Contents

Assessment Guidelines Based on the Science of Learning

When was the last time you were pleased with the consistency and quality of the assessment supplements that come with introductory texts? If you are like most professors, you probably find that these assessment packages do not always meet your needs. To address this issue, Norton has collaborated with Valerie Shute (Florida State University) and Diego Zapata-Rivera (Educational Testing Services) to develop a methodology for delivering high-quality, valid, and reliable assessment supplements through our test banks and extensive suite of support materials.

WHY A NEW APPROACH?

In evaluating the test banks that accompany introductory texts, we found four substantive problem areas: (a) item types are misclassified, (b) there is a prevalence of low-level (factual) questions that may misrepresent the goals of the course, (c) topics are unevenly distributed—where trivial topics are tested via multiple items while important concepts are not tested at all, and (d) links to the topic are often at a very general level, thus preventing diagnostic use of the item information.

STUDENT COMPETENCIES AND EVIDENCE-CENTERED DESIGN

In December 2007, we conducted a focus group with the brightest minds in educational testing to create a new model for assessment. A good assessment tool needs (a) to define what students need to know and the level of knowledge and skills expected; (b) to include test items that assess the material to be learned at the appropriate level; and (c) to enable instructors to accurately judge students' mastery of the material—what they know, what they don't know, and to what degree—based on the assessment outcomes. Accurate assessments of student mastery allow instructors to focus on areas where students need the most help.

HOW DOES IT WORK?

The Test Bank authors listed the learning objectives from each chapter that they believe are the most important for students to learn. The authors then developed three types of questions designed to test students' knowledge of a particular learning objective. By asking students questions that vary in both type and level of difficulty, instructors can gather different types of evidence, which will allow them to more effectively assess how well students understand specific concepts.

Three Question Types:

1. *Factual questions* (ask What?) test declarative knowledge, including textbook definitions and relationships between two or more pieces of information.
2. *Applied questions* (ask How?) pose problems in a context different from the one in which it was learned, requiring students to draw from their declarative and/or procedural understanding of important concepts.
3. *Conceptual questions* (ask Why?) ask students to draw from their prior experience and use critical thinking skills to take part in qualitative reasoning about the real world.

Three Difficulty Levels:

1. *Easy questions* require a basic understanding of the concepts, definitions, and examples.
2. *Medium questions* direct students to use critical thinking skills, to demonstrate an understanding of core concepts independent of specific textbook examples, and to connect concepts across chapters.
3. *Hard questions* ask students to synthesize textbook concepts with their own experience, making analytical inferences about biological topics and more.

Each question measures and explicitly links to a specific competency and is written with clear, concise, and grammatically correct language that suits the difficulty level of the specific competency being assessed. To ensure the validity of the questions, no extraneous, ambiguous, or confusing material is included, and no slang expressions are used. In developing the questions, every effort has been

made to eliminate bias (e.g., race, gender, cultural, ethnic, regional, handicap, age) to require specific knowledge of material studied, not of general knowledge or experience. This ensures accessibility and validity.

KEY TO THE QUESTION META-DATA

Each question in the Test Bank is tagged with five pieces of information designed to help instructors create the most ideal mix of questions for their quizzes and exams. These tags are:

ANS: the correct answer for each question, or, in the case of some short answer questions, a possible correct answer to the given question

DIF: the difficulty assigned to the problem; problems have been classified as Easy, Medium, or Difficult

REF: the section in the textbook from which a question is drawn

MSC: the knowledge type (see above) the question is designed to test

TOP: the learning objective that the question is designed to test

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, $c = 3 \times 10^8$ 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.

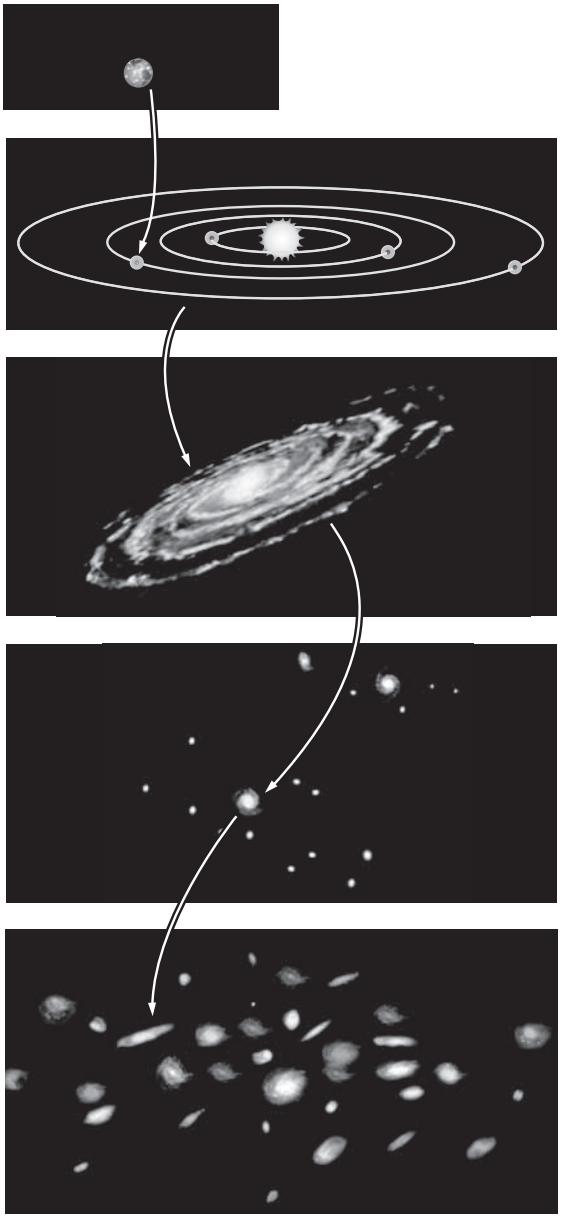
    ANS: T DIF: Easy REF: Section 1.4
    MSC: Factual TOP: 4Ii

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

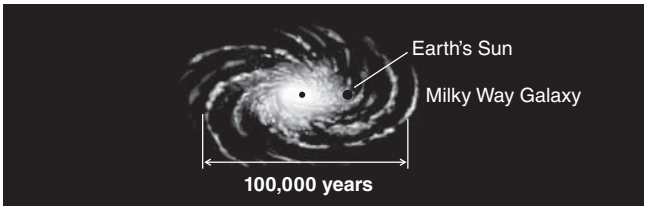
3. Which of the following is FALSE?
a. The Local Group is a member of the Virgo Supercluster, which contains thousands of galaxies.
b. The Local Group contains two large spiral galaxies and a few dozen dwarf galaxies.
c. Our Solar System has eight classical planets.
d. The Milky Way galaxy contains approximately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

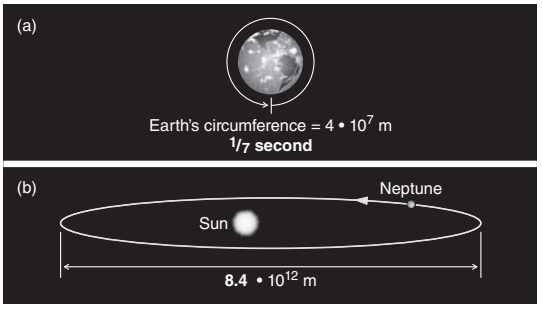
17. The distance to the center of the Virgo cluster of galaxies is 5×10^{23} m. How long does it take light to travel from these galaxies to us?
    a. 7,000 years
    b. 54,000 years
    c. 120,000 years
    d. 12 million years
    e. 54 million years

    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

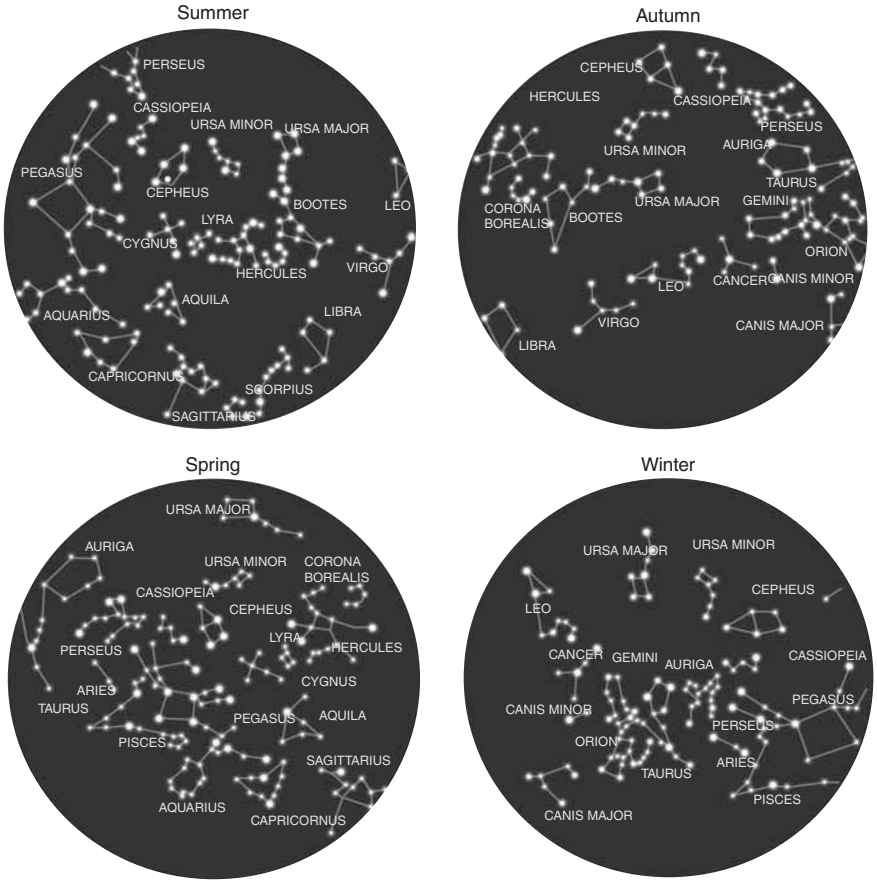
    ANS: B DIF: Easy REF: Section 1.3
    MSC: Conceptual TOP: 3IIii

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. $(6 \times 10^{5}) \times (3 \times 10^{-2}) =$
    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 $V = \frac{4}{3}\pi R^3$. Using algebra to invert this formula, we find that:
    a. $R = \left(\frac{4\pi V}{3}\right)^{1/3}$
    b. $R = \left(\frac{3V}{4(\pi)}\right)^{1/3}$
    c. $R = \left(\frac{4\pi}{3V}\right)^{1/3}$
    d. $\frac{3}{4(V)^3}$
    e. $R = \left(\frac{4\pi V}{3}\right)^{3}$

    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 $A = \frac{1}{4}\pi D^2$. Using algebra to invert this formula, we find that:
    a. $D = \left(\frac{4A}{\pi}\right)^{2}$
    b. $D = \left(\frac{\pi}{4A}\right)^{2}$
    c. $D = \left(\frac{\pi}{4A}\right)^{1/2}$
    d. $D = \left(\frac{4A}{\pi}\right)^{1/2}$
    e. $D = \left(\frac{4A}{\pi}\right)$

    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

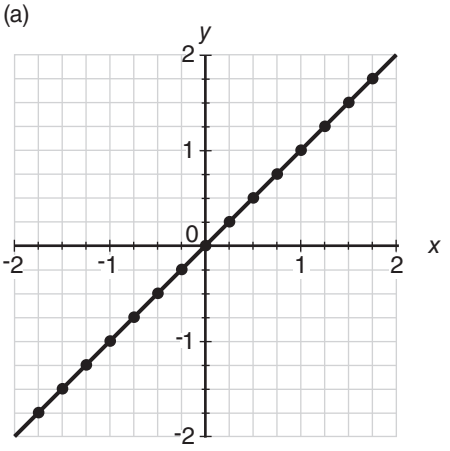
    ANS: A DIF: Difficult REF: Section 1.4
    MSC: Applied TOP: 4IIiv

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

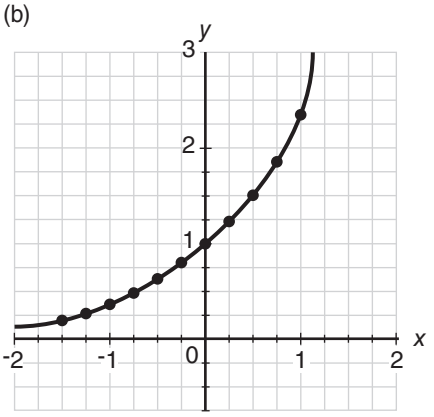
    ANS: C DIF: Difficult REF: Section 1.4
    MSC: Applied TOP: 4IIiv

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

(a)



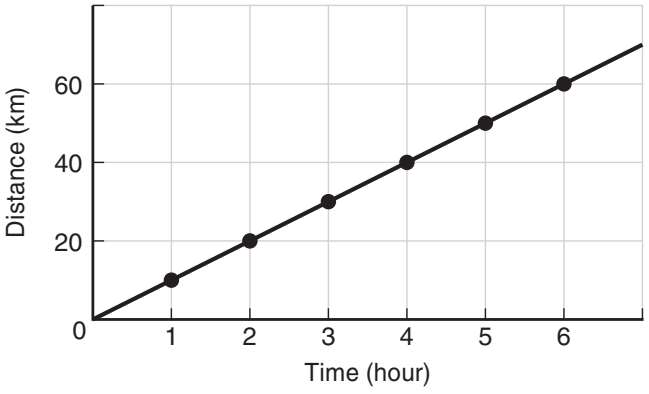
(b)



    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 $2 \times 6378\,\text{km} = 1.3 \times 10^7\,\text{m}$, and $80\,\text{AU} = 80 \times 1.5 \times 10^{11}\,\text{m} = 1.2 \times 10^{13}\,\text{m}$. Thus, the diameter

of the Solar System would be represented by: 1.2×10^{13} m $\times$ (1 minute) / $(1.3 \times 10^{7}$ 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 $\approx 3 \times 4.5$ 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 $t = d / v = 6 \times 10^{12}$ m/$(3 \times 10^{8}$ m/s) = 20,000 s $\times$ (1 hr/3600 s) = 5.5 hr. The time it takes light to travel across the diameter of the Galaxy is $t = 1.2 \times 10^{21}$ m/$(3 \times 10^{8}$ m/s) = 4×10^{12} s $\times$ (1 hr/3600 s) $\times$ (1 day/24 hr) $\times$ (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