual testing of a hypothesis shows it to be valid, it may become an accepted theory.
    c. A hypothesis must always have one or more testable predictions.
    d. A scientific theory may eventually be proven wrong when scientists acquire new data.
    e. Scientific observations are used to test a hypothesis.

    ANS: A DIF: Medium REF: Section 1.3 MSC: Conceptual TOP: 3Ii | 3Iiv | 3Iv | 3Ivi | 3IIi | 3IIii

29. The scientific method is a process by which scientists:
    a. prove theories to be known facts
    b. gain confidence in theories by failing to prove them wrong
    c. show all theories to be wrong
    d. test the ideas of Aristotle
    e. survey what the majority of people think about a theory

    ANS: B DIF: Medium REF: Section 1.3 MSC: Applied TOP: 3Ii

30. A _____ becomes a _____ when repeated testing of its predictions does not disprove it.
    a. hypothesis; scientific method
    b. theory; scientific revolution
    c. phenomenon; theory
    d. hypothesis; theory
    e. law; theory

    ANS: D DIF: Medium REF: Section 1.3 MSC: Applied TOP: 3Iiv | 3Iv

31. _____ is the idea that the simplest explanation for a phenomenon is usually the correct one.
    a. Newton’s hypothesis
    b. Occam’s razor
    c. Aristotle’s test
    d. Einstein’s excuse
    e. The Copernican principle

    ANS: B DIF: Difficult REF: Section 1.3 MSC: Conceptual TOP: 3Iix

32. If you have a stuffy nose, a fever, chills, and body aches and a doctor treats you for the flu rather than four separate diseases that account for each of your symptoms, this is an application of:
    a. Newton's hypothesis
    b. Occam's razor
    c. Aristotle's test
    d. Einstein's relativity
    e. Copernican principle

    ANS: B DIF: Difficult REF: Section 1.3 MSC: Applied TOP: 3Iix

33. The cosmological principle states that:
    a. the universe is expanding in all directions at the same rate
    b. a unique center of the universe exists
    c. the universe looks the same everywhere and in all directions as long as you look on large enough spatial scales
    d. physical laws change from place to place in the universe
    e. the universe is in a "steady state"

    ANS: C DIF: Medium REF: Section 1.3 MSC: Conceptual TOP: 3Ix

34. Because of _____, we can conclude that gravity works the same way on Earth as it does on Mars.
    a. Newton's theory of relativity
    b. Einstein's special theory of relativity
    c. Sagan's planetary principle
    d. the principle of universality
    e. the hypothetical statute

    ANS: D DIF: Medium REF: Section 1.3 MSC: Conceptual TOP: 3Ix

35. A scientific theory can be shown to be wrong if:
    a. cultural beliefs evolve to contradict it
    b. scientists gather new data that contradicts its predictions
    c. it cannot explain all phenomena
    d. it was first proposed as a conjecture
    e. a majority of people do not accept it

    ANS: B DIF: Easy REF: Section 1.3 MSC: Conceptual TOP: 3IIii

36. Albert Einstein is best known for his revolutionary theory of:
    a. relativity
    b. quantum mechanics
    c. astronomy
    d. electricity
    e. mathematics

    ANS: A DIF: Easy REF: Section 1.3 MSC: Factual TOP: 3IIiii

37. When you see a pattern in nature, it is usually evidence of:
    a. a theory being displayed
    b. quantum mechanics in action
    c. a breakdown of random clustering
    d. an underlying physical law
    e. A decrease in entropy

    ANS: D DIF: Easy REF: Section 1.4 MSC: Factual TOP: 4Ii

38. The figures above show the night sky as it appears for an observer in the United States at the same time of the night but at four different seasons of the year. Which conclusion below is NOT reasonable based on these observations?
    a. Constellations do not change their location relative to one another, but which constellations appear in the night sky does change from season to season.
    b. There are some constellations such as Ursa Minor, Ursa Major, Cassiopeia, and Cephus that are always seen in the night sky.
    c. Some constellations such as Capricornus and Sagittarius are only visible during summer and fall.
    d. A good time to harvest crops would be when the constellation Pegasus is directly overhead.
    e. A good time to plant crops would be when the constellation Sagittarius is directly overhead.

    ANS: E DIF: Medium REF: Section 1.4 MSC: Applied TOP: 4Iii

39. The language of science is:
    a. Greek
    b. mathematics
    c. calculus
    d. Java
    e. Latin

    ANS: B DIF: Easy REF: Section 1.4 MSC: Factual TOP: 4IIi

40. Scientific notation is used in astronomy primarily because it allows us to:
    a. write very large and very small numbers in a convenient way
    b. talk about science in an easy way
    c. change easy calculations into hard calculations
    d. change hard calculations into easy calculations
    e. explain science to engineers

    ANS: A DIF: Easy REF: Section 1.4 MSC: Factual TOP: 4IIii

41. The number 123,000 written in scientific notation is:
    a. 1.23×10^{6}
    b. 1.23×10^{5}
    c. 1.23×10^{-3}
    d. 1.23×10^{-6}
    e. 1.23×10^{3}

    ANS: B DIF: Easy REF: Section 1.4 MSC: Applied TOP: 4IIii

42. $(6 \times 10^{5}) \div (3 \times 10^{-2})$
    a. 1.8×10^{3}
    b. 1.8×10^{4}
    c. 1.8×10^{6}
    d. 1.8×10^{3}
    e. 1.8×10^{-3}

    ANS: B DIF: Medium REF: Section 1.4 MSC: Applied TOP: 4IIii

43. $(1.2 \times 10^{9}) \div (4 \times 10^{-3})$
    a. 3×10^{6}
    b. 3×10^{5}
    c. 3×10^{10}
    d. 3×10^{11}
    e. 3×10^{12}

    ANS: D DIF: Medium REF: Section 1.4 MSC: Applied TOP: 4IIii

44. If the radius of circle *B* is twice the radius of circle *A*, and the area of a circle is proportional to the radius squared $(A \propto r^2)$, then the ratio of the area of circle *B* to that of circle *A* is:
    a. 4
    b. 0.5
    c. 0.25
    d. 2
    e. 1.414

    ANS: A DIF: Easy REF: Section 1.4 MSC: Applied TOP: 4IIiii

45. If the radius of circle *B* is 5 times the radius of circle *A*, then the ratio of the area of circle *B* to that of circle *A* is:
    a. 25
    b. 5
    c. 0.2
    d. 0.04
    e. 0.025

    ANS: A DIF: Medium REF: Section 1.4 MSC: Applied TOP: 4IIiii

46. If the radius of sphere *B* is 5 times the radius of sphere *A*, then the ratio of the volume of sphere *B* to the volume of sphere *A* is:
    a. 0.008
    b. 0.2
    c. 5
    d. 25
    e. 125

    ANS: E DIF: Medium REF: Section 1.4 MSC: Applied TOP: 4IIiii

47. The volume of a sphere is related to its radius by the formula . Using algebra to invert this formula, we find that:
    a.
    b.
    c.
    d.
    e.

    ANS: B DIF: Difficult REF: Section 1.4 MSC: Applied TOP: 4IIiii

48. The area of a circle is related to its diameter by the formula . Using algebra to invert this formula, we find that:
    a.
    b.
    c.
    d.
    e.

    ANS: D DIF: Medium REF: Section 1.4 MSC: Applied TOP: 4IIiii

49. The type of mathematics that deals with infinitesimal changes is called:
    a. algebra
    b. calculus
    c. arithmetic
    d. geometry
    e. topology

    ANS: B DIF: Easy REF: Section 1.4 MSC: Factual TOP: 4IIiii

50. If the speed of light is 3 □ 10^5 km/s and 1 km □ 0.62 miles, what is the speed of light in miles/hr?
    a. 670 million miles/hr
    b. 670 thousand miles/hr
    c. 186 miles/hr
    d. 186 thousand miles/hr
    e. 3.2 billion miles/hr

    ANS: A DIF: Difficult REF: Section 1.4 MSC: Applied TOP: 4IIiv

51. The orbital period of Mercury is 1.9 years. What is its orbital period in units of seconds?
    a. 60,000 seconds
    b. 6 million seconds
    c. 6 billion seconds
    d. 600 billion seconds
    e. 60 million seconds

    ANS: C DIF: Difficult REF: Section 1.4 MSC: Applied TOP: 4IIiv

52. Which of the graphs shown below illustrates a linear relationship between the variables *x* and *y*?

a. (a)
b. (b)
c. Both (a) and (b) show linear relationships.
d. Neither (a) nor (b) show linear relationships.

ANS: A DIF: Medium REF: Section 1.4 MSC: Applied TOP: 4IIv

53. What is the slope of the line in the figure shown below?

a. 0.1 km/hr
b. 1 km/hr
c. 6 km/hr
d. 10 km/hr
e. 60 km/hr

ANS: D DIF: Difficult REF: Section 1.4 MSC: Applied TOP: 4IIvi

54. Pluto is classified as a:
a. planet
b. dwarf planet
c. asteroid
d. comet
e. meteroid

ANS: B DIF: Easy REF: Section 1.5 MSC: Factual TOP: 5Ii

55. Pluto's status was changed from a classical planet to a dwarf planet primarily because of its:
a. lack of an atmosphere
b. small mass
c. large distance
d. ice-covered surface
e. many moons.

ANS: B DIF: Medium REF: Section 1.5 MSC: Factual TOP: 5Ii

56. The decision to classify Pluto as a dwarf planet was made by:
    a. its discoverer Clyde Tombaugh in 1930
    b. the president of the U.S. Naval Observatory in 2001
    c. the International Astronomical Union in 2006
    d. the Secretary General of the United Nations in 2001
    e. a vote of the majority of Americans in 2006

    ANS: C DIF: Difficult REF: Section 1.5 MSC: Factual TOP: 5Ii

57. The study of whether or not life exists elsewhere in the Solar System and beyond is called:
    a. origins
    b. biochemistry
    c. cosmology
    d. astrobiology
    e. exoplanetology

    ANS: D DIF: Medium REF: Section 1.6 MSC: Factual TOP: 6Ii

SHORT ANSWER

1. Suppose you were writing to a pen pal in another universe. What address would you put on the envelope that included all the major structures in which we reside? (Hint: Your cosmic address should begin with “Earth” and end with “the universe.”)

    ANS: The address would be: Earth, the Solar System, the Milky Way, the Local Group, Virgo Supercluster, the universe.

    DIF: Medium REF: Section 1.1 MSC: Factual TOP: 1IIi

2. What is the *only* thing that makes the Sun an exceptional star?

    ANS: The fact that it is *our* star!

    DIF: Easy REF: Section 1.1 MSC: Conceptual TOP: 1IIii

3. What would you say to someone who said, “It would take light-years to get to the Andromeda galaxy”?

    ANS: You would have to tell them that light-years is a unit of distance not time.

    DIF: Medium REF: Section 1.1 MSC: Applied TOP: 1IIIiii

4. If you compare the diameter of the Earth to 1 minute of time, then what interval of time would represent the diameter of the Solar System? Assume the diameter of the Solar System is approximately 80 AU.

   ANS: The diameter of the Earth is 2 □ 6378 km □ 1.3 □ 10^7 m, and 80 AU □ 80 □ 1.5 □ 10^{11} m □ 1.2 □ 10^{13} m. Thus, the diameter of the Solar System would be represented by: 1.2 □ 10^{13} m □ (1 minute) / (1.3□ 10^7 m) □ 9.4 □ 10^5 minutes □ 1.8 years.

   DIF: Medium REF: Section 1.1 MSC: Conceptual TOP: 1IIIiv

5. Using the method of comparing times to get a handle on the large distances in astronomy, compare the size of Earth to the size of the visible universe. Start by making the size of the Earth comparable to a snap of your fingers, which lasts about 1/7 seconds. Show your computation.

   ANS: If the size of Earth is like a snap of your fingers (1/7 seconds), the size of the visible universe would be 13.7 billion years □ 3 □ 4.5 billion years □ 3 times the age of the Solar System.

   DIF: Medium REF: Section 1.1 MSC: Applied TOP: 1IIIiv

6. Using the method of comparing distances to time intervals to get a handle on the large distances in astronomy, compare the diameter of our Solar System, which is 6 □ 10^{12} to the diameter of the Galaxy, which is 1.2 □ 10^{21} by calculating the time it would take for light to travel these diameters. For reference, the speed of light is 3 □ 10^8 m/s.

   ANS: The time it takes light to travel across the diameter of the Solar System is t □ d / v □ 6 □ 10^{12} m/(3 □ 10^8 m/s) □ 20,000 s □ (1 hr/3600 s) □ 5.5 hr. The time it takes light to travel across the diameter of the Galaxy is t □ 1.2 □ 10^{21} m/(3 □ 10^8 m/s) □ 4 □ 10^{12} s □ (1 hr/3600 s) □ (1 day/24 hr) □ (1 yr/365 day) □ 130,000 yr.

   DIF: Difficult REF: Section 1.1 MSC: Applied TOP: 1IIIiv

7. Describe briefly why the phrase “we are stardust” is literally true.

   ANS: Massive stars make heavy elements during their lifetime. When they eventually explode in a supernova, some of these heavy elements, as well as additional ones that are created in the explosion itself, are ejected into space, where they eventually cool and form new solar systems and everything in them, including us.

   DIF: Medium REF: Section 1.1 MSC: Conceptual TOP: 1IViii

8. On which objects in our solar system, other than Earth, have humans actually landed? On which objects have unmanned robot spacecraft landed?

   ANS: Humans have landed only on the Moon. Unmanned spacecraft have landed on Mars, Venus, asteroids, and Saturn's moon Titan.

   DIF: Medium REF: Section 1.2 MSC: Factual TOP: 2Ii

9. Describe two important technological developments in the last 100 years that have greatly increased our ability to study the universe and describe how each did so.

   ANS: The invention of spacecraft allowed us to launch telescopes above Earth's atmosphere, giving us a much clearer view of the universe and access to wavelengths of radiation that do not penetrate the Earth's atmosphere. Computers can rapidly collect and analyze large amounts of data which allows us to get results more quickly and efficiently.

   DIF: Medium REF: Section 1.2 MSC: Applied TOP: 2Ii | 2Iii | 2Iiv

10. Describe two important reasons why the ability to put telescopes in space dramatically affected the science of astronomy.

    ANS: Images taken from telescopes in space do not suffer the blurring that is due to light's passage through the Earth's atmosphere, and thus the images are much sharper. Also, some wavelengths of radiation do not penetrate through the Earth's atmosphere, such as ultraviolet light or X-rays, and thus they can only be observed from space.

    DIF: Easy REF: Section 1.2 MSC: Applied TOP: 2Iii

11. Describe the main steps involved in the scientific method.

    ANS: First you make a hypothesis and then you make a prediction based on your hypothesis. Finally, you test your prediction through experimentation to prove or disprove your original hypothesis. You revise your hypothesis, if necessary, when the experiments disagree with your hypothesis.

    DIF: Medium REF: Section 1.3 MSC: Conceptual TOP: 3Ii | 3Iiv | 3Ivi

12. How would you respond to someone who stated that "Evolution is not proven; it is just a theory"?

    ANS: You would need to explain that in science, a theory is not something that is proven, rather it our best explanation based on available data. Thus calling something a theory does not diminish its importance.

DIF: Difficult REF: Section 1.3 MSC: Applied TOP: 3Iv| 3Iii

13. What two pre-Renaissance beliefs are contradicted by the cosmological principle?

    ANS: (1) Earth is at the center of our universe, and (2) celestial objects are made of a different substance than Earth and obey different rules.

    DIF: Medium REF: Section 1.3 MSC: Factual TOP: 3Ix

14. Describe the two main aspects of the cosmological principle.

    ANS: (1) What we see around us is representative of what the universe is like in general, and (2) the physical laws valid on Earth are valid everywhere.

    DIF: Easy REF: Section 1.3 MSC: Conceptual TOP: 3Ix

15. Describe two ways in which Einstein's new theories changed commonly accepted scientific views of his time.

    ANS: Mass and energy are manifestations of the same phenomenon. Thus you can convert one into the other. Time and space are not separable, but are intimately related to one another. Thus Newton's Law of gravity is only a special case of a more general law Einstein called general relativity.

    DIF: Medium REF: Section 1.3 MSC: Factual TOP: 3IIiii

16. There are many different areas of science, but a common factor in each is the evaluation and analysis of patterns. What patterns does astronomy deal with? (Describe it in general and give at least one concrete example.)

    ANS: Astronomy deals with patterns related to celestial objects. One example is that patterns in the sky mark the changing of seasons, the coming of rains, the movement of herds, and the planting and harvesting of crops. An additional example is that the Sun rises and sets at a specific time because the Earth goes around the Sun.

    DIF: Easy REF: Section 1.4 MSC: Conceptual TOP: 4Ii | 4Iii

17. An observed pattern in nature is usually a sign of some underlying physical reason. Give an example of this in astronomy, citing the pattern and the reason behind it.

    ANS: The Sun rises and sets each day. This pattern is due to the Earth's daily revolution on its axis. The stars visible in the sky at a given time of day change throughout the year, but the pattern repeats every year. This is due to the Earth's motion around the Sun in one year.

DIF: Easy REF: Section 1.4 MSC: Conceptual TOP: 4Ii | 4Iii

18. It is often said that “mathematics is the language of science.” Explain why this is true.

    ANS: Math is a formal system used when describing and analyzing patterns, and explaining the reasons for patterns is the heart of science. Thus math is the language of science.

    DIF: Easy REF: Section 1.4 MSC: Conceptual TOP: 4IIi

19. Describe the scientific reasons why astronomers reclassified Pluto as a dwarf planet in 2006.

    ANS: The reason is similar to why the first “minor planets” found in the 1800s are now known as asteroids. Since its discovery in 1930, Pluto has been found NOT to be unique, but rather one of many similar objects that lie in the Kuiper Belt beyond the orbit of Neptune. This includes the dwarf planet Eris.

    DIF: Medium REF: Section 1.5 MSC: Applied TOP: 5Ii

20. What is the primary concern of the subfield of astronomy known as *astrobiology*?

    ANS: Astrobiology is the investigation of the possibility that life exists elsewhere in our solar system and beyond.

    DIF: Easy REF: Section 1.6 MSC: Factual TOP: 6Ii

CHAPTER 2

Patterns in the Sky—Motions of Earth

CONCEPT MAP

Sec 2.1

1. A View from Long Ago
    I. Night Sky (MC: 1)
        i. Constellations (TF: 1)

Sec 2.2

2. The Earth Spins on Its Axis
    I. Important Concepts
        i. Celestial sphere (SA: 1, 3–5)
        ii. Equator, latitude, longitude on Earth (MC: 2–8, SA: 2, 6)
        iii. Horizon (MC: 4, 9, 15, SA: 1–3, 6, 10, 20)
        iv. Meridian (TF: 2, MC: 9, 10–13, SA: 3)
        v. Zenith/nadir (MC: 5, 9, 14, SA: 3)
        vi. North/South celestial poles (MC: 4–6, 9, 15, SA: 1)
        vii. Ecliptic (MC: 16, SA: 5)
        viii. Location of Polaris in the night sky (MC: 3, SA: 6)
    II. Relative Motions and Frame of Reference (SA: 7)
    III. Motion Due to Earth's Daily Revolution on Its Axis
        i. Rotation rate 360 degrees/24 hours (TF: 3, MC: 10–13, 17–19, SA: 8)
    IV. Observed Effect on Stars' Motions in the Night Sky
        i. Rising and setting of celestial objects on the eastern and western horizons, respectively (TF: 4, 5 MC: 10–13, 17–23, SA: 9, 10)
        ii. Circumpolar stars (TF: 5)
        iii. How the observed star motions change with an observer's longitude and latitude (TF:

3, SA: 9, 10)

Sec 2.3

3. Revolution about the Sun Leads to Changes during the Year
   I. Earth Orbits the Sun at an Average Distance of 1 AU
      i. 1 AU □ 1.5 □ 10^8 km
      ii. Earth rotates on its axis in the same direction it orbits the Sun (counterclockwise as viewed looking down on the North Pole) (TF: 6, MC: 10–13)
   II. Orbital Period
      i. 365.24 days □ 365¼ days (MC: 25–26)
      ii. Consequence: At a given time of day, a star/constellation's position in the sky will vary throughout the year (MC: 25–26)
      iii. Sun's apparent path over the year defines the ecliptic plane and constellations of the zodiac (MC: 10–13, 27)
   III. The Tilt of Earth's Equator with Respect to Earth's Orbital Plane
      i. Tilt □ 23.5° (MC: 7, 8, 28–31)
      ii. Seasons result because the angle of Sun's rays more perpendicular to Earth's surface in summer, and the surface density of the energy received is larger (TF: 7, MC: 30–33, SA: 11–12)
      iii. Seasons are NOT due to Earth being physically closer to the Sun in summer (a common misconception) (TF: 7)
      iv. Sun's azimuth at rising/setting or altitude at noon changes during the year (TF: 8–9, MC: 34)
      v. Vernal and autumnal equinoxes (TF: 10, SA: 5, 13)
      vi. Winter and summer solstices (TF: 11, MC: 8, 35–37, SA: 2, 13)
   IV. Location of the Earth's N/S Pole on the Celestial Sphere Moves with Time
      i. Precession, period □ 26,000 years (MC: 38)
      ii. The "North Star" will not always be Polaris (MC: 39)

Sec 2.4

4. The Motions and Phases of the Moon
   I. Moon Phases
      i. Important terms: full, new, crescent, gibbous, waxing, waning (TF: 12, MC: 17–19, 40–44, 38, SA: 14)
      ii. Predicting the Moon's phase given the position of the Sun, Earth, and Moon and vice

versa (MC: 17–19, 42, 43–48, SA: 14–16)

II. Periods
   i. Sidereal period (27.32 days)—orbital period measured by an outside observer (with respect to background stars) (MC: 45)
   ii. Synodic period (29.53 days)—the time required for the Moon to go through a complete cycle of phases (MC: 17–19, 41, 43–45)
   iii. Moon's sidereal period is NOT equal to the Moon's synodic period because of the Earth and Moon's motion around the Sun (MC: 45, 49)
   iv. Predicting the Moon's position in the sky given its phase and time of day; predicting the rising and setting times of the Moon (TF: 12, MC: 17–19, SA: 14, 17)

III. Moon's Rotation (MC: 50)
   i. Rotation rate 1 sidereal period
   ii. Consequence: synchronous rotation—Moon always keeps the same side toward Earth (TF: 13, SA: 18)

Sec 2.5

5. Cultures and Calendars

I. Leap Year
   i. Occurs because the Earth's orbital period is 365¼ days (MC: 51–53, SA: 19)

II. Gregorian Calendar (SA: 19)

Sec 2.6

6. Eclipses: Passing through a Shadow

I. Geometry of Eclipses
   i. Lunar eclipses (MC: 46, 54, SA: 20)
   ii. Solar eclipses (TF: 14, 15, MC: 47–48, 55–56, SA: 21)

II. Degree of Eclipse (MC: 55–56)
   i. Total, partial, or annular eclipse (MC: 54)
   ii. Umbra (MC: 57)
   iii. Penumbra (MC: 57)

III. Eclipses Are Rare
   i. 5.2° tilt of Moon's orbital plane relative to Earth's orbital plane (MC: 58, SA: 22)
   ii. Line of nodes (SA: 22)
   iii. Eclipse frequency: 2 of each type per 11 months (MC: 58–59, SA: 22)
   iv. Total/partial eclipses can be seen only at specific locations on the Earth (TF: 15)

Sec 2.7

7. Origins: The Obliquity of Earth
    I. Obliquity
        i. Change in the degree of Earth's axial tilt (SA: 12)

TRUE/FALSE

1. Constellations are arbitrary groupings of stars in the sky.

    ANS: T DIF: Easy REF: Section 2.1 MSC: Factual TOP: 1Ii

2. The meridian is half of an imaginary circle in the sky that passes through an observer's zenith and both celestial poles.

    ANS: T DIF: Easy REF: Section 2.2 MSC: Factual TOP: 2Iiv

3. Locations along the equator are the only place on Earth where you can see the entire celestial sphere (during the day or night) over the course of 24 hours.

    ANS: T DIF: Easy REF: Section 2.2 MSC: Factual TOP: 2IIIi | 2IViii

4. If a star rises due east on the horizon, it will set due west on the horizon six hours later.

    ANS: F DIF: Easy REF: Section 2.2 MSC: Applied TOP: 2IVi

5. For an observer in the Northern Hemisphere, as he or she looks north, stars travel in a clockwise direction around the north celestial pole over the course of the night.

    ANS: F DIF: Easy REF: Section 2.2 MSC: Factual TOP: 2IVi | 2IVii

6. Earth revolves around the Sun in the same direction Earth spins about its axis.

    ANS: T DIF: Easy REF: Section 2.3 MSC: Factual TOP: 3Iii

7. The seasons on Earth are caused by the change in distance between the Sun and Earth.

    ANS: F DIF: Medium REF: Section 2.3 MSC: Factual TOP: 3IIIii | 3IIIiii

8. The altitude of the Sun as it crosses the meridian changes during the year.

    ANS: T DIF: Medium REF: Section 2.3 MSC: Factual TOP: 3IIIiv

9. A person who lives at the equator will see the Sun directly overhead at noon every day of the year.

    ANS: F DIF: Medium REF: Section 2.3 MSC: Applied TOP: 3IIIiv

10. On the autumnal equinox, the lengths of both day and night are 12 hours.

    ANS: T DIF: Easy REF: Section 2.3 MSC: Factual TOP: 3IIIv

11. The longest day of the year in the Northern Hemisphere occurs on the summer solstice.

    ANS: T DIF: Easy REF: Section 2.3 MSC: Factual TOP: 3IIIvi

12. When in the New Moon phase, the moon will be visible in the eastern sky at sunrise.

    ANS: T DIF: Medium REF: Section 2.4 MSC: Applied TOP: 4Ii | 4IIiv

13. The fact that we always see the same side of the Moon indicates that the Moon does not rotate about an axis.

    ANS: F DIF: Medium REF: Section 2.4 MSC: Conceptual TOP: 4IIIii

14. When a solar eclipse occurs, the Sun lies between the Earth and Moon.

    ANS: F DIF: Easy REF: Section 2.6 MSC: Conceptual TOP: 6Iii

15. When a solar eclipse occurs, typically more people will witness it as a partial eclipse than as a total eclipse.

    ANS: T DIF: Medium REF: Section 2.6 MSC: Factual TOP: 6Iii | 6IIIiv

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: Factual TOP: 1I

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 2.2 MSC: Factual TOP: 2Iii

3. 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: Medium REF: Section 2.2 MSC: Applied TOP: 2Iii | 2Iviii

4. 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 2.2 MSC: Applied TOP: 2Iii | 2Iiii | 2Ivi

5. 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 2.2 MSC: Applied TOP: 2Iii | 2Iv | 2Ivi

6. 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 2.2 MSC: Applied TOP: 2Iii | 2Iiii | 2Ivi

7. 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 2.3 MSC: Applied TOP: 2Iii | 3IIIi

8. For a person living in Vancouver, Canada, at latitude of □49°, the Sun will reach a maximum height above the Southern horizon on winter solstice of
   a. 41.0°
   b. 17.5°
   c. 25.5°
   d. 37.0°
   e. 64.5°

   ANS: B DIF: Difficult REF: Section 2.3 MSC: Applied TOP: 2Iii | 3IIIi | 3IIIvi

9. 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 2.2 MSC: Factual TOP: 2Iiv | 2Iv | 2Ivi

Figure 1

10. Assume you are observing the night sky from a typical city in the United States with a latitude of 40°. Using Figure 1, 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 2.3 MSC: Applied TOP: 2Iiv | 2IIIi | 2IVi | 3Iii | 3IIiii

11. Assume you are observing the night sky from a typical city in the United States with a latitude of 40°. Using Figure 1, 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 2.3 MSC: Applied TOP: 2Iiv | 2IIIi | 2IVi | 3Iii | 3IIiii

12. Assume you are observing the night sky from a typical city in the United States with a latitude of 40°. Using Figure 1, which constellation of the zodiac would be nearest to the meridian at 10 P.M. in mid-May?
    a. Aries
    b. Libra
    c. Capricornus
    d. Gemini
    e. Sagittarius

    ANS: B DIF: Difficult REF: Section 2.3 MSC: Applied TOP: 2Iiv | 2IIIi | 2IVi | 3Iii | 3IIiii

13. Using Figure 1, 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 2.3 MSC: Applied TOP: 2Iiv | 2IIIi | 2IVi | 3Iii | 3IIiii

14. 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 2.2 MSC: Factual TOP: 2Iv

15. 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 2.2 MSC: Factual TOP: 2Ivi

16. 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 2.2 MSC: Factual TOP: 2Ivii

17. At 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 2.4 MSC: Applied TOP: 2IIIi | 2IVi | 4Ii | 4Iii | 4IIii | 4IIiv

18. 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 2.4 MSC: Applied TOP: 2IIIi | 2IVi | 4Ii | 4Iii | 4IIii | 4IIiv

19. 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 2.4 MSC: Applied TOP: 2IIIi | 2IVi | 4Ii | 4Iii | 4IIii | 4IIiv

20. A friend takes a time-lapse picture of the sky, as shown 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 2.2 MSC: Applied TOP: 2IVi

21. A friend takes a time-lapse picture of the sky, as shown 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: B DIF: Difficult REF: Section 2.2 MSC: Applied TOP: 2IVi

22. A friend takes a time-lapse picture of the sky, as shown 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 2.2 MSC: Applied TOP: 2IVi

23. A friend takes a time-lapse picture of the sky, as shown 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: D DIF: Difficult REF: Section 2.2 MSC: Applied TOP: 2IVi

24. How far away on average is the 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 2.3 MSC: Factual TOP: 3Ii

25. 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 2.3 MSC: Applied TOP: 3IIi | 3IIii

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

    ANS: B DIF: Easy REF: Section 2.3 MSC: Applied TOP: 3IIi | 3IIii

27. 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 2.3 MSC: Factual TOP: 3IIiii

28. When the Northern Hemisphere experiences fall, the Southern Hemisphere experiences:
    a. spring
    b. summer
    c. fall
    d. winter

    ANS: A DIF: Easy REF: Section 2.3 MSC: Applied TOP: 3IIIi

29. When the Northern Hemisphere experiences summer, the Southern Hemisphere experiences:
    a. spring
    b. summer
    c. fall
    d. winter

    ANS: D DIF: Easy REF: Section 2.3 MSC: Applied TOP: 3IIIi

30. If the 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 2.3 MSC: Factual TOP: 3IIIi | 3IIIii

31. If the 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 2.3 MSC: Factual TOP: 3IIIi | 3IIIii

32. We experience seasons because:
    a. the Earth's equator is tilted relative to the plane of the solar system
    b. the 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. the 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 2.3 MSC: Applied TOP: 3IIIii

33. 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 2.3 MSC: Factual TOP: 3IIIii

34. 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 2.3 MSC: Applied TOP: 3IIIiv

35. 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 2.3 MSC: Applied TOP: 3IIIvi

36. 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 2.3 MSC: Applied TOP: 3IIIvi

37. 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 2.3 MSC: Factual TOP: 3IIIvi

38. The 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 2.3 MSC: Factual TOP: 3IVi

39. 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 2.3 MSC: Factual TOP: 3IVii

40. 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. increasing in brightness
    e. decreasing in brightness

    ANS: D DIF: Easy REF: Section 2.4 MSC: Factual TOP: 4Ii

41. If you see a full moon tonight, 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 2.4 MSC: Factual TOP: 4Ii | 4IIii

42. If a person on Earth currently views the Moon in a waxing crescent phase, in what phase would the 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 2.4 MSC: Applied TOP: 4Ii | 4Iii

43. If tonight the Moon is in the waxing gibbous phase, in three days the Moon will most likely be in the:
    a. new phase
    b. full phase
    c. third-quarter phase
    d. first-quarter phase
    e. waxing crescent phase

    ANS: B DIF: Easy REF: Section 2.4 MSC: Applied TOP: 4Ii | 4Iii | 4IIii

44. If there is a full moon out tonight, approximately how long from now will it be in the third-quarter phase?
    a. three to four days
    b. one week
    c. two weeks
    d. three weeks
    e. one month

    ANS: B DIF: Easy REF: Section 2.4 MSC: Applied TOP: 4Ii | 4Iii | 4IIii

45. 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 2.4 MSC: Applied TOP: 4Iii | 4IIi | 4IIii | 4IIiii

Figure 2

46. In Figure 2, 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 2.6 MSC: Conceptual TOP: 4Iii | 6Ii

47. In Figure 2, 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 2.6 MSC: Conceptual TOP: 4Iii | 6Iii

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

    ANS: A DIF: Easy REF: Section 2.6 MSC: Conceptual TOP: 4Iii | 6Iii

49. 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 the Earth
    b. the Earth must rotate so an observer can see the Moon
    c. the Moon's orbit is tilted with respect to the Earth's rotational axis
    d. the 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 2.4 MSC: Conceptual TOP: 4IIiii

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

    ANS: A DIF: Easy REF: Section 2.4 MSC: Conceptual TOP: 4III

51. Leap years occur because:
    a. the Earth's orbital period around the Sun is decreasing
    b. the Earth's orbital period is 365.24 days
    c. the Gregorian calendar contains only 11 months
    d. the 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 2.5 MSC: Conceptual TOP: 5Ii

52. 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 2.5 MSC: Factual TOP: 5Ii

53. 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 2.5 MSC: Applied TOP: 5Ii

54. 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 2.6 MSC: Conceptual TOP: 6Ii | 6IIi

55. 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 2.6 MSC: Applied TOP: 6Iii | 6II

56. 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 2.6 MSC: Applied TOP: 6Iii | 6II

57. 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 2.6 MSC: Applied TOP: 6IIii | 6IIiii

58. Solar and lunar eclipses are rare because:
    a. the Moon's orbital plane is tipped by 5.2° relative to the plane defined by the Earth's equator
    b. the Moon's orbital plane is tipped by 5.2° relative to the Earth's orbital plane
    c. the Moon's orbital plane is tipped by 23.5° relative to the plane defined by the Earth's equator
    d. the Moon's orbital plane is tipped by 23.5° relative to the 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 2.6 MSC: Conceptual TOP: 6IIIi | 6IIIiii

59. 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 2.6 MSC: Factual TOP: 6IIIiii

SHORT ANSWER

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

   ANS: You can stand at either the North Pole or the South Pole.

   DIF: Medium REF: Section 2.2 MSC: Applied TOP: 2Ii | 2Iiii | 2Ivi

2. 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 southern most 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: Applied TOP: 2Ii | 2Iiii | 3IIIvi

3. 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 2.2 MSC: Factual TOP: 2Ii | 2Iiii | 2Iiv |2Iv

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

   ANS: At latitudes □ 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: Applied TOP: 2Ii

5. 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 2.3 MSC: Factual TOP: 2Ii | 2Ivii | 3IIIv

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 2.2 MSC: Applied TOP: 2Iii | 2Iiii | 2Iviii

7. 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. Since 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. Since 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 2.2 MSC: Conceptual TOP: 2II

8. 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 the 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 □r □ 2 □ 3.14159 □ 6.4 □ 10^3 □ 4.02 □ 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/hr.

   DIF: Difficult REF: Section 2.2 MSC: Applied TOP: 2IIIi

9. 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 2.2 MSC: Applied TOP: 2IVi | 2IViii

10. 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 hr − 8 hr) □ 360°/24 hr □ 60°, and the star will be 90° − 60° □ 30° above the western horizon.

    DIF: Medium REF: Section 2.2 MSC: Applied TOP: 2IVi | 2IViii

11. 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
    (2) Variation in the directness of the Sun's rays

    DIF: Medium REF: Section 2.3 MSC: Applied TOP: 3IIIii

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

    ANS: If the tilt of the 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 2.3 MSC: Applied TOP: 3IIIii | 7Ii

13. 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: Easy/Medium REF: Section 2.3 MSC: Factual TOP: 3IIIv | 3IIIvi

14. If the Moon was full three 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 2.4 MSC: Applied TOP: 4Ii | 4Iii | 4IIiv

15. Based on the location of the moon in the diagram 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 2.4 MSC: Conceptual TOP: 4Iii

16. Based on the location of the moon in the diagram 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 2.4 MSC: Conceptual TOP: 4Iii

17. 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. While 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 2.4 MSC: Applied TOP: 4IIiv

18. 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 2.4 MSC: Conceptual TOP: 4IIIii

19. 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 the Earth around the Sun. The others are lunar calendars based on the motion of the Moon around the Earth. The Gregorian calendar also includes leap years to avoid the shifting of the seasons due to the fact that the Earth orbits the Sun in 365.24 days.

    DIF: Medium REF: Section 2.5 MSC: Factual TOP: 5Ii | 5II

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

    ANS: The Moon, Earth, and Sun should all be drawn in a straight line with the Earth in between the Moon and the Sun.

    DIF: Medium REF: Section 2.6 MSC: Applied TOP: 6Ii

21. Draw a picture below showing the Moon's location relative to the 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 the Earth and the Sun.

    DIF: Medium REF: Section 2.6 MSC: Applied TOP: 6Iii

22. 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 six months apart.

DIF: Difficult REF: Section 2.6 MSC: Applied TOP: 6IIIi | 6IIIii | 6IIIiii