Chapter 1: Our Place in the Universe

LEARNING OBJECTIVES

1.1 Astronomy Gives Us a Universal Context

1.1a List our cosmic address.

1.1b Differentiate the various components of our cosmic address.

1.1c List the types of objects found in our Solar System.

1.1d List the means by which we explore our universe.

1.1e Relate astronomical distances with the travel time of light.

1.2 Science is a Way of Viewing the World

1.2a Compare the everyday and scientific meanings of *theory*.

1.2b Compare an *idea* with a *hypothesis*.

1.2c Explain what makes a scientific theory *falsifiable*.

1.2d Describe the steps of the scientific method.

1.2e Assess whether a given idea or explanation is scientific.

1.2f Understand the cosmological principle and Occam's razor.

1.3 Astronomers Use Mathematics to Find Patterns

1.3a Determine the slope of a line.

1.3b Interpret data from a graph.

1.3c Determine the relation of mathematics and science.

Working It Out 1.1

Working It Out 1.1a Differentiate among the metric units *nano*, *micro*, *milli*, *centi*, and *kilo*.

Working It Out 1.1b Write numbers in both scientific and standard notation.

Working It Out 1.1c Convert between different units of length, time, and speed.

Chapter 1: Our Place in the Universe

MULTIPLE CHOICE

1. Which of the following is the largest structure?

   a. Laniakea Supercluster
   b. Virgo Supercluster
   c. Local Group
   d. Milky Way Galaxy

   ANS: A DIF: Medium REF: 1.1

   OBJ: 1.1a List our cosmic address.

   MSC: Remembering

2. Our place in the universe is

   a. a location and a time.
   b. at its center.
   c. at its edge.
   d. between the center and the edge.

   ANS: A DIF: Easy REF: 1.1

   OBJ: 1.1a List our cosmic address.

   MSC: Remembering

3. We are located approximately

   a. at the center of the Milky Way.
   b. near the center of the Milky Way.
   c. halfway out from the center of the Milky Way.
   d. at the farthest outskirts of the Milky Way.

   ANS: C DIF: Easy REF: 1.1

   OBJ: 1.1b Differentiate the various components of our cosmic address.

   MSC: Remembering

4. Light from the Sun takes about _____ to reach Earth.

a. 8 seconds
c. 8 hours

b. 8 minutes
d. 8 years

ANS: B DIF: Easy REF: 1.1

OBJ: 1.1e Relate astronomical distances with the travel time of light.

MSC: Remembering

5. If an event were to take place on the Sun, how long would it take for the light to reach us?

a. 8 minutes
c. 1 second

b. 11 hours
d. 1 day

ANS: A DIF: Easy REF: 1.1

OBJ: 1.1e Relate astronomical distances with the travel time of light.

MSC: Applying

6. After the Sun, the next nearest star to us is approximately _____ away.

a. 4 light-seconds
c. 4 light-hours

b. 4 light-minutes
d. 4 light-years

ANS: D DIF: Easy REF: 1.1

OBJ: 1.1e Relate astronomical distances with the travel time of light.

MSC: Remembering

7. One of the nearest stars is Alpha Centauri, whose distance is 4.4 light-years. The time it takes light to travel from Alpha Centauri to us is

a. 1.25 seconds.
c. 4.4 years.

b. 8.3 minutes.
d. 600 years.

ANS: C DIF: Easy REF: 1.1

OBJ: 1.1e Relate astronomical distances with the travel time of light.

MSC: Applying

8. The distance to the nearest, large, spiral galaxy, Andromeda, is 2.5 million light-years. How long does it take light to travel from us to Andromeda?

   a. 360 years
   b. 1.2 thousand years
   c. 4.5 billion years
   d. 2.5 million years

   ANS: D DIF: Easy REF: 1.1

   OBJ: 1.1e Relate astronomical distances with the travel time of light.

   MSC: Applying

9. 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

   ANS: A DIF: Easy REF: 1.1

   OBJ: 1.1b Differentiate the various components of our cosmic address.

   MSC: Remembering

10. Our universe is approximately _____ years old.

    a. 14 million
    b. 14 billion
    c. 14 trillion
    d. 14 thousand

    ANS: B DIF: Easy REF: 1.1

    OBJ: 1.1c List the types of objects found in our Solar System.

    MSC: Remembering

11. The number of planets in the Solar System is

    a. 8.
    b. 9.
    c. 12.
    d. 6.

ANS: A DIF: Easy REF: 1.1

OBJ: 1.1c List the types of objects found in our Solar System.

MSC: Remembering

12. Which of the following most closely approximates the number of stars in the Milky Way?

a. 10 million
c. 10 billion
b. 100 million
d. 100 billion

ANS: D DIF: Medium REF: 1.1

OBJ: 1.1b Differentiate the various components of our cosmic address.

MSC: Remembering

13. Which of the following most closely approximates the number of stars in the Solar System?

a. 1
c. 10 billion
b. 2
d. 100 billion

ANS: A DIF: Easy REF: 1.1

OBJ: 1.1b Differentiate the various components of our cosmic address.

MSC: Remembering

14. What is the closest star to the Earth?

a. Alpha Centauri
c. the Sun
b. Proxima Centauri
d. Eta Carinae

ANS: C DIF: Medium REF: 1.1

OBJ: 1.1b Differentiate the various components of our cosmic address.

MSC: Remembering

15. What is the closest star to the Sun?

a. Alpha Centauri
c. the Sun

b. Proxima Centauri
d. Eta Carinae

ANS: B DIF: Medium REF: 1.1

OBJ: 1.1b Differentiate the various components of our cosmic address.

MSC: Remembering

16. Which space mission or craft has probed the farthest from the Earth?

a. *New Horizons*
c. *Apollo 15*

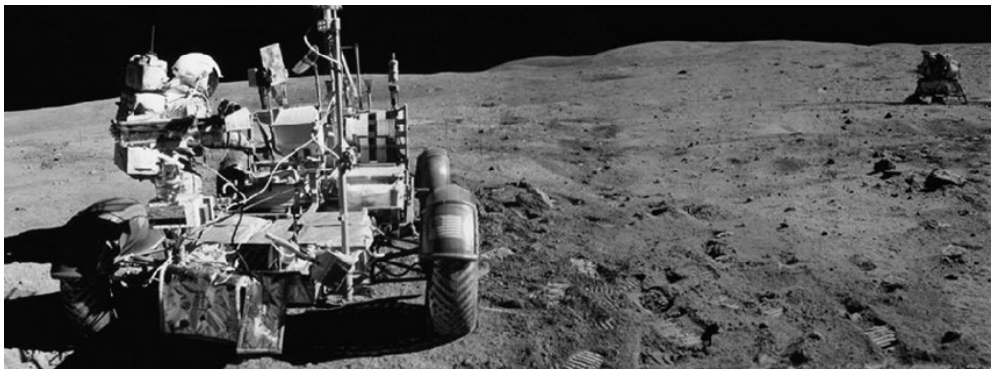
b. *Curiosity*
d. *Voyager 1*

ANS: D DIF: Medium REF: 1.1

OBJ: 1.1d List the means by which we explore our universe.

MSC: Remembering

17. Which space mission is associated with this image?



a. *New Horizons*
c. *Apollo 15*

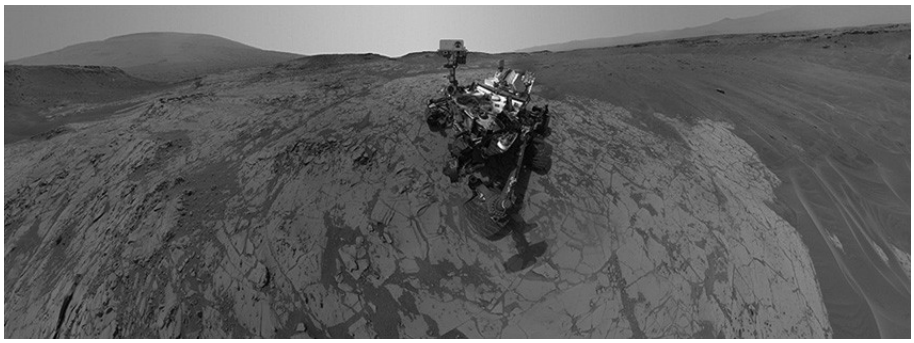
b. *Curiosity*
d. *Voyager 1*

ANS: C DIF: Easy REF: 1.1

OBJ: 1.1d List the means by which we explore our universe.

MSC: Remembering

18. Which space mission is associated with this image?



a. *New Horizons*
c. *Apollo 15*

b. *Curiosity*
d. *Voyager 1*

ANS: B DIF: Medium REF: 1.1

OBJ: 1.1d List the means by which we explore our universe.

MSC: Remembering

19. The speed of light is about

a. 20 km/s.
c. 300,000 km/s.

b. 30,000 km/s.
d. 5 million km/s.

ANS: C DIF: Medium REF: 1.1

OBJ: 1.1e Relate astronomical distances with the travel time of light.

MSC: Remembering

20. A light-year is a unit of measurement for

a. time.
c. mass.

b. speed.
d. distance.

ANS: D DIF: Medium REF: 1.1

OBJ: 1.1e Relate astronomical distances with the travel time of light.

MSC: Remembering

21. The most massive elements (such as those of the rocky planets like Earth) were formed

a. in the early universe.
c. through meteor collisions.
b. inside stars and supernovae.
d. in the core of Earth.

ANS: B DIF: Medium REF: 1.1

OBJ: 1.1c List the types of objects found in our Solar System.

MSC: Remembering

22. 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.

ANS: C DIF: Difficult REF: 1.1

OBJ: 1.1b Differentiate the various components of our cosmic address.

MSC: Applying

23. If the diameter of our galaxy is approximately 100,000 light-years and our Solar System's diameter is about 10 light-hours, our galaxy is (rounded up) _____ times larger than our Solar System.

a. 100
c. 10^6
b. 10^4
d. 10^8

ANS: D DIF: Difficult REF: 1.1

OBJ: 1.1e Relate astronomical distances with the travel time of light.

MSC: Applying

24. The Local Group is the environment around

a. the Sun that contains about a dozen stars.

b. the Milky Way that contains a few dozen galaxies.

c. the Sun that contains more than a billion stars.

d. the Milky Way that contains a few thousand galaxies.

ANS: B DIF: Difficult REF: 1.1

OBJ: 1.1b Differentiate the various components of our cosmic address.

MSC: Remembering

25. Which of the following is true?

a. The Local Group is a member of the Virgo Supercluster, which contains thousands of galaxies.

b. The Local Group contains dozens of large spiral galaxies and a few dozen dwarf galaxies.

c. Our Solar System has nine planets.

d. The Milky Way Galaxy contains approximately 100 million stars.

ANS: A DIF: Difficult REF: 1.1

OBJ: 1.1b Differentiate the various components of our cosmic address.

MSC: Remembering

26. Measuring distances in the amount of time it takes light to travel, if the circumference of Earth is a snap of your fingers, 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 time between sunrise and sunset.

d. the time you spent in high school.

ANS: C DIF: Difficult REF: 1.1

OBJ: 1.1e Relate astronomical distances with the travel time of light.

MSC: Applying

27. Which statement is true?

a. Twenty-four men have walked on the Moon.

b. Spacecraft have landed on all eight planets.

c. Spacecraft have landed on a comet and an asteroid.

d. Spacecraft have landed on Titan and Pluto.

ANS: C DIF: Difficult REF: 1.1

OBJ: 1.1d List the means by which we explore our universe.

MSC: Remembering

28. Which of the following is found at a distance of 4.2 light-years from the Sun?

a. Earth

b. Pluto

c. Proxima Centauri

d. the Andromeda Galaxy

ANS: C DIF: Easy REF: 1.1

OBJ: 1.1e Relate astronomical distances with the travel time of light.

MSC: Remembering

29. Which of the following is found at a distance of 2.5 million light-years from the Sun?

a. Earth

b. Pluto

c. Proxima Centauri

d. the Andromeda Galaxy

ANS: D DIF: Easy REF: 1.1

OBJ: 1.1e Relate astronomical distances with the travel time of light.

MSC: Remembering

30. Which of the following forms of light observed by astronomers is the lowest in energy?

a. gamma rays

c. visible

b. X-rays d. radio

ANS: D DIF: Difficult REF: 1.1

OBJ: 1.1d List the means by which we explore our universe.

MSC: Remembering

31. A scientific theory can be proved wrong if

a. cultural beliefs evolve to contradict it.

b. scientists gather new data that disprove its predictions.

c. it cannot explain all phenomena.

d. it is based only on conjecture.

ANS: B DIF: Easy REF: 1.2

OBJ: 1.2c Explain what makes a scientific theory falsifiable.

MSC: Remembering

32. A hypothesis may become a theory

a. after many repeated attempts to falsify it fail.

b. if a majority of scientists agree on its propositions.

c. after it has been logically proved.

d. if it makes at least one verifiable prediction.

ANS: A DIF: Easy REF: 1.2

OBJ: 1.2a Compare the everyday and scientific meanings of theory.

MSC: Remembering

33. Which of the following is true?

a. All choices are true.

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 proved wrong when scientists acquire new data.

ANS: A DIF: Medium REF: 1.2

OBJ: 1.2a Compare the everyday and scientific meanings of theory.

MSC: Evaluating

34. 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.

ANS: B DIF: Medium REF: 1.2

OBJ: 1.2d Describe the steps of the scientific method.

MSC: Remembering

35. 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

ANS: D DIF: Medium REF: 1.2

OBJ: 1.2d Describe the steps of the scientific method.

MSC: Remembering

36. 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. there are no special locations or directions in the universe.

d. physical laws may change from place to place in the universe.

ANS: C DIF: Medium REF: 1.2

OBJ: 1.2b Compare an idea with a hypothesis.

MSC: Remembering

37. _____ 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

ANS: B DIF: Difficult REF: 1.2

OBJ: 1.2d Describe the steps of the scientific method.

MSC: Remembering

38. One of the central assumptions in astronomy is that the physical laws of nature

a. change when objects move at high speed.

b. change throughout the age of the universe.

c. depend on the mass of the objects involved.

d. are the same everywhere in the universe.

ANS: D DIF: Difficult REF: 1.2

OBJ: 1.2b Compare an idea with a hypothesis.

MSC: Remembering

39. The statement “our universe is but one of a multitude of isolated universes” is best characterized as a

    a. speculative but unscientific idea because it is not testable and therefore not falsifiable.

    b. scientific fact.

    c. physical law.

    d. hypothesis that is currently being tested.

    ANS: A DIF: Difficult REF: 1.2

    OBJ: 1.2e Assess whether a given idea or explanation is scientific.

    MSC: Applying

40. The language of science is

    a. Greek.

    b. mathematics.

    c. Latin.

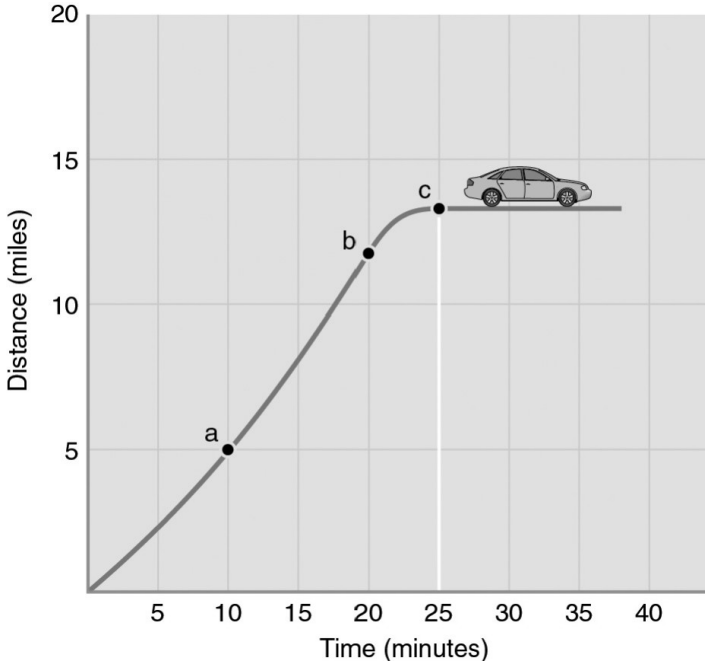
    d. Java.

    ANS: B DIF: Easy REF: 1.3

    OBJ: 1.3c Determine the relation of mathematics and science.

    MSC: Remembering

41. What are the speeds of the car at points a, b, and c as indicated by the graph in the following figure?



a. 0.5 miles per minute, 0.5 miles per minute, 0 miles per minute

b. 0.5 miles per minute, 0.5 miles per minute, 0.25 miles per minute

c. 0.5 miles per minute, 0.7 miles per minute, 0.56 miles per minute

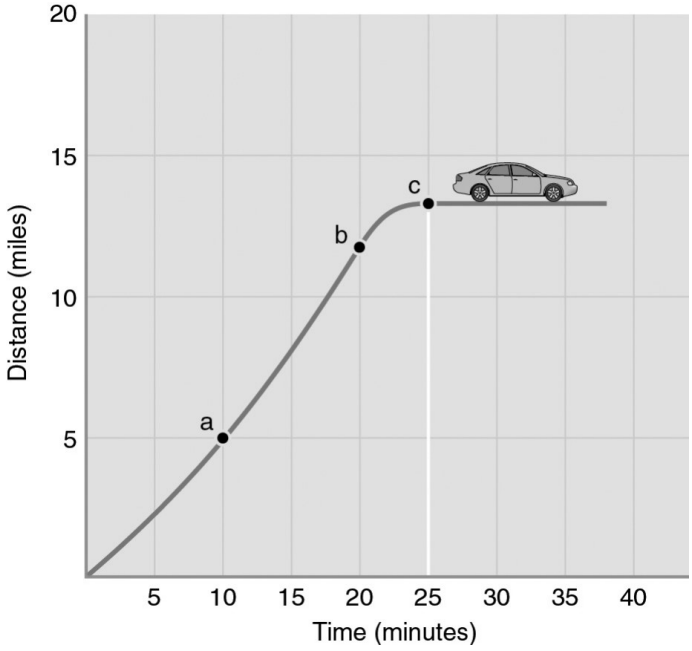
d. 0.5 miles per minute, 0.7 miles per minute, 0 miles per minute

ANS: D DIF: Medium REF: 1.3

OBJ: 1.3b Interpret data from a graph.

MSC: Applying

42. Examine the following image. What part of the data plotted has a zero slope?



a. a to b

b. b to c

c. a to c

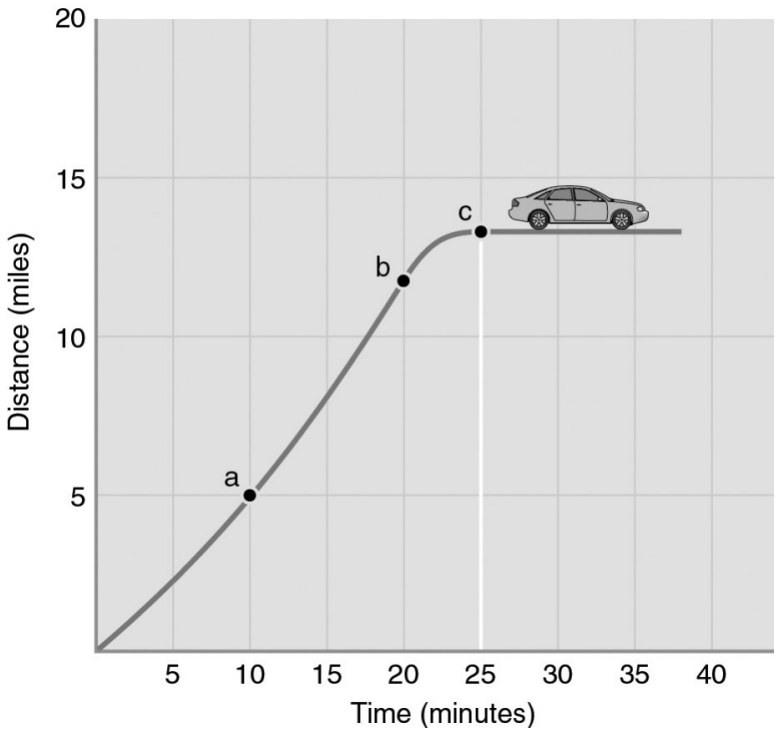
d. c to car

ANS: D DIF: Medium REF: 1.3

OBJ: 1.3a Determine the slope of a line.

MSC: Applying

43. Examine the following image. What part of the data plotted has a nearly constant and positive slope?



a. a to b

b. b to c

c. a to c

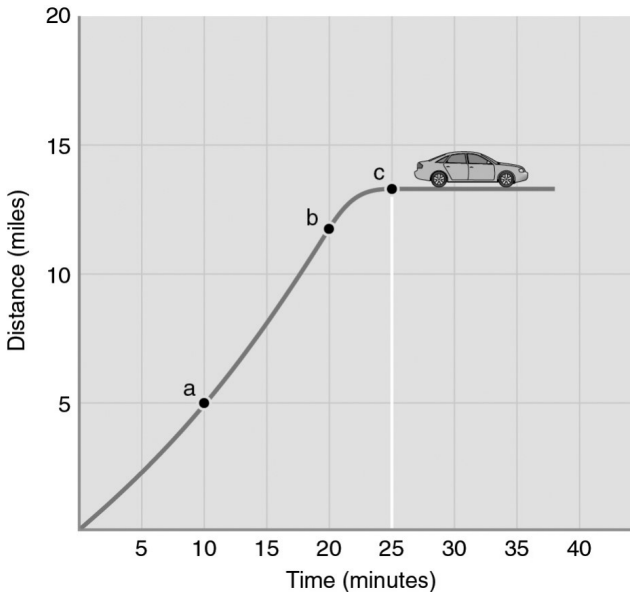
d. c to car

ANS: A DIF: Medium REF: 1.3

OBJ: 1.3a Determine the slope of a line.

MSC: Remembering

44. Examine the following image. Which statement about the slopes in the plotted data is true?



a. Some are positive.

b. Some are negative.

c. All are zero.

d. All are negative.

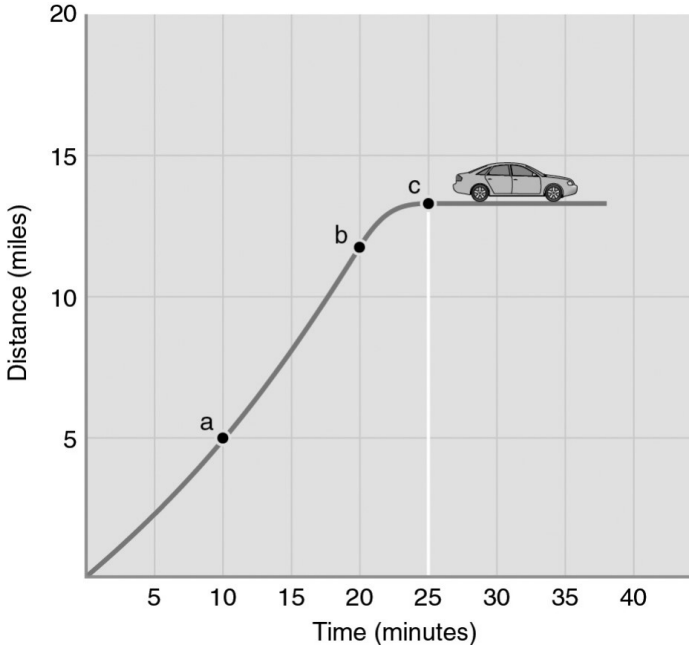
e. All are positive.

ANS: A DIF: Medium REF: 1.3

OBJ: 1.3a Determine the slope of a line.

MSC: Remembering

45. Examine the following image. What would a line sloping from the upper left to the lower right mean?



a. The car is approaching.

b. The car is slowing down.

c. The car is moving away.

d. The car is speeding up.

ANS: A DIF: Medium REF: 1.3

OBJ: 1.3a Determine the slope of a line.

MSC: Applying

46. How many nanometers are in a millimeter?

a. 100

b. 1,000

c. 1,000,000

d. 1,000,000,000

ANS: C DIF: Medium REF: 1.3

OBJ: Working It Out 1.1a Differentiate among the metric units nano, micro, milli, centi, and kilo.

MSC: Applying

47. Scientific notation 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. explain science to engineers.

ANS: A DIF: Easy REF: 1.3

OBJ: Working It Out 1.1b Write numbers in both scientific and standard notation.

MSC: Remembering

48. How many powers of 10 does the size of the visible universe span (in light-years)?

a. 13.8

b. 1 billion

c. 9

d. 10

ANS: D DIF: Medium REF: 1.3

OBJ: Working It Out 1.1b Write numbers in both scientific and standard notation.

MSC: Applying

49. Write 3,800,000,000 in scientific notation.

a. 3.8×10^{8}

b. 3.8×10^{9}

c. 3.8×10^{-8}

d. 3.8×10^{-9}

ANS: B DIF: Medium REF: 1.3

OBJ: Working It Out 1.1b Write numbers in both scientific and standard notation.

MSC: Applying

50. Write 0.00000037 in scientific notation.

a. 3.7×10^{-7}

b. 37×10^{-6}

c. 37×10^{6}

d. 3.7×10^{7}

ANS: A DIF: Medium REF: 1.3

OBJ: Working It Out 1.1b Write numbers in both scientific and standard notation.

MSC: Applying

51. Approximately how many feet are in 2 meters?

a. 1.3
c. 6
b. 4
d. 12

ANS: C DIF: Medium REF: 1.3

OBJ: Working It Out 1.1c Convert between different units of length, time, and speed.

MSC: Applying

52. Approximately how many meters are in 9 ft?

a. 3
c. 12
b. 4
d. 36

ANS: A DIF: Difficult REF: 1.3

OBJ: Working It Out 1.1c Convert between different units of length, time, and speed.

MSC: Applying

SHORT ANSWER

1. What is the ONLY thing that makes the Sun an exceptional star?

ANS:

The fact that it is *our* star!

DIF: Easy REF: 1.1

OBJ: 1.1b Differentiate the various components of our cosmic address.

MSC: Understanding

2. Describe the location of the Sun in the Milky Way Galaxy.

ANS:

The Sun is located in the disk about halfway out from the center of the Milky Way Galaxy.

DIF: Easy REF: 1.1

OBJ: 1.1b Differentiate the various components of our cosmic address.

MSC: Remembering

3. Describe the shape, size, and composition of the Milky Way Galaxy.

   ANS:

   A flattened disk with spiral arms around 100,000 light-years wide, it is composed of about 100 billion stars (including our Sun), gas, and dust.

   DIF: Medium REF: 1.1

   OBJ: 1.1b Differentiate the various components of our cosmic address.

   MSC: Remembering

4. Name five places where people or space probes have visited beyond Earth.

   ANS:

   People: Moon; probe landings: Venus, Mars, Titan, a comet, an asteroid; probe orbit or flyby: all planets, Pluto, some comets, asteroids, interstellar space, and the Sun

   DIF: Medium REF: 1.1

   OBJ: 1.1d List the means by which we explore our universe.

   MSC: Remembering

5. If the elements that make up Earth and our bodies were not present in the early universe, where did they come from?

   ANS:

   They were formed by nuclear fusion inside stars and supernovae.

   DIF: Easy REF: 1.1

   OBJ: 1.1c List the types of objects found in our Solar System.

MSC: Applying

6. Why might the universe be described as a sort of “time machine”?

   ANS:

   The finite speed of light means that objects observed at larger distances are observed as they existed further in the past.

   DIF: Easy REF: 1.1

   OBJ: 1.1e Relate astronomical distances with the travel time of light.

   MSC: Remembering

7. What is the Local Group?

   ANS:

   The group of a dozen or so galaxies including the Milky Way that are within a few million light-years of each other.

   DIF: Easy REF: 1.1

   OBJ: 1.1b Differentiate the various components of our cosmic address.

   MSC: Remembering

8. Describe how talking about time can give us a feeling for distance.

   ANS:

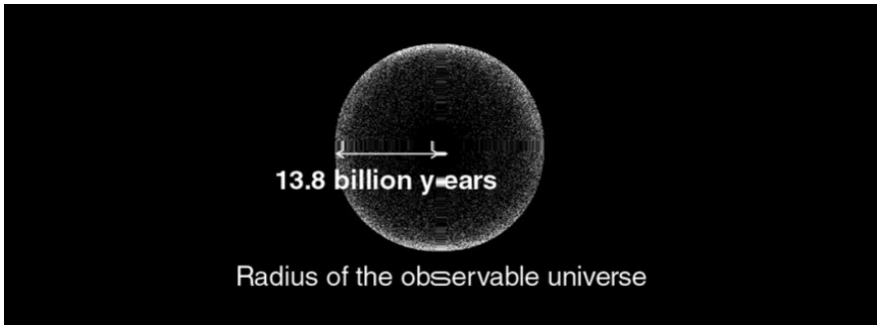
   If speed is constant, a difference in time is directly related to a difference in distance. A time difference is easier to conceptualize.

   DIF: Medium REF: 1.1

   OBJ: 1.1e Relate astronomical distances with the travel time of light.

   MSC: Understanding

9. Refer to the following figure and explain how time can describe distance and the significance of this particular time.



ANS:

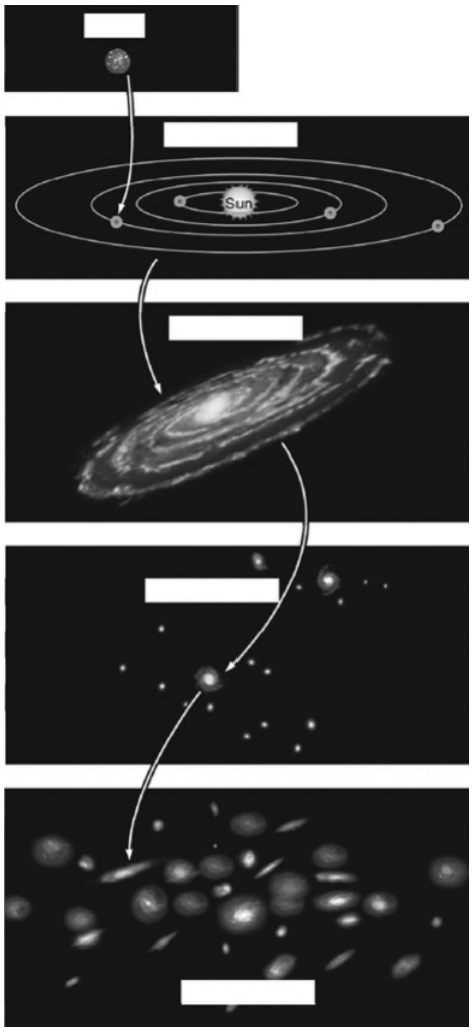
Using the constant speed of light, it tells us the distance to the edge of the observable universe and its age.

DIF: Medium REF: 1.1

OBJ: 1.1e Relate astronomical distances with the travel time of light.

MSC: Understanding

10. The following figure shows images representing our place in the universe. Label each box with its appropriate location.



ANS:

Top to bottom: Earth, Solar System, Milky Way Galaxy, Local Group, Virgo Supercluster.

DIF: Medium REF: 1.1

OBJ: 1.1a List our cosmic address.

MSC: Remembering

11. Suppose you were writing to a pen pal across the 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: 1.1

OBJ: 1.1a List our cosmic address.

MSC: Remembering

12. Name three dwarf planets.

ANS:

Pluto, Ceres, Eris.

DIF: Medium REF: 1.1

OBJ: 1.1c List the types of objects found in our Solar System.

MSC: Remembering

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

ANS:

Massive stars make heavy elements during their lifetimes. 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 star systems (and everything in them, including, in the specific example of the Solar system, us!).

DIF: Medium REF: 1.1

OBJ: 1.1c List the types of objects found in our Solar System.

MSC: Understanding

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.

2. The physical laws valid on Earth are valid everywhere.

DIF: Easy REF: 1.2

OBJ: 1.2f Understand the cosmological principle and Occam's razor.

MSC: Remembering

15. In pre-Renaissance times, it was believed that celestial objects were made of a different substance than Earth and obeyed different rules. Which modern scientific principle is a better description of the universe?

ANS:

The cosmological principle.

DIF: Medium REF: 1.2

OBJ: 1.2f Understand the cosmological principle and Occam's razor.

MSC: Applying

16. Why does a theory that continues to be supported by the results of experimental tests need further tests?

ANS:

There may be observational tests or measurements that might be performed with greater precision for which the predictions of the theory might fail.

DIF: Medium REF: 1.2

OBJ: 1.2c Explain what makes a scientific theory falsifiable.

MSC: Remembering

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

ANS:

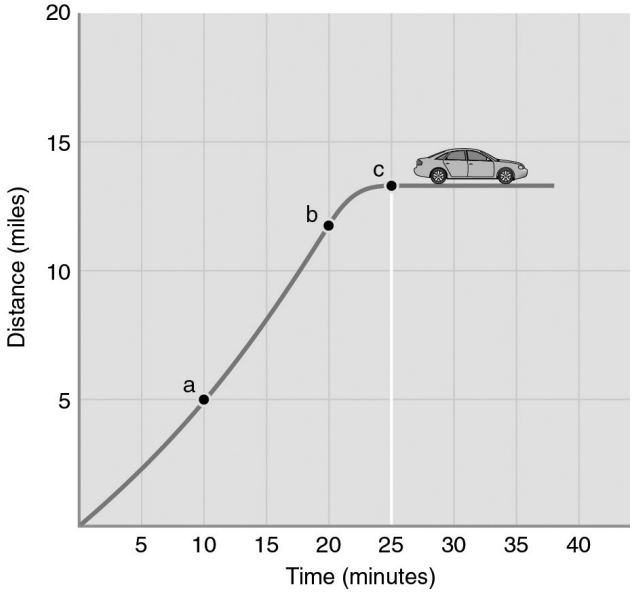
First you make a hypothesis; then you make a prediction based on your hypothesis. Finally, you test your prediction through experimentation or observation, prove or disprove your original hypothesis, and revise your hypothesis if necessary.

DIF: Difficult REF: 1.2

OBJ: 1.2d Describe the steps of the scientific method.

MSC: Remembering

18. Referring to the plot in this figure, what is the relationship between the speed of the car and the slope of the graph?



ANS:

The speed of the car at a particular point in time is the slope of the graph position x time at that particular point in time.

DIF: Medium REF: 1.3

OBJ: 1.3a Determine the slope of a line.

MSC: Applying

19. What are the three key pieces of a graph and where are they located?

ANS:

The dependent variable is located on the y-axis, the independent variable is on the x-axis, and the plotted data is in the graph.

DIF: Difficult REF: 1.3

OBJ: 1.3b Interpret data from a graph.

MSC: Remembering

20. What is an example of an independent variable of a graph and where is it located? What makes it independent?

ANS:

Time (x-axis). The experimenter can control it.

DIF: Difficult REF: 1.3

OBJ: 1.3b Interpret data from a graph.

MSC: Understanding