Georgia Milestones

Assessment System

Study/Resource Guide

Study/Resource Guide for Students and Parents

Grade 8

The Study/Resource Guides are intended to serve as a resource for parents and students. They contain practice questions and learning activities for each content area. The standards identified in the Study/Resource Guides address a sampling of the state-mandated content standards.

For the purposes of day-to-day classroom instruction, teachers should consult the wide array of resources that can be found at www.georgiastandards.org.

SCIENCE

DESCRIPTION OF TEST FORMAT AND ORGANIZATION

The Grade 8 Science EOG assessment has a total of 76 items.

The test will be given in two sections.

- You may have up to 70 minutes per section to complete Sections 1 and 2.
- The total estimated testing time for the Grade 8 Science EOG assessment ranges from approximately 90 to 140 minutes.

CONTENT

The Grade 8 Science EOG assessment will measure the Grade 8 Science standards that are described at www.georgiastandards.org. The Science Georgia Standards of Excellence are designed to provide foundational knowledge and skills for all students to develop proficiency in science. These standards focus on a limited number of core disciplinary ideas and crosscutting concepts which build from Kindergarten to high school. The standards are written with the core knowledge to be mastered integrated with the science and engineering practices needed to engage in scientific inquiry and engineering design. Crosscutting concepts are used to make connections across different science disciplines.

The content of the assessment covers standards that are reported under these domains:

- Matter
- Energy
- Motion
- Waves
- Force

ITEM TYPES

Operational items in the Science portion of the Grade 8 EOG assessment consist of selected-response (multiple-choice) and technology-enhanced (multiple-select or two-part) items.

GRADE 8 SCIENCE: DOMAIN STRUCTURES AND CONTENT WEIGHTS

Reporting Category	Standards Assessed	Approximate Percentage of Test	Approximate Number of Points
Matter	S8P1 (a, b, c, d, e, f)	28%	17
Energy	S8P2 (a, b, c, d)	18%	11
Motion	S8P3 (a, b, c)	15%	9
Waves	S8P4 (a, b, c, d, e, f, g)	24%	14
Force	S8P5 (a, b, c)	15%	9

SCIENCE DEPTH OF KNOWLEDGE EXAMPLE ITEMS

Example items that represent applicable DOK levels of the Science assessment are provided for you on the following pages. The items and explanations of what is expected of you to answer them will help you prepare for the test.

All example and sample items contained in this guide are the property of the Georgia Department of Education.

Example Item 1

Selected-Response

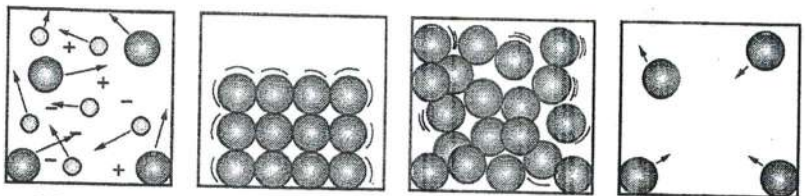
DOK Level 1: This is a DOK level 1 item because the question requires the student to recall information concerning a known relationship between scientific quantities.

Science Grade 8 Content Domain: Matter

Standard: S8P1. Obtain, evaluate, and communicate information about the structure and properties of matter.

b. Develop and use models to describe the movement of particles in solids, liquids, gases, and plasma states when thermal energy is added or removed.

Look at the illustrations.



Model 1 Model 2 Model 3 Model 4

Which model shows the structure and movement of particles in a solid?

A. model 1
B. model 2
C. model 3
D. model 4

Example Item 2

Selected-Response

DOK Level 2: This is a DOK level 2 item because the question requires the student to apply learned information to abstract and real-life situations.

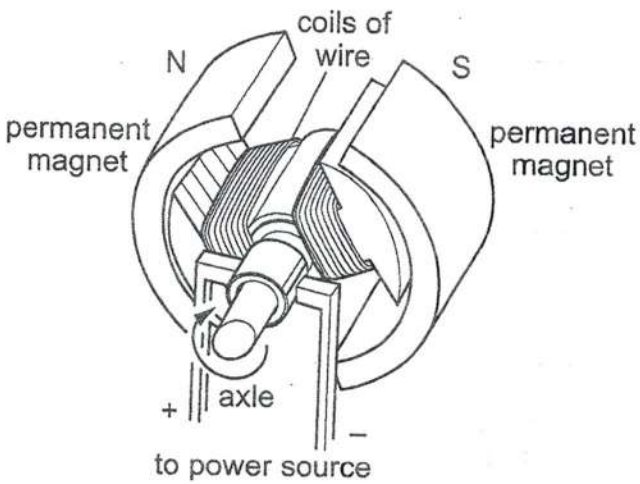
Science Grade 8 Content Domain: Force

Standard: S8P5. Obtain, evaluate, and communicate information about gravity, electricity, and magnetism as major forces acting in nature.

a. Plan and carry out investigations to identify the factors (e.g., distance between objects, magnetic force produced by an electromagnet with varying number of wire turns, varying number or size of dry cells, and varying size of iron core) that affect the strength of electric and magnetic forces. (*Clarification statement*: Including, but not limited to, generators or motors.)

A group of students is investigating the different factors that affect the strength of an electric motor. A diagram of the motor is shown.

Inner Workings of an Electric Motor



What step should the students take next in the investigation to increase the strength of the motor?

A. Reduce the size of the axle running through the center of the motor.

B. Increase the number of coils of wire within the two sections of the motor.

C. Decrease the voltage of the power source being used to operate the motor.

D. Place the permanent magnets and coils of wire farther apart inside the motor.

Example Item 3

Selected-Response

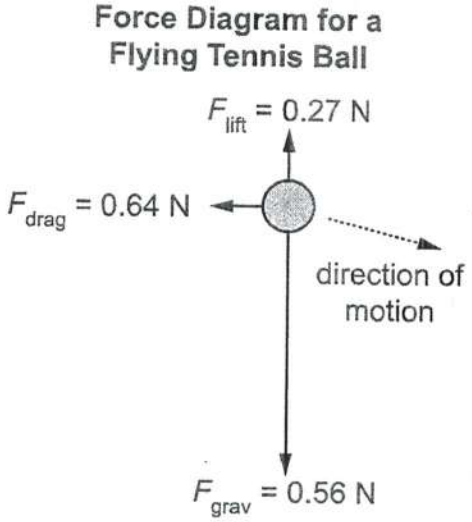
DOK Level 3: This is a DOK level 3 item because the question requires the student to construct arguments supported by evidence, to analyze and interpret data, to construct explanations and design solutions, and to plan and carry out investigations.

Science Grade 8 Content Domain: Motion

Standard: S8P3. Obtain, evaluate, and communicate information about cause and effect relationships between force, mass, and the motion of objects.

b. Construct an explanation using Newton's Laws of Motion to describe the effects of balanced and unbalanced forces on the motion of an object.

A force diagram of a tennis ball flying through the air toward the right is shown in the diagram below. The arrows show the direction of the gravitational force (F_{grav}), the drag force (F_{drag}), the lift force (F_{lift}), and the velocity of the tennis ball.



Which pair of statements is a valid description and explanation of the motion of the ball based on evidence from the diagram?

A. **description:** The ball slows down as it moves to the right because the horizontal forces are unbalanced, with the larger force acting to the left.
explanation: The ball speeds up as it moves downward because the vertical forces are unbalanced, with the larger force acting downward.

B. **description:** The ball speeds up as it moves to the right because the horizontal forces are unbalanced, with the larger force acting to the right.
explanation: The ball speeds up as it moves downward because the vertical forces are unbalanced, with the larger force acting downward.

C. **description:** The ball moves at a constant speed to the right because the horizontal forces are unbalanced, with the larger force acting to the left.
explanation: The ball slows down as it moves downward because the vertical forces are unbalanced, with the larger force acting upward.

D. **description:** The ball slows down as it moves to the right because the horizontal forces are unbalanced, with the larger force acting to the right.
explanation: The ball moves at a constant speed downward because the vertical forces are unbalanced, with the larger force acting upward.

Example Item 4

Selected-Response: 1 point

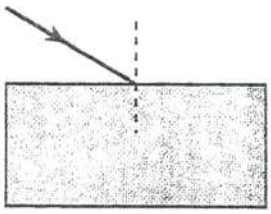
DOK Level: 3

Science Grade 8 Content Domain: Energy

Standard: S8P4. Obtain, evaluate, and communicate information to support the claim that electromagnetic (light) waves behave differently than mechanical (sound) waves.

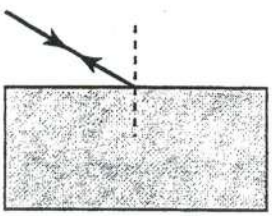
d. Develop and use a model to compare and contrast how light and sound waves are reflected, refracted, absorbed, diffracted, or transmitted through various materials.

A student is drawing a diagram of a light ray as it enters a pane of glass.

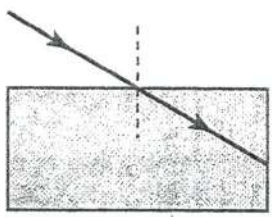


Which of these shows the correctly completed diagram?

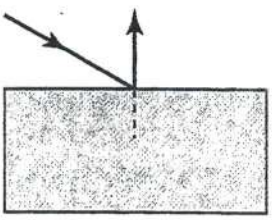
A.



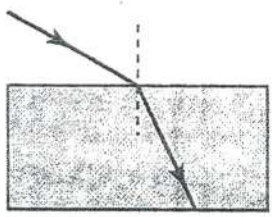
B.



C.



D.



Example Item 5

Selected-Response: 1 point

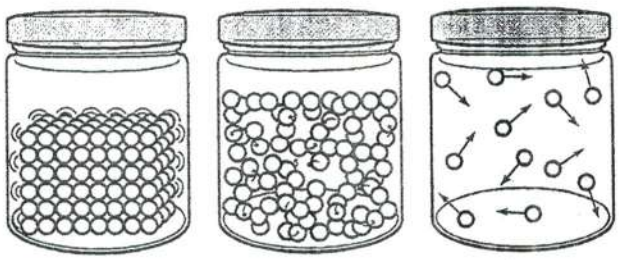
DOK Level: 3

Science Grade 8 Content Domain: Matter

Standard: S8P1. Obtain, evaluate, and communicate information about the structure and properties of matter.

d. Construct an argument based on observational evidence to support the claim that when a change in a substance occurs, it can be classified as either chemical or physical.

The three jars show the movement of particles in three states of matter.



Dry ice is solid carbon dioxide. As dry ice is heated, it goes directly from a solid to a gas through a process called sublimation.

Which sequence of jars shows the change in the motion of particles of dry ice as it sublimes?

A. jar P to jar Q
B. jar P to jar R
C. jar Q to jar R
D. jar R to jar P

Force

This section will focus on developing a conceptual understanding of the relationship between force, mass, and the motion of objects; and energy transformations. You will develop an understanding that all objects and substances in the natural world are composed of matter that is influenced by forces. You will explore the relationship between velocity and acceleration through graphical representations of the motion of objects. You will gain a qualitative understanding of the universal laws of motion through scenarios in which forces act through direct physical contact between objects as well as examples in which forces act on objects at a distance (via gravitational force).

KEY CONCEPTS

Displacement is the length and direction of a straight line between two locations, or positions. Since displacement considers only the length and direction of a straight line, it doesn't depend on the actual path of a moving object. If Town A is 10 miles east of Town B, the displacement of Town A is 10 miles east relative to Town B. For a moving object, displacement can be defined as the change between the initial and final position of the object. (S8P3a)

Distance is a measure of the length of a path that a moving object travels. If the only road between the two towns has to wind through hills, the distance traveled between the two towns is longer than 10 miles, even though the displacement between the two towns is 10 miles east. (S8P3a)

Velocity is a quantity that measures the rate at which the position of an object changes in time. Velocity always describes a distance and a direction. Since velocity has direction, one way to show this numerically is to assume that travelling in a certain direction is symbolized with positive numbers while traveling opposite that direction is shown using negative numbers. (S8P3a)

Speed measures the rate at which an object moves along a path. Unlike velocity, speed is not considered to have a direction. (S8P3a)

Acceleration is a quantity that measures the rate at which an object changes its velocity. People often talk about an object decelerating when the object slows down. An object that slows down is actually experiencing a negative acceleration. This means the rate of change is a negative value. An object can have a velocity but not acceleration if it is moving at a constant velocity. For example, a car takes one hour to make a trip of 80 kilometers on a straight road pointing due east. In the middle of the trip, the car accelerated to 100 kilometers per hour (kph) and operated at that speed for 10 minutes and then accelerated to 60 kph and operated at that speed for 10 minutes. After the first acceleration the speed of the car was 100 kph, and during that time, the velocity of the car was 100 kph eastward. After the second acceleration the speed of the car was 60 kph and the velocity of the car during that time was 60 kph eastward. Finally, the car accelerated again back to 80 kph. The average velocity of the car over the whole trip was 80 kph eastward, and the average speed was 80 kph. (S8P3a)

A **force** is a push or pull on an object. Force can be the result of contact, such as when you push a book across your desk. Forces between objects that are not in contact with each other can be explained by the presence of force fields, like the magnetic field and the gravitational field. When one magnet repels another magnet, there is a push force that acts on the magnets even though the magnets are not in contact. (S8P3b)

When two or more forces act on an object but the object's velocity does not change, the object is being acted on by **balanced forces**. A book on your desk that is not moving is said to be **stationary**. The book is said to be at **rest** in relation to the desk. Gravity is acting to pull the book down. The desk pushes up against the book, and the book is at rest in relation to the desk. (S8P3b)

An accelerating object is being acted on by **unbalanced forces**. When you push your book across your desk, you are applying force to one side of the book. The force of friction acts on the book in the opposite direction that the book is moving, reducing the speed at which the book moves. Because the book still begins to move in the direction you are pushing it, these forces are unbalanced. (S8P3b)

Friction is the force that resists motion between two surfaces. (S8P3b)

Inertia is the resistance to any change in the state of motion of any physical object. All matter has inertia, and the inertia of matter does not change until the matter is acted on by unbalanced forces that cause a change in motion. (S8P3b)

Mass is the total amount of matter of an object. Mass is a numerical measure of the object's inertia. The mass of an object does not change, regardless of where the object is located. (S8P3c)

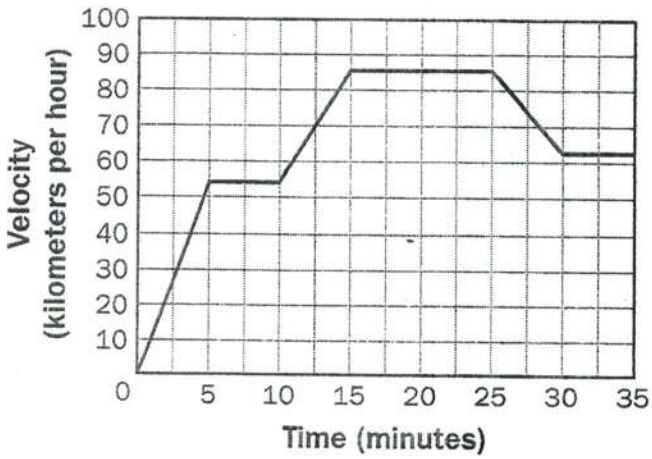
Gravity is the force of attraction that exists between any two or more masses. Gravity can refer to the force that Earth exerts on everything. (S8P3b, S8P5a)

Important Tip

- When thinking of energy transforming from one form to another, remember that, in most cases, it is not a matter of one form of energy being transformed into only one other form of energy. When you rub your hands together, the kinetic energy of your hands is transformed by friction into heat energy. You can also hear your hands rubbing together, which is the result of the friction converting some of the kinetic energy into sound energy. (S8P2c)

Selected-Response: 1 point

The graph shows the velocity of a moving train over time.



During which two intervals of time was the train moving with a constant, positive acceleration?

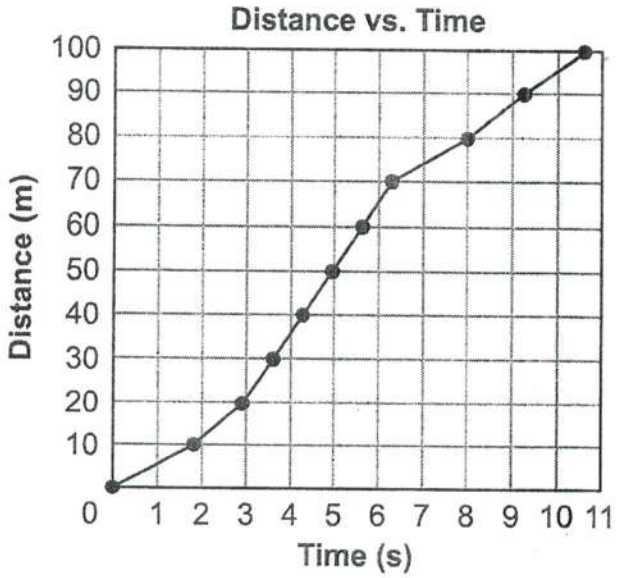
A. 0–5 minutes and 10–15 minutes
B. 5–10 minutes and 15–25 minutes
C. 10–15 minutes and 25–30 minutes
D. 15–20 minutes and 30–35 minutes

Sample Items 1–3

Item 1

Selected-Response

A coach at a track meet measured the time of a runner every 10 meters (m) during a 100 m dash. The data for the runner are shown.



Which statement is the BEST analysis of the data for the runner?

A. The runner covers the first 80 m running at a constant speed and then slows down, reaching a minimum speed during the final 20 m.

B. The runner starts slower and speeds up, reaching a constant speed between 20 and 80 m, and then speeds up again during the final 20 m.

C. The runner covers the first 70 m running at a constant speed and then speeds up, reaching a maximum speed during the final 30 m.

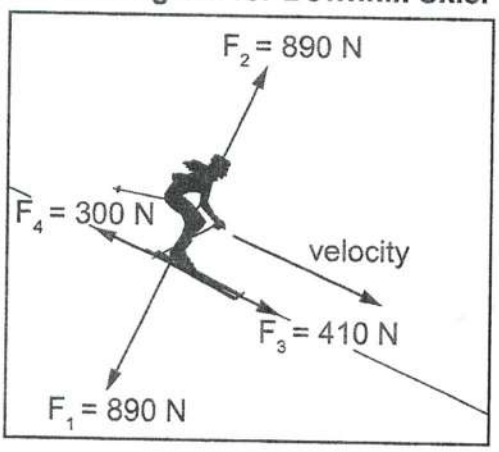
D. The runner starts slower and speeds up, reaching a maximum speed between 50 and 70 m, and then slows down during the final 30 m.

Item 2

Selected-Response

A force diagram for a downhill skier is shown.

Force Diagram for Downhill Skier



Which statement is a valid description and explanation of the skier's motion based on evidence from the diagram?

A. The skier's speed decreases going down the hill because forces F_1 and F_2 are balanced and acting perpendicular to the direction of the velocity, causing the skier to speed up.

B. The skier's speed increases going down the hill because forces F_1 and F_2 are balanced and acting perpendicular to the direction of the velocity causing the skier to slow down.

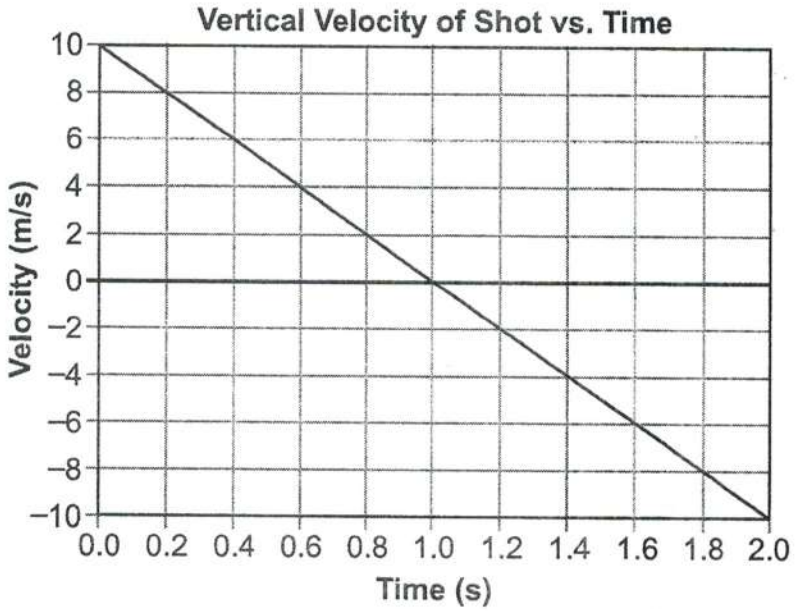
C. The skier's speed increases going down the hill because forces F_3 and F_4 are unbalanced, with F_3 acting in the same direction as the velocity, causing the skier to speed up.

D. The skier's speed decreases going down the hill because forces F_3 and F_4 are unbalanced, with F_4 acting in the opposite direction of the velocity, causing the skier to slow down.

Item 3

Selected-Response

During a shot put event, athletes throw a very heavy round ball, called a shot, as far as possible. The graph shows the vertical velocity of a shot that was thrown by an athlete.



Which statement is an accurate analysis of the vertical motion of the shot?

A. The direction of the velocity is upward for both the first second and the last second, and the acceleration remains constant for the entire period.

B. The direction of the velocity is downward for both the first second and the last second, and the acceleration decreases during the entire period.

C. The direction of the velocity is upward for the first second and then downward for the last second, and the acceleration decreases during the entire period.

D. The direction of the velocity is upward for the first second and then downward for the last second, and the acceleration remains constant for the entire period.

Structure and Properties of Matter

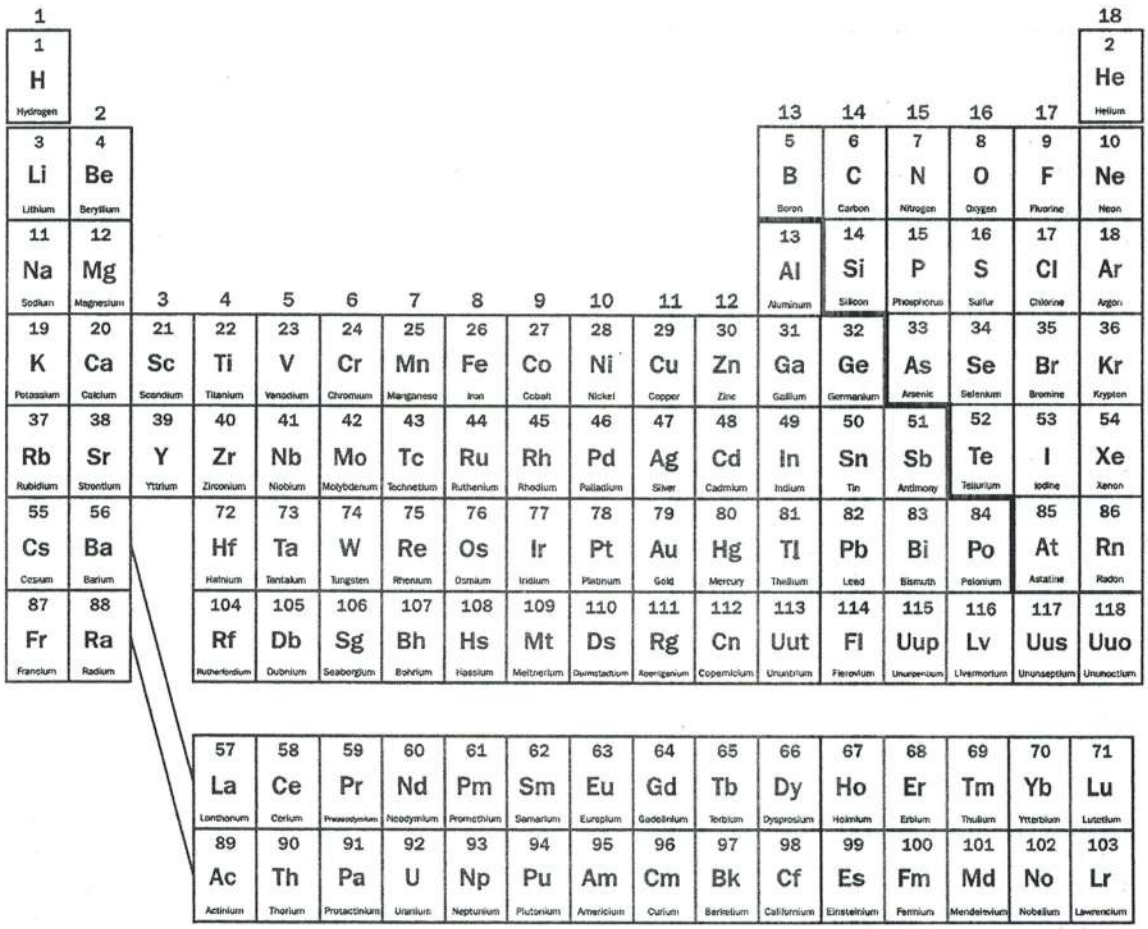
In this section, you will develop a conceptual understanding of the nature of matter. You will understand that, in a chemical reaction, matter can be neither created nor destroyed, only transformed. You will learn about the characteristics of matter (i.e., physical and chemical properties) that are useful to classify and differentiate substances.

KEY CONCEPTS

Atoms are the smallest unit of matter that defines the chemical element. **Elements** are pure chemical substances that are made up of one type of atom. A **molecule** is made of two or more atoms joined together chemically. Molecules can be made of the same element or more than one element. Water molecules are made up of two atoms of hydrogen and one atom of oxygen. (S8P1a, e)

The **Periodic Table of Elements** is a table arranging all the known elements into groups with common properties. This arrangement also demonstrates trends based on those properties. (S8P1e)

Periodic Table of Elements



Substance is matter of any form that cannot be broken down into separate elements by physical means but can be broken down using chemical changes. (S8P1a)

A **compound** is a pure chemical substance that is made up of two or more different elements. Salt is a compound whose molecules are made up of one atom of sodium and one atom of chlorine. (S8P1a)

A **mixture** is made of two or more substances that are not combined chemically. Salted popcorn is an example of a mixture. (S8P1a)

Matter is anything that has mass and occupies space. Matter can be found in several states (e.g., solid, liquid, gas, plasma). (S8P1b, c)

Physical properties are any properties that are measurable and can be observed. Physical properties can be determined without changing the chemical properties of an object. Color, hardness, area, length, strength, temperature, and state of matter are some examples of physical properties. (S8P1c)

The **states of matter** are the different forms that matter can be found in. Water is a **liquid**, the state of matter that has a definite volume but no fixed shape. When water is ice, it is a **solid**. Solids have a definite shape and volume. Their shape and volume cannot be easily changed. When water is steam, or water vapor, it is a **gas**. Gases have no definite shape and take the shape of their container. **Plasma** is gas that is charged. Plasma conducts electricity easily. Stars and neon lights are examples of plasma. Plasma is different from the other states of matter in that it is a high-energy state of matter. (S8P1b)

Mass is the total amount of matter of an object. Mass is a numerical measure of the object's inertia. The mass of an object does not change regardless of where the object is located. (S8P3c)

Volume is the amount of space that an object or substance occupies. Volume is a physical property. (S8P1b)

Density is the physical property that describes how tightly matter is put together. A pure element, such as gold, will have a characteristic density and mass. (S8P1c)

Boiling point is the physical property that describes the temperature at which a substance will change from a liquid to a gas. Water boils at 100°C (212°F). (S8P1c)

Melting point is the physical property that describes the temperature at which a solid will become a liquid. Ice, a solid, will change into liquid water at 0°C (32°F). This is the melting point of water. (S8P1c)

Chemical properties are any properties that can be measured only by chemically changing an object. Paper starts to burn at around 249°C (480°F). At this temperature the paper combines with oxygen in the air and new substances are formed. (S8P1c)

Combustibility is the chemical property of how easily a substance will set on fire. For example, paper's heat of combustion is around 249 degrees Celsius. (S8P1c)

Reactivity is the chemical property of the capacity of an atom or molecule to go through a chemical reaction with another atom or molecule. Sodium is a very reactive metal. Sodium reacts rapidly and energetically with other substances. Gold is a metal that is not very reactive. It won't tarnish from oxygen or water. (S8P1c)

A **physical change** happens when matter has a change in its physical properties but not its chemical properties. For example, salt can be dissolved in water, but if the water evaporates, the salt is still there. (S8P1d)

A **chemical change** happens when matter breaks down into two or more substances or when more than one substance is combined to form a new substance. Hydrogen peroxide forming bubbles on its own is an example of matter breaking down into two substances. Vinegar and baking soda turning into bubbling foam is an example of two substances combining to create other substances. (S8P1d)

A **chemical reaction** is a process where two or more substances combine chemically in some way to form one or more other substances. When iron is combined with air and water, the iron is slowly converted into rust. (S8P1f)

A **precipitate** is a solid that is formed by a chemical reaction. Precipitates can form in a solution or inside another solid. (S8P1d)

The **law of conservation of matter** states that the total amount of matter in a system cannot be created or destroyed. When a piece of paper burns, it becomes ash, water vapor, and carbon dioxide. If the mass of the ash, water vapor, and carbon dioxide were found, it would be the same as the mass of the paper before the paper was burnt. (S8P1f)

Important Tip

✍ The movement of particles within the different states of matter can vary greatly. Particles in solids are packed together very tightly, and they do not move around easily. This is why solids tend to be hard. Particles in a liquid move around and are packed loosely. Particles in gases move in all sorts of directions, and the particles are spread very far apart. (S8P1b)

_____ is the center of the atom; where _____ and _____ are located. _____ are located outside the nucleus.

_____ is the positively charged particle in an atom; _____ is the negatively charged particle in an atom; _____ is the particle with no charge.

_____ is the number of protons and electrons in an atom; the whole number on the element on the periodic table.

_____ is the sum of protons and neutrons in an atom; the decimal number on the element on the periodic table.

_____ is a description of a chemical reaction using element symbols and chemical formulas; equations must be balanced (Law of Conservation of Matter);

$$2H_2 + O_2 \longrightarrow 2H_2O$$

Sample Items 4–7

Item 4

Selected-Response

A student is planning an investigation to explore different properties of matter.

Which investigation will help the student explore a physical property of matter?

A. **investigation:** Place a solid in a beaker and add a small amount of liquid.
observation: The beaker becomes warm to the touch.

B. **investigation:** Add a small amount of solid to a liquid in a beaker.
observation: The solid dissolves in the liquid.

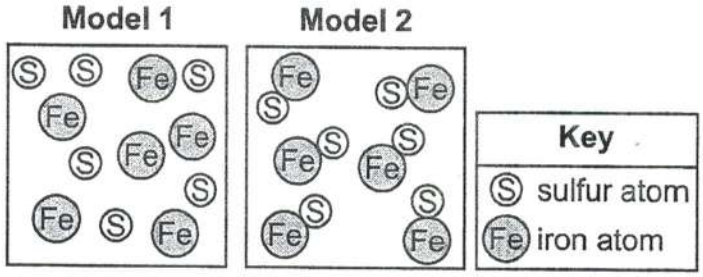
C. **investigation:** Add a small amount of solid to a liquid in a beaker.
observation: The solution starts to fizz and overflows the container.

D. **investigation:** Place a solid in a beaker and add a small amount of liquid.
observation: Bubbles form on the top of the solid.

Item 5

Selected-Response

Iron can be found as a gray powder and sulfur can be found as a yellow powder. A student is shown models of two substances made of iron (Fe) and sulfur (S).



The student is asked to classify each substance as a mixture or a pure substance and describe how it would appear. Which classification and description of the models is correct?

A.

Model	Classification	Description
1	pure substance	uniform
2	homogeneous mixture	gray and yellow particles visible but evenly distributed

B.

Model	Classification	Description
1	pure substance	gray and yellow particles visible but evenly distributed
2	heterogeneous mixture	uniform

C.

Model	Classification	Description
1	homogeneous mixture	uniform
2	pure substance	gray and yellow particles visible but evenly distributed

D.

Model	Classification	Description
1	heterogeneous mixture	gray and yellow particles visible but evenly distributed
2	pure substance	uniform

Item 6

Multi-Part Technology-Enhanced

A student is shown a simple model of particles that make up a liquid, as shown.

Part A

How should the model be changed to show the particles of a solid?

A. Increase the velocities of the particles, and increase the space between the particles.
B. Increase the velocities of the particles, and decrease the space between the particles.
C. Decrease the velocities of the particles, and increase the space between the particles.
D. Decrease the velocities of the particles, and decrease the space between the particles.

Part B

How should the model be changed to show the particles of a liquid at a higher temperature?

A. Separate the particles into positive and negative charges, and increase the space between the particles.
B. Separate the particles into positive and negative charges, but maintain the same space between the particles.
C. Decrease the velocities of the particles, and decrease the space between the particles.
D. Increase the velocities of the particles, but maintain the same space between the particles.

Item 7

Multi-Part Technology-Enhanced

A student is asked to conduct an investigation that will determine a physical property of a cube-shaped solid block of salt sample.

Part A

Which procedure BEST measures a physical property of the sample?

A. 1. Measure 10 mL of vinegar (acetic acid) in a graduated cylinder.
2. Pour the acetic acid into a beaker.
3. Drop the sample into the beaker of acetic acid to determine what happens to the sample.
4. Record your observations.

B. 1. Gently break the solid sample into smaller pieces using a hammer.
2. Use long-handled forceps to pick up one of the small sample pieces.
3. Hold the small sample piece in the flame of a Bunsen burner for a few seconds to determine what happens to the sample.
4. Record your observations.

C. 1. Use a ruler to measure the length of one side of the sample.
2. Record this value to the nearest millimeter.
3. Cube the value in step 2.
4. Place the cubed sample on the digital balance.
5. Record this value to the nearest tenth of a gram.
6. Divide the value in step 5 by the value in step 3.

D. 1. Cut away two different-sized pieces of the sample and place into a container on a hot plate.
2. Place two thermometers in the containers, one touching each sample.
3. Record the time it takes the temperature of the smaller sample to increase 1°C.
4. Continue to heat the sample.
5. Record the time it takes the temperature of the larger sample to increase 1°C.
6. Subtract the value in step 3 from the value in step 5.

Part B

Which statement supports the answer to Part A?

A. The physical property being tested is density; the procedure selected measures the mass and the volume of the sample.

B. The physical property being tested is reactivity; the procedure selected determines whether the sample will change to a different substance due to mixing with acetic acid.

C. The physical property being tested is melting point; the procedure selected measures the temperature at which the sample changes to a liquid.

D. The physical property being tested is combustibility; the procedure selected determines whether the sample will begin to burn due to exposure to a flame.

Energy and Force

In this section, you will develop an understanding that energy exists in many forms. You will learn that in a closed system, energy can be transferred and transformed, but the total amount of energy available is always the same—it is conserved. You will also learn about two of the four main forces in the universe: gravitational and electromagnetic forces. You'll determine how these forces influence the motion of objects and are responsible for the work that a system does or for the work that is done on a system.

KEY CONCEPTS

The **law of conservation of energy** states that the total amount of energy in a system cannot change unless energy enters or leaves that system by some form and that energy cannot be created or destroyed. Energy can only change forms. An **energy transformation** refers to the changing of energy from one form to another. (S8P2b, c)

Gravitational potential energy is the energy stored in an object due to its position. The energy stored in a ball sitting at the top of a ramp is all potential energy. In the case of the ball, gravity is pulling down on the ball. Although the ball is not rolling down the hill, it has potential energy due to the pull of gravity. (S8P2a, b)

Kinetic energy is the energy of **motion**. As the ball starts to roll down the ramp, the potential energy of the ball transforms into kinetic energy. The energy in the system is converted from potential energy to kinetic energy. (S8P2a, b)

Mechanical energy is the total of all the potential energy and kinetic energy in an object. (S8P2b)

Thermal energy is the random motion of particles (whether vibrations in solids or molecules in free motion in a gas). This energy is distributed among all the particles in a system through collisions and interactions at a distance. Thermal energy flows from an object that has a higher temperature to one that has a lower temperature. (S8P2c, d)

Conduction is the movement of heat through an object or from one object to another when they are touching. In conduction, thermal energy is transferred between atoms when they collide with each other. Thermal energy moves from warmer areas, those with higher energy, to cooler areas, those with less energy. This is why ice in a glass of water melts on a warm day. Warm air molecules collide with the molecules of the glass container and transfer thermal energy to them. The molecules in the container then pass the thermal energy between themselves by direct contact. Finally, the energy is transferred to the water and ice by the water molecules coming in contact with both. The thermal energy flows toward the ice and the energy turns the ice into water. (S8P2d)

Convection is the movement of heat through fluids and gases. In convection, thermal energy is transferred due to differences in density caused by temperature variations. When you heat a pot of soup, the liquid becomes warm through convection. As the liquid at the bottom of the pot becomes warmer, its density decreases. The increased thermal energy causes the molecules to move faster, which spaces them farther apart, increasing the volume and thus decreasing the density. The change in density causes the warm liquid to rise to the top of the soup and the colder liquid to sink. It is this motion of the warm and cold masses that is called convection. (S8P2d)

Heat can also move by means of **radiation**. Thermal radiation does not require any form of matter to move through, as conduction and convection require. Thermal radiation energy moves via electromagnetic waves. Because of this, thermal radiation moves very fast. (S8P2d)

Electric energy is the energy of electrons moving through a conductor. Electricity is the name for the motion of electrons along the path formed by a conductor. (S8P2c)

Magnetic energy is produced when magnetic fields are generated. (S8P2c)

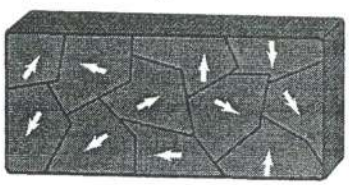
Gravity also refers to the **gravitational force** every object exerts on every other object. (S8P3b)

A **force** is a push or pull on an object. Force can be the result of contact, such as when you push a book across your desk. Forces between objects that are not in contact with each other can be explained by the presence of force fields, like the magnetic field and the gravitational field. When one magnet pushes another magnet, there is a force that acts on the magnets even though the magnets are not in contact. (S8P3b)

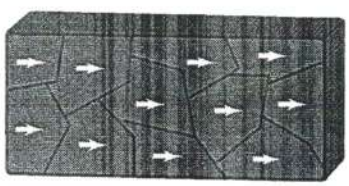
When two or more forces act on an object, but the object's velocity does not change, the object is being acted on by **balanced forces**. A book on your desk that is not moving is said to be **stationary**. The book is said to be at **rest** in relation to the desk. Gravity is acting to pull the book down. The desk pushes up against the book, and the book is at rest in relation to the desk. (S8P3b)

An accelerating object is being acted on by **unbalanced forces**. When you push your book across your desk, you are applying force to one side of the book. The force of friction acts on the book in the opposite direction that the book is moving, reducing the speed at which the book moves. Because the book still begins to move in the direction you are pushing it, these forces are unbalanced. (S8P3b)

Magnetic materials have what are known as magnetic domains—they are sort of like pieces of a big puzzle, as shown in the illustration of magnetized material below. The two poles of a magnet result when these magnetic domains align in such a way that they point in the same direction. If you cut a magnet in half, the domains of each half will still line up so that the two new magnets each have a north pole and a south pole. In an object that is not magnetized, the domains lie in many different directions (as shown in the illustration below) and mostly cancel each other out. (S8P5a, c)



Not Magnetized



Magnetized

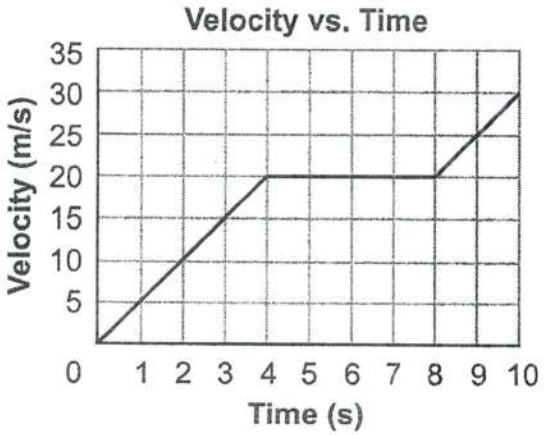
An **electromagnet** is created when a wire is coiled and an electric current flows through it. Generally, electromagnets have a metal core that helps to increase the strength of the electromagnet. Magnetic force is created by the movement of electrical charges through a wire. A magnetic field is created around the wire, and this magnetic field lines up the domains in the core, turning the core into a temporary magnet. When the electric current is turned off, the magnetic field quickly fades. An electromagnet can be made using a circuit with a battery, a switch, and wire wrapped around a nail. (S8P5c)

Sample Items 8–12

Item 8

Selected-Response

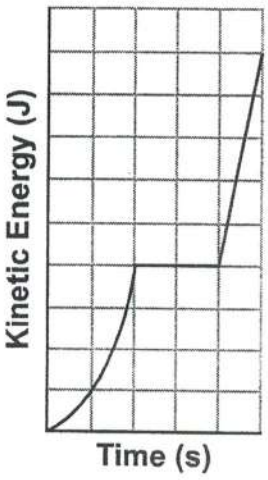
A physics student used radar to measure the velocity of a vehicle over a 10-second period. The student presented the data in the graph shown.



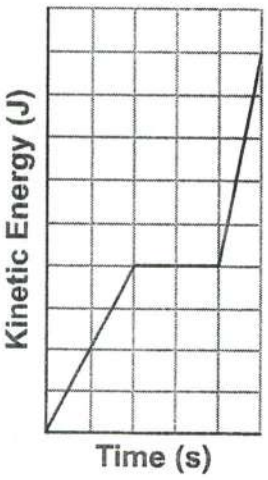
(Answer the question on the next page.)

Which graph of the kinetic energy of the vehicle versus time corresponds to the velocity versus time graph?

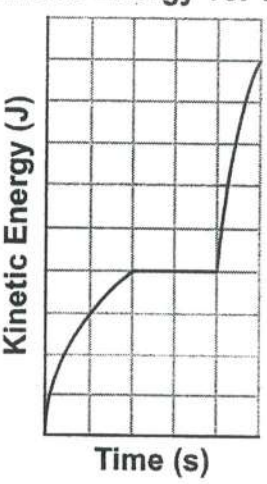
A. **Kinetic Energy vs. Time**



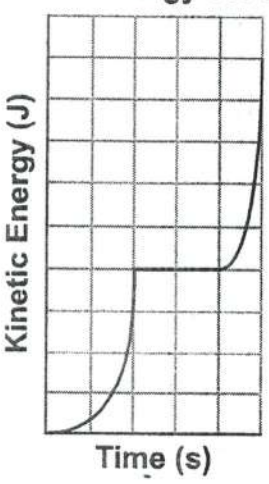
B. **Kinetic Energy vs. Time**



C. **Kinetic Energy vs. Time**



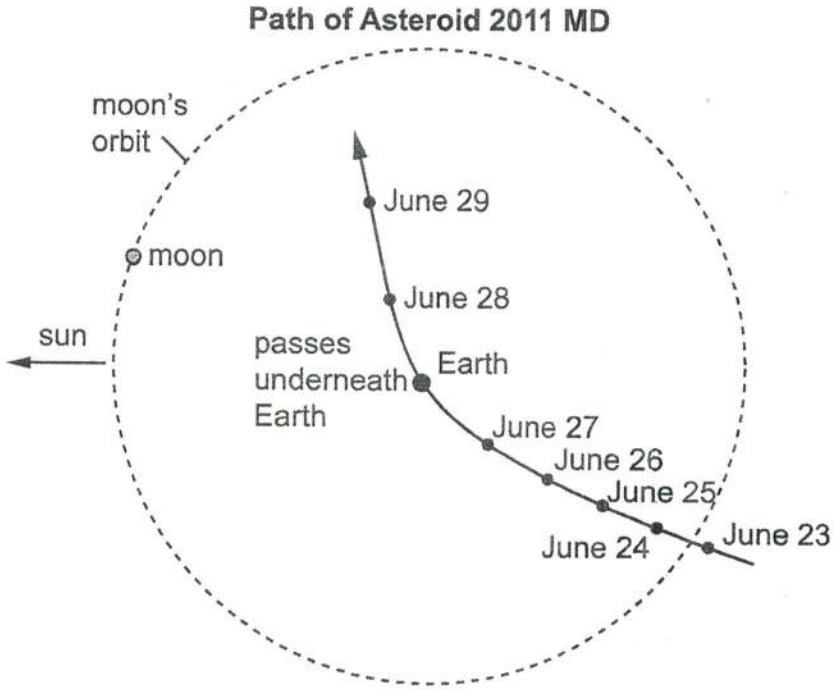
D. **Kinetic Energy vs. Time**



Item 9

Selected-Response

A space agency tracked the path of an asteroid named 2011 MD, which passed within 12,300 kilometers of Earth's surface. The path of the asteroid is projected onto the plane of the moon's orbit around Earth in the diagram.



Space scientists claimed that Earth's strong gravitational field was responsible for the path of asteroid 2011 MD. Which argument BEST supports this claim?

A. The velocity of the asteroid changed as evidenced by the changing direction of the asteroid.

B. The velocity of the asteroid changed as evidenced by the straight line path after it passes Earth.

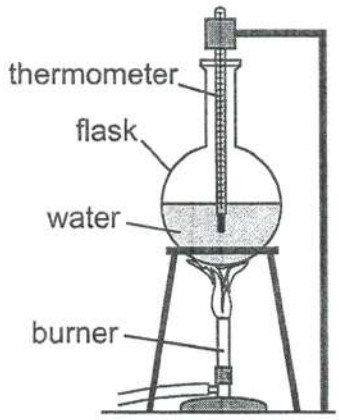
C. The position of the asteroid bends slightly away from Earth as evidenced by the different locations relative to Earth.

D. The position of the asteroid bends slightly toward the sun as evidenced by the different locations relative to the sun.

Item 10

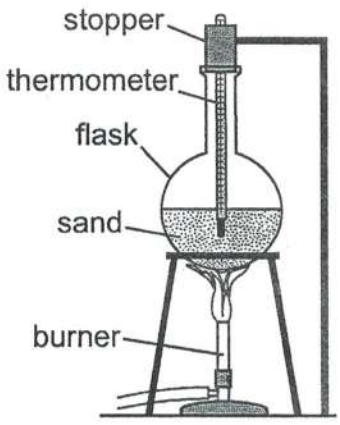
Selected-Response

A student is planning an investigation in which different modes of heat transfer will be used to heat a thermometer. The diagram shows the setup used to conduct the first part of the investigation.

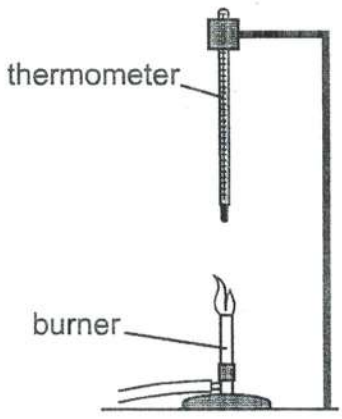


In this setup, the thermometer is being heated by conduction and convection. How should the student change the setup to heat the thermometer by using only radiation?

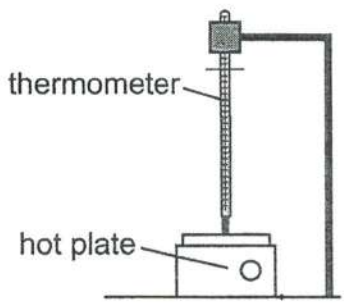
A.



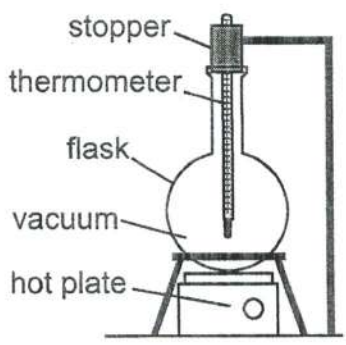
B.



C.



D.

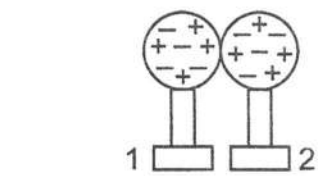


Item 11

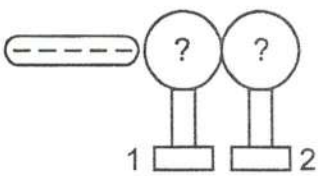
Selected-Response

A student is investigating how a negatively charged rubber rod affects how charges are distributed on two stainless steel spheres that are touching each other. A diagram that shows two steps of the investigation is shown.

Investigation of the Process of Induction



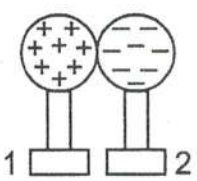
Step 1
Place two stainless steel spheres, both on hard rubber stands, in contact with each other.



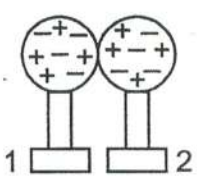
Step 2
Bring a negatively charged rubber rod near sphere 1.

Which diagram for step 2 correctly predicts the distribution of charges on the stainless steel spheres?

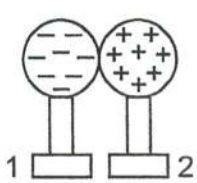
A.



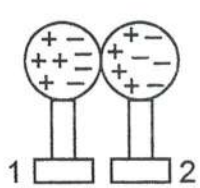
B.



C.



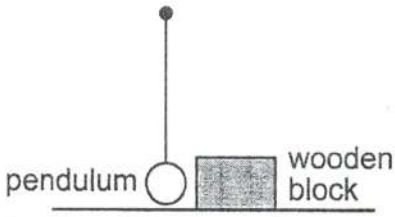
D.



Item 12

Selected-Response

A student wishes to use the pendulum and wooden block shown to investigate energy transfer between kinetic and potential.



Which procedure would BEST allow the student to complete measurements for the investigation and which energy transformation will occur during the investigation?

A. **step 1:** Release the pendulum from a measured height and allow it to swing down and collide with the wooden block at the bottom of the swing.
step 2: Allow the wooden block to come to rest, then measure the distance the block slid.
step 3: Repeat steps 1 and 2 using different starting heights for the pendulum. Compare the data for the different starting heights.
transformation: The potential energy of the pendulum transforms into kinetic energy, which then is transferred to the wooden block. The higher the pendulum is raised, the more potential energy the pendulum has. This means the pendulum will have more kinetic energy when it hits the block. This kinetic energy causes the block to travel. The more kinetic energy that is transferred from the pendulum, the farther the block will travel.

B. **step 1:** Release the pendulum from a measured height and allow it to swing down and collide with the wooden block at the bottom of the swing.
step 2: Allow the wooden block to come to rest, then measure the distance the block slid.
step 3: Repeat steps 1 and 2 using different starting heights for the pendulum. Compare the data for the different starting heights.
transformation: The kinetic energy of the pendulum transforms into potential energy, which then is transferred to the wooden block. The higher the pendulum is raised, the more kinetic energy the pendulum has. This means the pendulum will have more potential energy when it hits the block. This potential energy causes the block to travel. The more potential energy that is transferred from the pendulum, the farther the block will travel.

C. **step 1:** Pull the pendulum back and throw it downwards, allowing it to swing down and collide with the wooden block at the bottom of the swing.
step 2: Allow the wooden block to come to rest, then measure the distance the block slid.
step 3: Repeat steps 1 and 2, throwing the pendulum with different amounts of force. Compare the data for the different throws.
transformation: The potential energy of the pendulum transforms into kinetic energy, which then is transferred to the wooden block. The larger the force used to throw the pendulum, the more potential energy the pendulum has. This means the pendulum will have more kinetic energy when it hits the block. This kinetic energy causes the block to travel. The more kinetic energy that is transferred from the pendulum, the farther the block will travel.

D. **step 1:** Pull the pendulum back and throw it downwards, allowing it to swing down and collide with the wooden block at the bottom of the swing.
step 2: Allow the wooden block to come to rest, then measure the distance the block slid.
step 3: Repeat steps 1 and 2, throwing the pendulum with different amounts of force. Compare the data for the different throws.
transformation: The kinetic energy of the pendulum transforms into potential energy, which then is transferred to the wooden block. The larger the force used to throw the pendulum, the more kinetic energy the pendulum has. This means the pendulum will have more potential energy when it hits the block. This potential energy causes the block to travel. The more potential energy that is transferred from the pendulum, the farther the block will travel.

Waves

In this section, you will acquire a conceptual understanding of the nature of sound and electromagnetic radiation. You will study how sound behaves in the presence of different obstacles and how light is manipulated by positioning mirrors and lenses in its path.

KEY CONCEPTS

Waves are constant fluctuations that travel through space (either in the vacuum of outer space or through matter), transferring energy. When you throw a rock in a puddle, the water forms waves that move outward from the place where the rock hit the water. Waves can move through solids, liquids, gases, and empty space (i.e., a vacuum, a volume containing no matter). (S8P4a)

Frequency is the number of vibrations a wave makes per a unit of time, commonly measured in Hertz, which is waves per second. If you counted the number of wave peaks that occurred in a minute after throwing a rock in a puddle, you could determine the frequency of that wave. (S8P4f)

Wavelength is the distance from one peak of a wave to the next peak of the wave. (S8P4f)

Amplitude is the property of a wave that describes half the distance between the height of the peak of the wave and the trough (the bottom) of the wave, or the maximum distance from the resting position. In a surf wave, the amplitude represents the amount of water displaced, which can be very large. (S8P4f)

Electromagnetic radiation is a form of energy that is produced by oscillating electric and magnetic disturbances, or by the movement of electrically charged particles traveling through a vacuum or matter. It is used to describe radio waves, microwaves, infrared radiation, visible light, ultraviolet radiation, X-rays, and gamma rays. The **electromagnetic spectrum** consists of all the different kinds of electromagnetic radiation. Radio waves have the smallest frequency and longest wavelength in the electromagnetic (EM) spectrum (the complete set of electromagnetic radiation) and therefore contain the least energy. Gamma rays have the largest frequency and shortest wavelength in the EM spectrum and therefore contain the most energy. (S8P4a)

Electromagnetic waves do not require a medium to move through. Electromagnetic waves transport energy that is stored in the electric and magnetic fields. (S8P4a)

Mechanical waves are caused by a disturbance or vibration that causes the molecules in matter to bump into each other and transfer the energy from one molecule to the next in a set direction. Mechanical waves require matter to provide a **medium** for the waves to move through, so mechanical waves cannot occur in the vacuum of space. (S8P4a, e)

Sound is a mechanical wave that can be heard as it moves through a medium, such as air, and temporarily displaces the particles of the medium, either by rarefaction (the particles temporarily move farther apart, creating lower pressure) or compression (the particles temporarily move closer together, creating higher pressure). When fireworks go off on the Fourth of July, you can hear the sound. With some of the larger fireworks, you can also feel the air as the pressure from the firework exploding pushes the air away from the firework. (S8P4d)

When people refer to **light**, they are usually referring to the visible light they can see. Light is not considered matter and has no mass. The behavior of light can be explained by the introduction of a massless particle called a photon or by studying the way that electromagnetic waves interact with matter. (S8P4d)

There are several processes that light can go through as it encounters matter. **Reflection** occurs when light bounces off a medium. When light is reflected, not all the light is reflected. **Refraction** occurs when light moves from one medium to a new medium and bends as the medium changes the speed of the light as it moves through the new medium. When you look through a glass of water and an object behind

the glass appears to change shape, the light reflected by that object has been refracted by the glass. **Diffraction** occurs when light encounters an obstacle and slightly bends as it passes around the object. If you hold a CD and see the colors of the rainbow, this is the light being diffracted by the surface of the CD.

Absorption occurs when light strikes a surface and the energy of the photon is taken up by the matter. An object lying in the sun will warm up as the sunlight transforms into heat energy. (S8P4d)

When the human eye sees **colors**, it is seeing the parts of the spectrum of light that are reflected from an object. A blue object reflects the wavelengths of light that we see as blue. (S8P4d)

Important Tip

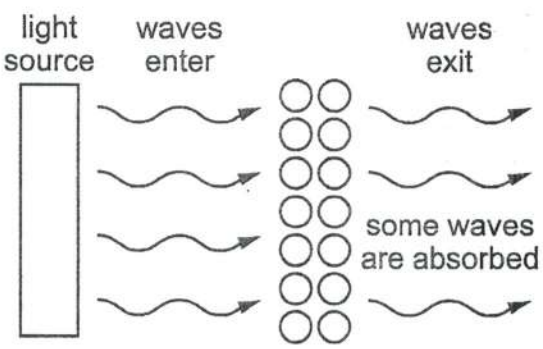
- The ways waves travel is known as wave propagation. As waves propagate, some of the energy is transferred. When light travels through a glass of water, it slows down and is refracted. Some of the energy that is lost from the wave—and that causes the light to slow down—is transferred into the water and glass as thermal energy. (S8P4b, d)

Sample Items 13–16

Item 13

Selected-Response

The model shows how light waves are transmitted through a transparent substance.



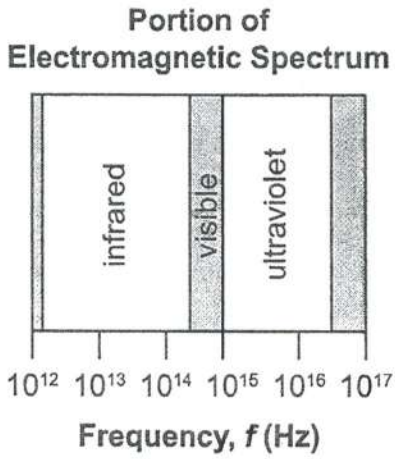
How would the model be different for a sound wave that is being transmitted through the same substance?

A. The wavy arrows representing sound waves would have a smaller wavelength.
B. The wavy arrows representing sound waves would go in the opposite direction.
C. The atoms in the model would move parallel to the direction of the incoming wave.
D. The atoms in the model would move perpendicular to the direction of the incoming wave.

Item 14

Selected-Response

The diagram shows three types of electromagnetic radiation and their range of frequencies.



Which explanation correctly uses the data in the diagram to show how infrared radiation and ultraviolet radiation are related in terms of energy?

A. Ultraviolet radiation has less energy than infrared radiation because energy is inversely proportional to frequency and the frequency of ultraviolet radiation is higher.

B. Ultraviolet radiation has more energy than infrared radiation because energy is inversely proportional to frequency and the frequency of ultraviolet radiation is lower.

C. Ultraviolet radiation has less energy than infrared radiation because energy is proportional to frequency and the frequency of ultraviolet radiation is lower.

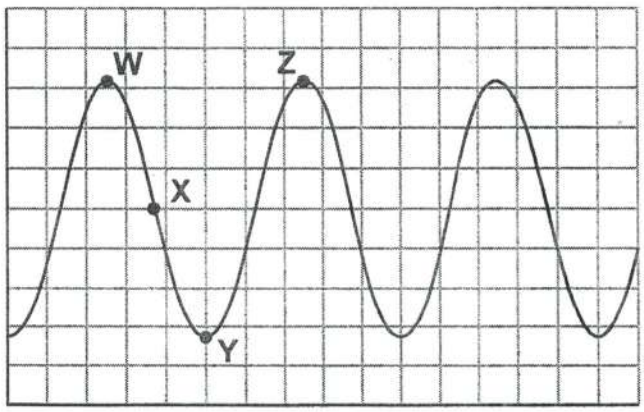
D. Ultraviolet radiation has more energy than infrared radiation because energy is proportional to frequency and the frequency of ultraviolet radiation is higher.

Item 15

Selected-Response

A student drew the diagram below to model an electromagnetic wave from the sun.

Model of Electromagnetic Wave from Sun



Scientists have shown that ultraviolet light from the sun that has a wavelength of 315 to 400 nm can damage the retina. Which question is the BEST question for the student to ask to determine whether the electromagnetic wave modeled will cause damage to the retina?

A. What is the vertical distance between point Y and point Z on the model?
B. What is the vertical distance between point X and point Y on the model?
C. What is the horizontal distance between point W and point Z on the model?
D. What is the horizontal distance between point W and point Y on the model?

Item 16

Multi-Select Technology-Enhanced

A student questioned how the properties of different materials affect the speed of sound waves traveling through them. The student found the following data in a chemistry handbook for the speed of sound in gases, liquids, and solids.

Speed of Sound in Different Materials at Room Temperature

State	Material	Density (kg/m^3)	Speed of Sound (m/s)
gas	carbon dioxide	1.842	267
	helium	0.166	1,007
	methane	0.668	446
liquid	benzene	874	1,310
	ethanol	789	1,162
	water	1,000	1,497
solid	aluminum	2,700	6,420
	copper	8,790	5,010
	gold	19,290	3,240

The student analyzed the data to make predictions about the speed of sound on materials with various densities and states of matter. Which TWO predictions can be made based on the data shown in the table?

A. The speed of sound generally increases as it moves from gases to liquids to solids.
B. The speed of sound generally increases as it moves from liquids to gases to solids.
C. The speed of sound generally increases as it moves from solids to gases to liquids.
D. As the density of liquids and solids increases, the speed of sound generally increases.
E. As the density of gases and liquids increases, the speed of sound generally decreases.
F. As the density of solids and gases increases, the speed of sound generally decreases.

_____ An object at rest will remain at rest unless acted on by an unbalanced force. An object in motion continues in motion with the same speed and in the same direction unless acted upon by an unbalanced force. This law is often called "the law of inertia".

_____ Acceleration is produced when a force acts on a mass. The greater the mass (of the object being accelerated) the greater the amount of force needed (to accelerate the object).

_____ For every action there is an equal and opposite re-action.

Lenses use the principle of _____ to change the path of light waves.

_____ lens is thicker in the middle that it is at the edges; Directs light so it converges, or comes together, at a point called the focus (focal point); Works to make something look larger (binoculars, telescopes, magnifying glasses).

_____ lens is thinner in the middle than it as at the edges; Causes light to diverge, or spread out; work to make something look smaller (eyeglasses have either concave or convex); The lenses bend the light just the right amount to focus an image.

_____ is when an object becomes charged by rubbing; objects are now opposite charges; only the electrons in an atom are free to move around and transfer.

_____ is when an object becomes charged without touching; the side of the object closest to the charger receives a charge opposite that of the charger; a temporary charge.

_____ is when an object becomes charged by touching; that object receives a charge that is the same as the charger; a permanent charge.

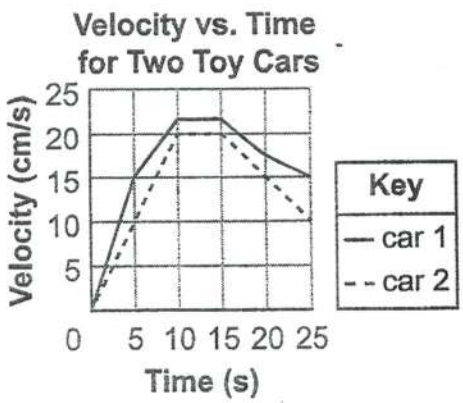
_____ (like metals) allow electrons to move freely, and when charging, the electrons spread out across the surface of the object.

_____ (like plastic) do *not* allow electrons to move freely, and when charging, the electrons stay in that area where it was charged.

Item 17

Selected-Response

Two toy cars move in the same direction with velocities that are shown in the graph.



Based on the information in the graph, which statement describes the motion of the two toy cars?

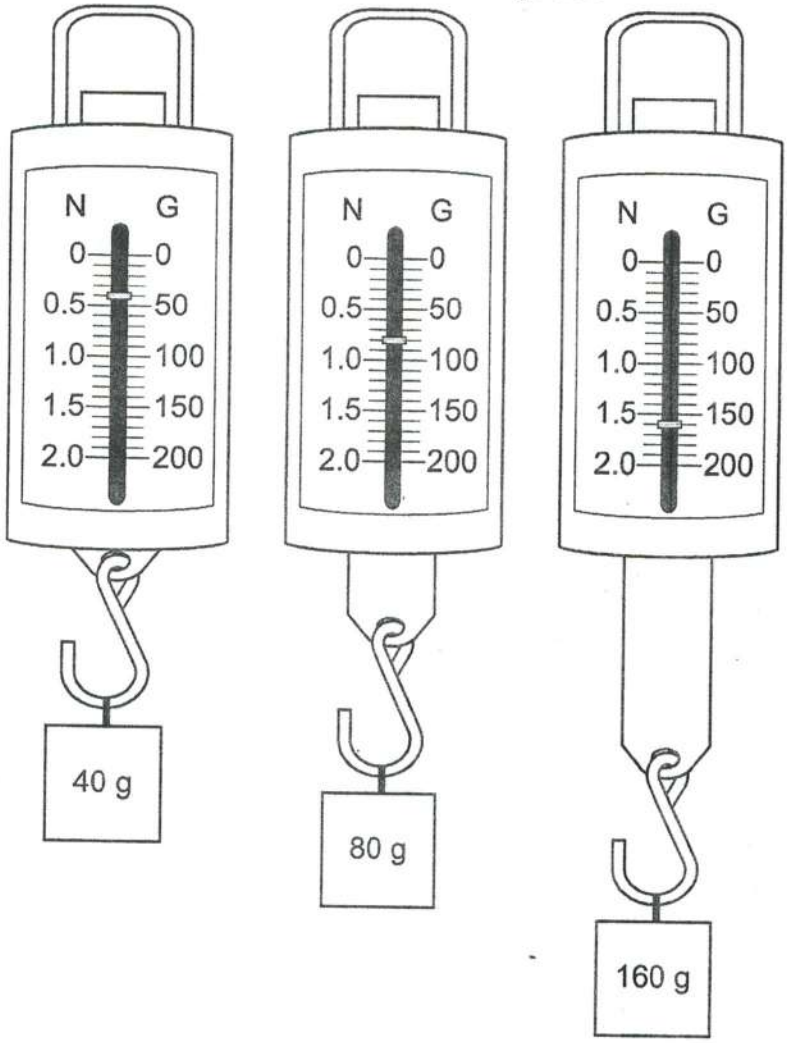
A. Car 1 is traveling faster than car 2.
B. Car 2 is traveling farther than car 1.
C. Car 1 has constant velocity between 0 and 10 seconds.
D. Car 2 is changing direction between 10 and 15 seconds.

Item 18

Selected-Response

A lab group is investigating how Earth's gravitational acceleration affects the force exerted on toy blocks of different masses. The diagram shows the results of their investigation.

Force vs. Mass Investigation



The group claims that the amount of force needed to accelerate a toy block is directly proportional to its inertia.

Which explanation presents the BEST argument for whether the group's claim is true?

A. The claim is false because every time the mass of the metal cube is increased, the pointer on the spring scale moves downward.

B. The claim is true because every time the mass of the metal cube is doubled, the gravitational force doubles.

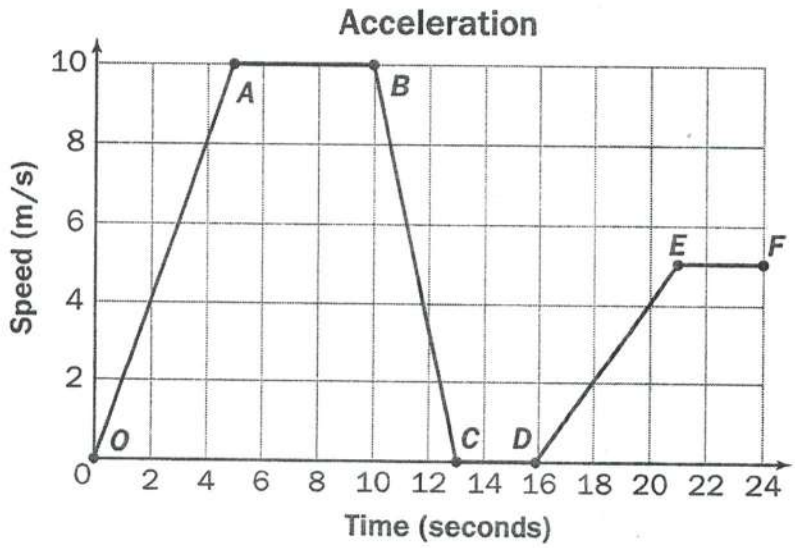
C. The claim is false because every time the volume of the metal cube is increased, the pointer on the spring scale moves downward.

D. The claim is true because every time the volume of the metal cube is doubled, the gravitational force doubles.

Item 19

Selected-Response

Students are exploring the relationship between velocity and acceleration. This graph shows the acceleration of a remote-controlled toy car.



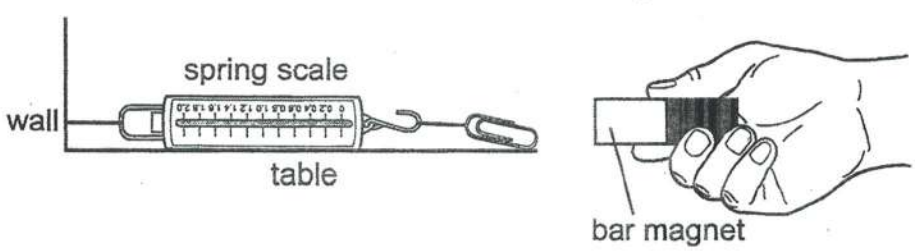
Which statement is TRUE based on the graph?

A. Segment *BC* and segment *EF* show constant speed.
B. Segment *OA* and segment *BC* show constant speed.
C. Segment *AB* and segment *CD* show positive acceleration.
D. Segment *OA* and segment *DE* show positive acceleration.

Item 20

Multi-Select Technology-Enhanced

A magnet is moved toward a paper clip, as shown in the drawing. Students want to investigate how the strength of the force between the paper clip and a magnet changes under different conditions.



Which TWO factors should the students vary to BEST investigate the strength of the force between the paper clip and a magnet?

A. Attach the spring scale to the table.
B. Move the magnet farther away from the paper clip.
C. Replace the bar magnet with a horseshoe magnet.
D. Replace the spring scale with a larger spring scale.
E. Increase the length of the string attaching the spring scale to the wall.
F. Increase the length of the string attaching the spring scale to the paper clip.