KEY TERMS

accuracy how close a measurement is to the correct value for that measurement

ampere the SI unit for electrical current

atom smallest and most basic units of matter

classical physics physics, as it developed from the Renaissance to the end of the nineteenth century

constant a quantity that does not change

conversion factor a ratio expressing how many of one unit are equal to another unit

dependent variable the vertical, or *y*-axis, variable, which changes with (or is dependent on) the value of the independent variable

derived units units that are derived by combining the fundamental physical units

English units (also known as the customary or imperial system) system of measurement used in the United States; includes units of measurement such as feet, gallons, degrees Fahrenheit, and pounds

experiment process involved with testing a hypothesis

exponential relationship relation between variables in which a constant change in the independent variable is accompanied by change in the dependent variable that is proportional to the value it already had

fundamental physical units the seven fundamental physical units in the SI system of units are length, mass, time, electric current, temperature, amount of a substance, and luminous intensity

hypothesis testable statement that describes how something in the natural world works

independent variable the horizontal, or *x*-axis, variable, which is not influence by the second variable on the graph, the dependent variable

inverse proportionality a relation between two variables expressible by an equation of the form $y = k/x$ where k stays constant when x and y change; the special form of inverse relationship that satisfies this equation

inverse relationship any relation between variables where one variable decreases as the other variable increases

kilogram the SI unit for mass, abbreviated (kg)

linear relationships relation between variables that produce a straight line when graphed

log-log plot a plot that uses a logarithmic scale in both axes

logarithmic scale a graphing scale in which each tick on an axis is the previous tick multiplied by some value

meter the SI unit for length, abbreviated (m)

method of adding percents calculating the percent uncertainty of a quantity in multiplication or division by adding the percent uncertainties in the quantities being added or divided

model system that is analogous to the real system of interest in essential ways but more easily analyzed

modern physics physics as developed from the twentieth century to the present, involving the theories of relativity and quantum mechanics

observation step where a scientist observes a pattern or trend within the natural world

order of magnitude the size of a quantity in terms of its power of 10 when expressed in scientific notation

physics science aimed at describing the fundamental aspects of our universe—energy, matter, space, motion, and time

precision how well repeated measurements generate the same or closely similar results

principle description of nature that is true in many, but not all situations

quadratic relationship relation between variables that can be expressed in the form $y = ax^2 + bx + c$, which produces a curved line when graphed

quantum mechanics major theory of modern physics which describes the properties and nature of atoms and their subatomic particles

science the study or knowledge of how the physical world operates, based on objective evidence determined through observation and experimentation

scientific law pattern in nature that is true in all circumstances studied thus far

scientific methods techniques and processes used in the constructing and testing of scientific hypotheses, laws, and theories, and in deciding issues on the basis of experiment and observation

scientific notation way of writing numbers that are too large or small to be conveniently written in simple decimal form; the measurement is multiplied by a power of 10, which indicates the number of placeholder zeros in the measurement

second the SI unit for time, abbreviated (s)

semi-log plot A plot that uses a logarithmic scale on one axis of the graph and a linear scale on the other axis.

SI units International System of Units (SI); the international system of units that scientists in most countries have agreed to use; includes units such as meters, liters, and grams; also known as the metric system

significant figures when writing a number, the digits, or number of digits, that express the precision of a measuring tool used to measure the number

slope the ratio of the change of a graph on the *y* axis to the change along the *x*-axis, the value of m in the equation of a line, $y = mx + b$

theory explanation of patterns in nature that is supported by much scientific evidence and verified multiple times by various groups of researchers

theory of relativity theory constructed by Albert Einstein which describes how space, time and energy are different

for different observers in relative motion

uncertainty a quantitative measure of how much measured values deviate from a standard or expected value

universal applies throughout the known universe

***y*-intercept** the point where a plot line intersects the *y*-axis

SECTION SUMMARY

1.1 Physics: Definitions and Applications

- Physics is the most fundamental of the sciences, concerning itself with energy, matter, space and time, and their interactions.
- Modern physics involves the theory of relativity, which describes how time, space and gravity are not constant in our universe can be different for different observers, and quantum mechanics, which describes the behavior of subatomic particles.
- Physics is the basis for all other sciences, such as chemistry, biology and geology, because physics describes the fundamental way in which the universe functions.

1.2 The Scientific Methods

- Science seeks to discover and describe the underlying order and simplicity in nature.
- The processes of science include observation, hypothesis, experiment, and conclusion.
- Theories are scientific explanations that are supported by a large body experimental results.
- Scientific laws are concise descriptions of the universe that are universally true.

1.3 The Language of Physics: Physical Quantities and Units

- Physical quantities are a characteristic or property of an object that can be measured or calculated from other measurements.
- The four fundamental units we will use in this textbook are the meter (for length), the kilogram (for mass), the second (for time), and the ampere (for electric current). These units are part of the metric system, which uses powers of 10 to relate quantities over the vast ranges encountered in nature.
- Unit conversions involve changing a value expressed in one type of unit to another type of unit. This is done by using conversion factors, which are ratios relating equal quantities of different units.
- Accuracy of a measured value refers to how close a measurement is to the correct value. The uncertainty in a measurement is an estimate of the amount by which the measurement result may differ from this value.
- Precision of measured values refers to how close the agreement is between repeated measurements.
- Significant figures express the precision of a measuring tool.
- When multiplying or dividing measured values, the final answer can contain only as many significant figures as the least precise value.
- When adding or subtracting measured values, the final answer cannot contain more decimal places than the least precise value.

KEY EQUATIONS

1.3 The Language of Physics: Physical Quantities and Units

slope intercept form	$y = mx + b$
quadratic formula	$y = ax^2 + bx + c$
positive exponential formula	$y = a^x$
negative exponential formula	$y = a^{-x}$

CHAPTER REVIEW

Concept Items

1.1 Physics: Definitions and Applications

1. Which statement best compares and contrasts the aims and topics of natural philosophy had versus physics?
   a. Natural philosophy included all aspects of nature including physics.
   b. Natural philosophy included all aspects of nature excluding physics.
   c. Natural philosophy and physics are different.
   d. Natural philosophy and physics are essentially the

same thing.

2. Which of the following is not an underlying assumption essential to scientific understanding?
   a. Characteristics of the physical universe can be perceived and objectively measured by human beings.
   b. Explanations of natural phenomena can be established with absolute certainty.
   c. Fundamental physical processes dictate how characteristics of the physical universe evolve.
   d. The fundamental processes of nature operate the same way everywhere and at all times.

3. Which of the following questions regarding a strain of genetically modified rice is not one that can be answered by science?
   a. How does the yield of the genetically modified rice compare with that of existing rice?
   b. Is the genetically modified rice more resistant to infestation than existing rice?
   c. How does the nutritional value of the genetically modified rice compare to that of existing rice?
   d. Should the genetically modified rice be grown commercially and sold in the marketplace?

4. What conditions imply that we can use classical physics without considering special relativity or quantum mechanics?
   a. 1. matter is moving at speeds of less than roughly 1 percent the speed of light,
      2. objects are large enough to be seen with the naked eye, and
      3. there is the involvement of a strong gravitational field.

   b. 1. matter is moving at speeds greater than roughly 1 percent the speed of light,
      2. objects are large enough to be seen with the naked eye, and
      3. there is the involvement of a strong gravitational field.

   c. 1. matter is moving at speeds of less than roughly 1 percent the speed of light,
      2. objects are too small to be seen with the naked eye, and
      3. there is the involvement of only a weak gravitational field.

   d. 1. matter is moving at speeds of less than roughly 1 percent the speed of light,
      2. objects are large enough to be seen with the naked eye, and
      3. there is the involvement of a weak gravitational field.

5. How could physics be useful in weather prediction?
   a. Physics helps in predicting how burning fossil fuel releases pollutants.
   b. Physics helps in predicting dynamics and movement of weather phenomena.
   c. Physics helps in predicting the motion of tectonic plates.
   d. Physics helps in predicting how the flowing water affects Earth's surface.

6. How do physical therapists use physics while on the job? Explain.
   a. Physical therapists do not require knowledge of physics because their job is mainly therapy and not physics.
   b. Physical therapists do not require knowledge of physics because their job is more social in nature and unscientific.
   c. Physical therapists require knowledge of physics know about muscle contraction and release of energy.
   d. Physical therapists require knowledge of physics to know about chemical reactions inside the body and make decisions accordingly.

7. What is meant when a physical law is said to be universal?
   a. The law can explain everything in the universe.
   b. The law is applicable to all physical phenomena.
   c. The law applies everywhere in the universe.
   d. The law is the most basic one and all laws are derived from it.

8. What subfield of physics could describe small objects traveling at high speeds or experiencing a strong gravitational field?
   a. general theory of relativity
   b. classical physics
   c. quantum relativity
   d. special theory of relativity

9. Why is Einstein's theory of relativity considered part of modern physics, as opposed to classical physics?
   a. Because it was considered less outstanding than the classics of physics, such as classical mechanics.
   b. Because it was popular physics enjoyed by average people today, instead of physics studied by the elite.
   c. Because the theory deals with very slow-moving objects and weak gravitational fields.
   d. Because it was among the new 19th-century discoveries that changed physics.

1.2 The Scientific Methods

10. Describe the difference between an observation and a hypothesis.

a. An observation is seeing what happens; a hypothesis is a testable, educated guess.
b. An observation is a hypothesis that has been confirmed.
c. Hypotheses and observations are independent of each other.
d. Hypotheses are conclusions based on some observations.

11. Describe how modeling is useful in studying the structure of the atom.
a. Modeling replaces the real system by something similar but easier to examine.
b. Modeling replaces the real system by something more interesting to examine.
c. Modeling replaces the real system by something with more realistic properties.
d. Modeling includes more details than are present in the real system.

12. How strongly is a hypothesis supported by evidence compared to a theory?
a. A theory is supported by little evidence, if any, at first, while a hypothesis is supported by a large amount of available evidence.
b. A hypothesis is supported by little evidence, if any, at first. A theory is supported by a large amount of available evidence.
c. A hypothesis is supported by little evidence, if any, at first. A theory does not need any experiments in support.
d. A theory is supported by little evidence, if any, at first. A hypothesis does not need any experiments in support.

1.3 The Language of Physics: Physical Quantities and Units

13. Which of the following does not contribute to the uncertainty?
a. the limitations of the measuring device
b. the skill of the person making the measurement
c. the regularities in the object being measured
d. other factors that affect the outcome (depending on the situation)

14. How does the independent variable in a graph differ from the dependent variable?
a. The dependent variable varies linearly with the independent variable.
b. The dependent variable depends on the scale of the axis chosen while independent variable does not.
c. The independent variable is directly manipulated or controlled by the person doing the experiment, while dependent variable is the one that changes as a result.
d. The dependent and independent variables are fixed by a convention and hence they are the same.

15. What could you conclude about these two lines?

1. Line A has a slope of -4.7
2. Line B has a slope of 12.0

a. Line A is a decreasing line while line B is an increasing line, with line A being much steeper than line B.
b. Line A is a decreasing line while line B is an increasing line, with line B being much steeper than line A.
c. Line B is a decreasing line while line A is an increasing line, with line A being much steeper than line B.
d. Line B is a decreasing line while line A is an increasing line, with line B being much steeper than line A.

16. Velocity, or speed, is measured using the following formula: $v = \frac{d}{t}$, where v is velocity, d is the distance travelled, and t is the time the object took to travel the distance. If the velocity-time data are plotted on a graph, which variable will be on which axis? Why?
a. Time would be on the x-axis and velocity on the y-axis, because time is an independent variable and velocity is a dependent variable.
b. Velocity would be on the x-axis and time on the y-axis, because time is the independent variable and velocity is the dependent variable.
c. Time would be on the x-axis and velocity on the y-axis, because time is a dependent variable and velocity is a independent variable.
d. Velocity would be on x-axis and time on the y-axis, because time is a dependent variable and velocity is a independent variable.

17. The uncertainty of a triple-beam balance is $0.05\ \text{g}$. What is the percent uncertainty in a measurement of $0.445\ \text{kg}$?
a. 0.011%
b. 0.11%
c. 1.1%
d. 11%

18. What is the definition of uncertainty?
a. Uncertainty is the number of assumptions made prior to the measurement of a physical quantity.
b. Uncertainty is a measure of error in a measurement due to the use of a non-calibrated instrument.
c. Uncertainty is a measure of deviation of the measured value from the standard value.
d. Uncertainty is a measure of error in measurement

due to external factors like air friction and temperature.

Critical Thinking Items

1.1 Physics: Definitions and Applications

19. In what sense does Einstein's theory of relativity illustrate that physics describes fundamental aspects of our universe?

a. It describes how speed affects different observers' measurements of time and space.
b. It describes how different parts of the universe are far apart and do not affect each other.
c. It describes how people think of other people's views from their own frame of reference.
d. It describes how a frame of reference is necessary to describe position or motion.

20. Can classical physics be used to accurately describe a satellite moving at a speed of 7500 m/s? Explain why or why not.

a. No, because the satellite is moving at a speed much smaller than the speed of the light and is not in a strong gravitational field.
b. No, because the satellite is moving at a speed much smaller than the speed of the light and is in a strong gravitational field.
c. Yes, because the satellite is moving at a speed much smaller than the speed of the light and it is not in a strong gravitational field.
d. Yes, because the satellite is moving at a speed much smaller than the speed of the light and is in a strong gravitational field.

21. What would be some ways in which physics was involved in building the features of the room you are in right now?

a. Physics is involved in structural strength, dimensions, etc., of the room.
b. Physics is involved in the air composition inside the room.
c. Physics is involved in the desk arrangement inside the room.
d. Physics is involved in the behavior of living beings inside the room.

22. What theory of modern physics describes the interrelationships between space, time, speed, and gravity?

a. atomic theory
b. nuclear physics
c. quantum mechanics
d. general relativity

23. According to Einstein's theory of relativity, how could you effectively travel many years into Earth's future, but not age very much yourself?

a. by traveling at a speed equal to the speed of light
b. by traveling at a speed faster than the speed of light
c. by traveling at a speed much slower than the speed of light
d. by traveling at a speed slightly slower than the speed of light

1.2 The Scientific Methods

24. You notice that the water level flowing in a stream near your house increases when it rains and the water turns brown. Which of these are the best hypothesis to explain why the water turns brown. Assume you have all of the means to test the contents of the stream water.

a. The water in the stream turns brown because molecular forces between water molecules are stronger than mud molecules
b. The water in the stream turns brown because of the breakage of a weak chemical bond with the hydrogen atom in the water molecule.
c. The water in the stream turns brown because it picks up dirt from the bank as the water level increases when it rains.
d. The water in the stream turns brown because the density of the water increases with increase in water level.

25. Light travels as waves at an approximate speed of 300,000,000 m/s (186,000 mi/s). Designers of devices that use mirrors and lenses model the traveling light by straight lines, or light rays. Describe why it would be useful to model the light as rays of light instead of describing them accurately as electromagnetic waves.

a. A model can be constructed in such a way that the speed of light decreases.
b. Studying a model makes it easier to analyze the path that the light follows.
c. Studying a model will help us to visualize why light travels at such great speed.
d. Modeling cannot be used to study traveling light as our eyes cannot track the motion of light.

26. A friend says that he doesn't trust scientific explanations because they are just theories, which are basically educated guesses. What could you say to convince him that scientific theories are different from the everyday use of the word theory?

a. A theory is a scientific explanation that has been repeatedly tested and supported by many experiments.
b. A theory is a hypothesis that has been tested and

supported by some experiments.
c. A theory is a set of educated guesses, but at least one of the guesses remain true in each experiment.
d. A theory is a set of scientific explanations that has at least one experiment in support of it.

27. Give an example of a hypothesis that cannot be tested experimentally.
a. The structure of any part of the broccoli is similar to the whole structure of the broccoli.
b. Ghosts are the souls of people who have died.
c. The average speed of air molecules increases with temperature.
d. A vegetarian is less likely to be affected by night blindness.

28. Would it be possible to scientifically prove that a supreme being exists or not? Briefly explain your answer.
a. It can be proved scientifically because it is a testable hypothesis.
b. It cannot be proved scientifically because it is not a testable hypothesis.
c. It can be proved scientifically because it is not a testable hypothesis.
d. It cannot be proved scientifically because it is a testable hypothesis.

1.3 The Language of Physics: Physical Quantities and Units

29. A marathon runner completes a $42.188\ \text{km}$ course in $2\ \text{h}$, $30\ \text{min}$, and $12\ \text{s}$. There is an uncertainty of $25\ \text{m}$ in the distance traveled and an uncertainty of $1\ \text{s}$ in the elapsed time.

1. Calculate the percent uncertainty in the distance.
2. Calculate the uncertainty in the elapsed time.
3. What is the average speed in meters per second?
4. What is the uncertainty in the average speed?

a. $0.059\ \%, 0.01\ \%, 0.468\text{m/s}, 0.0003\text{m/s}$
b. $0.059\ \%, 0.01\ \%, 0.468\ \text{m/s}, 0.07\ \text{m/s}$
c. $0.59\ \%, 8.33\ \%, 4.681\ \text{m/s}, 0.003\ \text{m/s}$
d. $0.059\ \%, 0.01\ \%, 4.681\ \text{m/s}, 0.003\ \text{m/s}$

30. A car engine moves a piston with a circular cross section of $7.500 \pm 0.002\ \text{cm}$ diameter a distance of $3.250 \pm 0.001\ \text{cm}$ to compress the gas in the cylinder. By what amount did the gas decrease in volume in cubic centimeters? Find the uncertainty in this volume.
a. $143.6 \pm 0.002\ \text{cm}^3$
b. $143.6 \pm 0.003\ \text{cm}^3$
c. $143.6 \pm 0.005\ \text{cm}^3$
d. $143.6 \pm 0.1\ \text{cm}^3$

31. What would be the slope for a line passing through the two points below?

Point 1: (1, 0.1) Point 2: (7, 26.8)

a. 2.4
b. 4.5
c. 6.2
d. 6.8

32. The sides of a small rectangular box are measured $1.80\ \text{cm}$ and $2.05\ \text{cm}$ long and $3.1\ \text{cm}$ high. Calculate its volume and uncertainty in cubic centimeters. Assume the measuring device is accurate to $\pm 0.05\ \text{cm}$.
a. $11.4 \pm 0.1\ \text{cm}^3$
b. $11.4 \pm 0.6\ \text{cm}^3$
c. $11.4 \pm 0.8\ \text{cm}^3$
d. $11.4 \pm 0.10\ \text{cm}^3$

33. Calculate the approximate number of atoms in a bacterium. Assume that the average mass of an atom in the bacterium is ten times the mass of a hydrogen atom. (Hint—The mass of a hydrogen atom is on the order of 10^{-27} kg and the mass of a bacterium is on the order of 10^{-15} kg .)
a. 10^{10} atoms
b. 10^{11} atoms
c. 10^{12} atoms
d. 10^{13} atoms

Problems

1.3 The Language of Physics: Physical Quantities and Units

34. A commemorative coin that sells for $40 is advertised to be plated with 15 mg of gold. Suppose gold is worth about $1,300 per ounce. Which of the following best represents the value of the gold in the coin?
a. $0.33
b. $0.69
c. $3.30
d. $6.90

35. If a marathon runner runs $9.5\ \text{miles}$ in one direction, $8.89\ \text{miles}$ in another direction and $2.333\ \text{miles}$ in a third direction, how much distance did the runner run? Be sure to report your answer using the proper number of significant figures.
a. 20
b. 20.7
c. 20.72

d. 20.732

36. The speed limit on some interstate highways is roughly 80 km/h. What is this in meters per second? How many miles per hour is this?
a. 62 m/s, 27.8 mi/h
b. 22.2 m/s, 49.7 mi/h
c. 62 m/s, 2.78 mi/h
d. 2.78 m/s, 62 mi/h

37. The length and width of a rectangular room are measured to be 3.955 ± 0.005 m by 3.050 ± 0.005 m. Calculate the area of the room and its uncertainty in square meters.
a. $12.06 \pm 0.29\ \text{m}^2$
b. $12.06 \pm 0.01\ \text{m}^2$
c. $12.06 \pm 0.25\ \text{m}^2$
d. $12.06 \pm 0.04\ \text{m}^2$

Performance Task

1.3 The Language of Physics: Physical Quantities and Units

38. a. Create a new system of units to describe something that interests you. Your unit should be described using at least two subunits. For example, you can decide to measure the quality of songs using a new unit called *song awesomeness*. Song awesomeness is measured by: the number of songs downloaded and the number of times the song was used in movies.
b. Create an equation that shows how to calculate your unit. Then, using your equation, create a sample dataset that you could graph. Are your two subunits related linearly, quadratically, or inversely?

TEST PREP

Multiple Choice

1.1 Physics: Definitions and Applications

39. Modern physics could best be described as the combination of which theories?
a. quantum mechanics and Einstein's theory of relativity
b. quantum mechanics and classical physics
c. Newton's laws of motion and classical physics
d. Newton's laws of motion and Einstein's theory of relativity

40. Which of the following could be studied accurately using classical physics?
a. the strength of gravity within a black hole
b. the motion of a plane through the sky
c. the collisions of subatomic particles
d. the effect of gravity on the passage of time

41. Which of the following best describes why knowledge of physics is necessary to understand all other sciences?
a. Physics explains how energy passes from one object to another.
b. Physics explains how gravity works.
c. Physics explains the motion of objects that can be seen with the naked eye.
d. Physics explains the fundamental aspects of the universe.

42. What does radiation therapy, used to treat cancer patients, have to do with physics?
a. Understanding how cells reproduce is mainly about physics.
b. Predictions of the side effects from the radiation therapy are based on physics.
c. The devices used for generating some kinds of radiation are based on principles of physics.
d. Predictions of the life expectancy of patients receiving radiation therapy are based on physics.

1.2 The Scientific Methods

43. The free-electron model of metals explains some of the important behaviors of metals by assuming the metal's electrons move freely through the metal without repelling one another. In what sense is the free-electron theory based on a model?
a. Its use requires constructing replicas of the metal wire in the lab.
b. It involves analyzing an imaginary system simpler than the real wire it resembles.
c. It examines a model, or ideal, behavior that other metals should imitate.
d. It attempts to examine the metal in a very realistic, or model, way.

44. A scientist wishes to study the motion of about 1,000 molecules of gas in a container by modeling them as tiny billiard balls bouncing randomly off one another. Which of the following is needed to calculate and store data on their detailed motion?
a. a group of hypotheses that cannot be practically tested in real life

b. a computer that can store and perform calculations on large data sets
c. a large amount of experimental results on the molecules and their motion
d. a collection of hypotheses that have not yet been tested regarding the molecules

45. When a large body of experimental evidence supports a hypothesis, what may the hypothesis eventually be considered?
a. observation
b. insight
c. conclusion
d. law

46. While watching some ants outside of your house, you notice that the worker ants gather in a specific area on your lawn. Which of the following is a testable hypothesis that attempts to explain why the ants gather in that specific area on the lawn.
a. The worker thought it was a nice location.
b. because ants may have to find a spot for the queen to lay eggs
c. because there may be some food particles lying there
d. because the worker ants are supposed to group together at a place.

1.3 The Language of Physics: Physical Quantities and Units

47. Which of the following would describe a length that is 2.0×10^{-3} of a meter?
a. 2.0 kilometers
b. 2.0 megameters
c. 2.0 millimeters
d. 2.0 micrometers

48. Suppose that a bathroom scale reads a person's mass as 65 kg with a 3 percent uncertainty. What is the uncertainty in their mass in kilograms?
a. a. 2 kg
b. b. 98 kg
c. c. 5 kg
d. d. 0

49. Which of the following best describes a variable?
a. a trend that shows an exponential relationship
b. something whose value can change over multiple measurements
c. a measure of how much a plot line changes along the y-axis
d. something that remains constant over multiple measurements

50. A high school track coach has just purchased a new stopwatch that has an uncertainty of ±0.05 s . Runners on the team regularly clock 100-m sprints in 12.49 s to 15.01 s . At the school's last track meet, the first-place sprinter came in at 12.04 s and the second-place sprinter came in at 12.07 s . Will the coach's new stopwatch be helpful in timing the sprint team? Why or why not?
a. No, the uncertainty in the stopwatch is too large to effectively differentiate between the sprint times.
b. No, the uncertainty in the stopwatch is too small to effectively differentiate between the sprint times.
c. Yes, the uncertainty in the stopwatch is too large to effectively differentiate between the sprint times.
d. Yes, the uncertainty in the stopwatch is too small to effectively differentiate between the sprint times.

Short Answer

1.1 Physics: Definitions and Applications

51. Describe the aims of physics.
a. Physics aims to explain the fundamental aspects of our universe and how these aspects interact with one another.
b. Physics aims to explain the biological aspects of our universe and how these aspects interact with one another.
c. Physics aims to explain the composition, structure and changes in matter occurring in the universe.
d. Physics aims to explain the social behavior of living beings in the universe.

52. Define the fields of magnetism and electricity and state how are they are related.
a. Magnetism describes the attractive force between a magnetized object and a metal like iron. Electricity involves the study of electric charges and their movements. Magnetism is not related to the electricity.
b. Magnetism describes the attractive force between a magnetized object and a metal like iron. Electricity involves the study of electric charges and their movements. Magnetism is produced by a flow electrical charges.
c. Magnetism involves the study of electric charges and their movements. Electricity describes the attractive force between a magnetized object and a metal. Magnetism is not related to the electricity.
d. Magnetism involves the study of electric charges and their movements. Electricity describes the attractive force between a magnetized object and a metal. Magnetism is produced by the flow electrical charges.

53. Describe what two topics physicists are trying to unify with relativistic quantum mechanics. How will this unification create a greater understanding of our universe?

a. Relativistic quantum mechanics unifies quantum mechanics with Einstein's theory of relativity. The unified theory creates a greater understanding of our universe because it can explain objects of all sizes and masses.
b. Relativistic quantum mechanics unifies classical mechanics with Einstein's theory of relativity. The unified theory creates a greater understanding of our universe because it can explain objects of all sizes and masses.
c. Relativistic quantum mechanics unifies quantum mechanics with Einstein's theory of relativity. The unified theory creates a greater understanding of our universe because it is unable to explain objects of all sizes and masses.
d. Relativistic quantum mechanics unifies classical mechanics with the Einstein's theory of relativity. The unified theory creates a greater understanding of our universe because it is unable to explain objects of all sizes and masses.

54. The findings of studies in quantum mechanics have been described as strange or weird compared to those of classical physics. Explain why this would be so.

a. It is because the phenomena it explains are outside the normal range of human experience which deals with much larger objects.
b. It is because the phenomena it explains can be perceived easily, namely, ordinary-sized objects.
c. It is because the phenomena it explains are outside the normal range of human experience, namely, the very large and the very fast objects.
d. It is because the phenomena it explains can be perceived easily, namely, the very large and the very fast objects.

55. How could knowledge of physics help you find a faster way to drive from your house to your school?

a. Physics can explain the traffic on a particular street and help us know about the traffic in advance.
b. Physics can explain about the ongoing construction of roads on a particular street and help us know about delays in the traffic in advance.
c. Physics can explain distances, speed limits on a particular street and help us categorize faster routes.
d. Physics can explain the closing of a particular street and help us categorize faster routes.

56. How could knowledge of physics help you build a sound and energy-efficient house?

a. An understanding of force, pressure, heat, electricity, etc., which all involve physics, will help me design a sound and energy-efficient house.
b. An understanding of the air composition, chemical composition of matter, etc., which all involves physics, will help me design a sound and energy-efficient house.
c. An understanding of material cost and economic factors involving physics will help me design a sound and energy-efficient house.
d. An understanding of geographical location and social environment which involves physics will help me design a sound and energy-efficient house.

57. What aspects of physics would a chemist likely study in trying to discover a new chemical reaction?

a. Physics is involved in understanding whether the reactants and products dissolve in water.
b. Physics is involved in understanding the amount of energy released or required in a chemical reaction.
c. Physics is involved in what the products of the reaction will be.
d. Physics is involved in understanding the types of ions produced in a chemical reaction.

1.2 The Scientific Methods

58. You notice that it takes more force to get a large box to start sliding across the floor than it takes to get the box sliding faster once it is already moving. Create a testable hypothesis that attempts to explain this observation.

a. The floor has greater distortions of space-time for moving the sliding box faster than for the box at rest.
b. The floor has greater distortions of space-time for the box at rest than for the sliding box.
c. The resistance between the floor and the box is less when the box is sliding then when the box is at rest.
d. The floor dislikes having objects move across it and therefore holds the box rigidly in place until it cannot resist the force.

59. Design an experiment that will test the following hypothesis: driving on a gravel road causes greater damage to a car than driving on a dirt road.

a. To test the hypothesis, compare the damage to the car by driving it on a smooth road and a gravel road.
b. To test the hypothesis, compare the damage to the car by driving it on a smooth road and a dirt road.
c. To test the hypothesis, compare the damage to the car by driving it on a gravel road and the dirt road.
d. This is not a testable hypothesis.

60. How is a physical model, such as a spherical mass held

in place by springs, used to represent an atom vibrating in a solid, similar to a computer-based model, such as that predicting how gravity affects the orbits of the planets?

a. Both a physical model and a computer-based model should be built around a hypothesis and could be able to test the hypothesis.
b. Both a physical model and a computer-based model should be built around a hypothesis but they cannot be used to test the hypothesis.
c. Both a physical model and a computer-based model should be built around the results of scientific studies and could be used to make predictions about the system under study.
d. Both a physical model and a computer-based model should be built around the results of scientific studies but cannot be used to make predictions about the system under study.

61. Explain the advantages and disadvantages of using a model to predict a life-or-death situation, such as whether or not an asteroid will strike Earth.

a. The advantage of using a model is that it provides predictions quickly, but the disadvantage of using a model is that it could make erroneous predictions.
b. The advantage of using a model is that it provides accurate predictions, but the disadvantage of using a model is that it takes a long time to make predictions.
c. The advantage of using a model is that it provides predictions quickly without any error. There are no disadvantages of using a scientific model.
d. The disadvantage of using models is that it takes longer time to make predictions and the predictions are inaccurate. There are no advantages to using a scientific model.

62. A friend tells you that a scientific law cannot be changed. State whether or not your friend is correct and then briefly explain your answer.

a. Correct, because laws are theories that have been proved true.
b. Correct, because theories are laws that have been proved true.
c. Incorrect, because a law is changed if new evidence contradicts it.
d. Incorrect, because a law is changed when a theory contradicts it.

63. How does a scientific law compare to a local law, such as that governing parking at your school, in terms of whether or not laws can be changed, and how universal a law is?

a. A local law applies only in a specific area, but a scientific law is applicable throughout the universe. Both the local law and the scientific law can change.
b. A local law applies only in a specific area, but a scientific law is applicable throughout the universe. A local law can change, but a scientific law cannot be changed.
c. A local law applies throughout the universe but a scientific law is applicable only in a specific area. Both the local and the scientific law can change.
d. A local law applies throughout the universe, but a scientific law is applicable only in a specific area. A local law can change, but a scientific law cannot be changed.

64. Can the validity of a model be limited, or must it be universally valid? How does this compare to the required validity of a theory or a law?

a. Models, theories and laws must be universally valid.
b. Models, theories, and laws have only limited validity.
c. Models have limited validity while theories and laws are universally valid.
d. Models and theories have limited validity while laws are universally valid.

1.3 The Language of Physics: Physical Quantities and Units

65. The speed of sound is measured at 342 m/s on a certain day. What is this in km/h? Report your answer in scientific notation.

a. 1.23×10^4 km/h
b. 1.23×10^3 km/h
c. 9.5×10^1 km/h
d. 2.05×10^{-1} km/h

66. Describe the main difference between the metric system and the U.S. Customary System.

a. In the metric system, unit changes are based on powers of 10, while in the U.S. customary system, each unit conversion has unrelated conversion factors.
b. In the metric system, each unit conversion has unrelated conversion factors, while in the U.S. customary system, unit changes are based on powers of 10.
c. In the metric system, unit changes are based on powers of 2, while in the U.S. customary system, each unit conversion has unrelated conversion factors.
d. In the metric system, each unit conversion has unrelated conversion factors, while in the U.S. customary system, unit changes are based on

powers of 2.

67. An infant's pulse rate is measured to be 130 ± 5 beats/min. What is the percent uncertainty in this measurement?

a. 2%
b. 3%
c. 4%
d. 5%

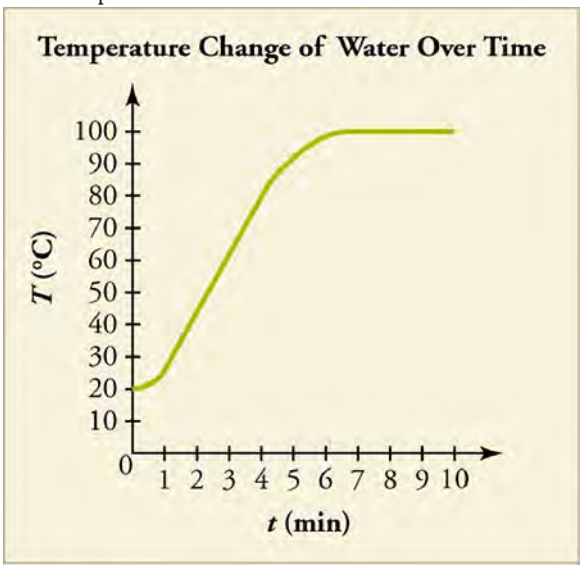
68. Explain how the uncertainty of a measurement relates to the accuracy and precision of the measuring device. Include the definitions of accuracy and precision in your answer.

a. A decrease in the precision of a measurement increases the uncertainty of the measurement, while a decrease in accuracy does not.
b. A decrease in either the precision or accuracy of a measurement increases the uncertainty of the measurement.
c. An increase in either the precision or accuracy of a measurement will increase the uncertainty of that measurement.
d. An increase in the accuracy of a measurement will increase the uncertainty of that measurement, while an increase in precision will not.

69. Describe all of the characteristics that can be determined about a straight line with a slope of -3 and a y-intercept of 50 on a graph.

a. Based on the information, the line has a negative slope. Because its y-intercept is 50 and its slope is negative, this line gradually rises on the graph as the x-value increases.
b. Based on the information, the line has a negative slope. Because its y-intercept is 50 and its slope is negative, this line gradually moves downward on the graph as the x-value increases.
c. Based on the information, the line has a positive slope. Because its y-intercept is 50 and its slope is positive, this line gradually rises on the graph as the x-value increases.
d. Based on the information, the line has a positive slope. Because its y-intercept is 50 and its slope is positive, this line gradually moves downward on the graph as the x-value increases.

70. The graph shows the temperature change over time of a heated cup of water.



What is the slope of the graph between the time period 2 min and 5 min?

a. −15 °C/min
b. −0.07 °C/min
c. 0.07 °C/min
d. 15 °C/min

Extended Response

1.2 The Scientific Methods

71. You wish to perform an experiment on the stopping distance of your new car. Create a specific experiment to measure the distance. Be sure to specifically state how you will set up and take data during your experiment.

a. Drive the car at exactly 50 mph and then press harder on the accelerator pedal until the velocity reaches the speed 60 mph and record the distance this takes.
b. Drive the car at exactly 50 mph and then apply the brakes until it stops and record the distance this takes.
c. Drive the car at exactly 50 mph and then apply the brakes until it stops and record the time it takes.
d. Drive the car at exactly 50 mph and then apply the accelerator until it reaches the speed of 60 mph and record the time it takes.

72. You wish to make a model showing how traffic flows around your city or local area. Describe the steps you would take to construct your model as well as some hypotheses that your model could test and the model's limitations in terms of what could not be tested.

a. 1. Testable hypotheses like the gravitational pull on each vehicle while in motion and the average speed of vehicles is 40 mph
   2. Non-testable hypotheses like the average number of vehicles passing is 935 per day and carbon emission from each of the moving vehicle

b. 1. Testable hypotheses like the average number of vehicles passing is 935 per day and the average speed of vehicles is 40 mph
   2. Non-testable hypotheses like the gravitational pull on each vehicle while in motion and the carbon emission from each of the moving vehicle

c. 1. Testable hypotheses like the average number of vehicles passing is 935 per day and the carbon emission from each of the moving vehicle
   2. Non-testable hypotheses like the gravitational pull on each vehicle while in motion and the average speed of the vehicles is 40 mph

d. 1. Testable hypotheses like the average number of vehicles passing is 935 per day and the gravitational pull on each vehicle while in motion
   2. Non-testable hypotheses like the average speed of vehicles is 40 mph and the carbon emission from each of the moving vehicle

73. What would play the most important role in leading to an experiment in the scientific world becoming a scientific law?

a. Further testing would need to show it is a universally followed rule.
b. The observation would have to be described in a published scientific article.
c. The experiment would have to be repeated once or twice.
d. The observer would need to be a well-known scientist whose authority was accepted.

1.3 The Language of Physics: Physical Quantities and Units

74. Tectonic plates are large segments of the Earth's crust that move slowly. Suppose that one such plate has an average speed of $4.0\ \text{cm/year}$. What distance does it move in 1.0 s at this speed? What is its speed in kilometers per million years? Report all of your answers using scientific notation.

a. 1.3×10^{-9} m; 4.0×10^{1} km/million years
b. 1.3×10^{-6} m; 4.0×10^{1} km/million years
c. 1.3×10^{-9} m; 4.0×10^{-11} km/million years
d. 1.3×10^{-6} m; 4.0×10^{-11} km/million years

75. At x = 3, a function f(x) has a positive value, with a positive slope that is decreasing in magnitude with increasing x. Which option could correspond to f(x)?

a. $y = 13x$
b. $y = x^2$
c. $y = 2x + 9$
d. $y = \frac{x}{2} + 9$