Grade 4 Science, Quarter 1, Unit 1.1

Physical Changes to Matter

Overview

Number of instructional days: 12 (1 day = 45 minutes)

Content to be learned

- Collect and organize data about physical properties in order to classify and draw conclusions about objects and their properties.
- Observe and describe physical changes.
- Make logical predictions about the changes in the state of matter when adding or taking away heat.
- Describe properties of solids, liquids, and gases.
- Measure the weight of objects to prove that all matter has weight.
- Use measures of weight to prove that the whole equals the sum of the parts.
- Show that the weight of an object remains the same despite a change in its shape.

Science processes to be integrated

- Make predictions based on given examples or illustrations.
- Conduct experiments and use data to classify materials.
- Collect and use experimental data to classify materials.
- Observe and describe how objects and energy interact within systems.
- Describe the interaction between structures and processes within a system.

Essential questions

- In what ways can objects be described and classified?
- What properties determine whether an object or material is a solid, a liquid, or a gas?
- What happens to matter when heat is added or taken away?
- How can you prove that an object has weight? Provide evidence to support your thinking.
- What happens to the weight of an object when its shape is changed or when it is broken into pieces?

Written Curriculum

Grade-Span Expectations

PS1 - All living and nonliving things are composed of matter having characteristic properties that distinguish one substance from another (independent of size or amount of substance).

PS1 (K-4) INQ –1

Collect and organize data about physical properties in order to classify objects or draw conclusions about objects and their characteristic properties (e.g., temperature, color, size, shape, weight, texture, flexibility).

PS1 (3-4)–1 Students demonstrate an understanding of characteristic properties of matter by …

Students demonstrate an understanding of physical changes by …

1c observing and describing physical changes (e.g. freezing, thawing, torn piece of paper).

PS1 (K-4) POC –2

Make a prediction about what might happen to the state of common materials when heated or cooled or categorize materials as solid, liquid, or gas.

PS1 (3-4) –2 Students demonstrate an understanding of states of matter by …

2c making logical predictions about the changes in the state of matter when adding or taking away heat (e.g., ice melting, water boiling or freezing, condensation/evaporation).

2a describing properties of solids, liquids, and gases.

PS1 (K-4) SAE –3

Use measures of weight (data) to demonstrate that the whole equals the sum of its parts.

PS1 (3-4)–3 Students demonstrate an understanding of conservation of matter by …

3a measuring the weight of objects to prove that all matter has weight.

3b using measures of weight to prove that the whole equals the sum of its parts.

3c showing that the weight of an object remains the same despite a change in its shape.

Clarifying the Standards

Prior Learning

In grades K–2, students identified, compared, and sorted objects according to physical properties (such as size, shape, color, texture, smell, and weight). They recorded their observations and data, and used attributes of physical properties to state why objects are grouped. Using simple tools, students explored the property of weight. They made logical predictions about the changes in state of matter when adding or subtracting heat. In addition, students described, identified, and compared solids and liquids, and described the properties of solids and liquids.

In grade 3, students identified, compared, and sorted objects by physical properties, including temperature and flexibility, and they cited evidence to support conclusions about why objects are grouped/not grouped together. Students described the properties of solids, liquids, and gases, and identified and compared solids, liquids, and gases. Third-graders also observed and described physical changes in terms of freezing and thawing. They showed that heat moves from one object to another, causing a change in temperature, and described how heat moves from warm objects to cold objects until both objects are the same temperature. Students also made logical predictions about the changes in the state of matter when adding or taking away heat.

Current Learning

At the reinforcement level of instruction, students in grade 4 continue to observe and describe physical changes. They demonstrate an understanding of different states of matter by describing the properties of solids, liquids, and gases, and making logical predictions regarding changes in the state of matter when adding or taking away heat, including, water boiling or freezing, and condensation/evaporation. In order to observe evaporation and condensation, groups of students can fill a glass bowl half full of water and cover the top with plastic wrap. After a few minutes, students place an ice cube on top of the plastic wrap, then observe, describe, and explain what happens.

At the developmental level of instruction, students measure the weight of objects to prove that all objects have weight. They use measures of weight to prove that the whole equals the sum of its parts, and will show that the weight of an object remains the same despite a change in its shape.

Some of the concepts in this unit are abstract; therefore, collecting and using data and making observations are important process skills in this unit of study. Students will use data to identify, compare, and contrast states of matter by conducting experiments on a variety of solids, liquids, and gases. Students should also conduct a variety of activities in which they observe that matter can undergo physical changes, including a change in state. Using ice, students can observe and describe how heat causes a change in shape as well as a change in state. When adding heat to ice, a solid with definite volume and shape, it becomes water, a liquid with a definite volume. If we continue to add heat, water becomes water vapor, a gas that does not have a definite volume or shape. Students should collect data from demonstrations conducted by the teacher and/or from their own experiments. This will allow them to observe, explain, and predict the effects of adding or taking away heat or cold on states of matter.

When students investigate the weight of objects, they should have multiple opportunities to use spring scales or balances. By using a these tools, students can measure in grams, then can change the shape or break apart the objects in order to compare the weight of the parts to the weight of the whole. This will allow students to develop a conceptual understanding that the weight of an object remains the same despite a change in its shape. Teachers should keep in mind that students at this grade level are more capable of collecting quantitative data, but they should continue to collect and record qualitative data as well. Determining that the weight of an object remains the same, despite its shape presents a developmental challenge for students; however, this is foundational for developing an understanding of conservation of matter. Therefore, students should focus on measuring weight of objects, both before and after they undergo physical changes.

Students have been exposed to these vocabulary words before, however, during this unit of study, students will further understand the following terms: condensation, evaporation, boiling, thawing, melting, matter, solids, liquids, gases, flexibility, texture, and weight.

Future Learning

In grades 5–6, students will recognize that regardless of the size of the sample, substances have different characteristic properties, which allow them to be identified. They will classify, compare, and differentiate substances using characteristic properties of solids, liquids, and gases. Students will explain that regardless of how parts of objects are arranged, the mass of the whole is always the same as the sum of the masses of its parts. Students will demonstrate their understanding of characteristic properties of matter by comparing the masses of objects of equal volume made of different substances. They will also predict the effects of heating and cooling on the physical state, volume, and mass of a substance.

Additional Findings

The structure of matter may have the most implications for students' eventual understanding of the picture that science paints of how the world works. And it may offer great challenges, too. The particle model of matter powerfully explains many phenomena, but it demands imagination and the joining of several lines of evidence. Students must know about the properties of materials and their combinations, changes of state, effects of temperature, behavior of large collections of pieces, and the construction of items from parts. Therefore, bringing the particle theory of matter into earlier grades is a great temptation, but most students are not ready to understand this theory before adolescence. Students need to become familiar with the physical and chemical properties of many different kinds of materials through firsthand experiences before they can be expected to consider theories that explain them (*Benchmarks for Science Literacy*, p. 75).

During grades 3–5, the study of materials should become more systematic and quantitative. Objects and materials can be described by more sophisticated properties, including conduction of heat and electricity, and response to magnets. Students should measure, estimate, and calculate sizes, capacities, and weights. If young children can't feel the weight of something, they may believe it to have no weight at all. Many experiences of weighing, including weighing piles of small things and dividing to find the weight of each will help. It is not obvious to elementary students that wholes weigh the same as the sum of their parts. That idea is preliminary to, but far short of, the conservation principle to be learned later that weight doesn't change in spite of striking changes in other properties as long as all the parts are accounted for. By the end of 5th grade, students should know that heating and cooling cause changes in the properties of materials, and that many kinds of changes occur faster under hotter conditions. No matter how parts of an object are assembled, the weight of the whole object made is always the same as the sum of the parts; and when an object is broken into parts, the parts have the same total weight as the original object. In addition, materials may be composed of parts that are too small to be seen without magnification (*Benchmarks*, pp. 76–77).

Students sometimes confuse the name of an object with the name of the material from which it is made. It is suggested that teachers help children to discriminate between an object and the materials of which it is made. Although in science the word "material" is used to designate any kind of matter or "stuff" that can be observed or detected in the world around us, children may initially use the word to mean those things that are required to make objects—for example, fabrics for clothing or bricks for buildings. Although the word "stuff" may not be accepted as a scientific word, it has tangible connotations for students, and therefore is useful for developing the idea that there are different kinds of "stuff" and that they are recognized by their different properties (*Making Sense of Secondary Science*, pp. 73–74).

Younger children tend to regard any rigid material as a solid, any powders as liquid because they can be poured, and any non-rigid material, such as a sponge or cloth, may be seen as something between solid and liquid, because they are "soft" or "crumble" or "can be torn. Therefore, children decide the state of a

material according to its appearance and behavior with the result that they associate solidity with hardness, strength, and non-malleability. Researchers suggest that teachers develop the idea that a powder is composed of small pieces of solid. Additionally, children identify a liquid as a material that is "runny" or "can be poured." Further, because in a child's view, the exemplary liquid is water, all liquids may be regarded as "watery," or "made of water," or "containing water." Therefore, classifying thicker liquids, like paste, honey, and tomato sauce can be more challenging than classifying "runny" liquids (*Making Sense*, pp. 79–80).

Children may not initially be aware that air and other gases have material character. For example they understand that air and smoke exist, but think of them as having characteristics similar to thoughts. They see air and gas as contrasting ideas, with air being "good" because we breathe it, and gas being "bad" because it is poisonous. By ages 9–13, children may believe that gas has a negative weight and think the more gas you add to a container, the lighter it becomes. Until students have constructed the idea that gases have mass, they are unlikely to conserve mass when describing changes that involve gases as products (*Making Sense*, p. 80).

Researchers have found that, from a very early age, children notice how objects differ in the way they appear to "press down" on the hands, shoulder, or head (i.e., they learn to "feel the weight" of objects). Children compare objects by their "felt weight" and, over time, generate an idea that "felt weight" is a characteristic property of an object (*Making Sense*, p. 77).

Every substance can exist in a variety of different states, depending on temperature and pressure. Just as water can exist as ice, water, and vapor, all but a few substances can also take solid, liquid, and gaseous form. When matter gets cold enough, the particles of matter lock in place in a more or less orderly fashion as solids. Increasing the temperature means increasing the average energy of motion of the particles, causing matter to change from a solid to a liquid state. At still higher temperatures, liquids change to gases (*Science for All Americans*, pp. 47–48).

The way in which students perceive a physical change may determine whether or not they regard materials as being conserved during that change. For example, if a student's view of a particular change is dominated by the apparent disappearance of some material (such as water changing to water vapor), then pupils are unlikely to conserve the mass. Further, students' ideas about the physical state of a material are found to influence how they interpret a change. If, for example, they regard gases as weightless, then they are unlikely to conserve overall weight or mass in changes involving gases (*Making Sense*, p. 77).

Notes About Resources and Materials

- Use a balance and gram cubes to measure the weight of different objects
- Hot plate, water, and ice
- Condensation/evaporation—Glass container, water, ice and plastic wrap

Grade 4 Science, Quarter 1, Unit 1.2

Electricity and Light

Overview

Number of instructional days: 10 (1 day = 45 minutes)

Content to be learned

- Given an example or illustration, predict the observable effects of energy.
- Describe or show that heat can be produced in many ways.
- Draw, diagram, build, and explain a complete electrical circuit.
- Use experimental data to classify a variety of materials as conductors or insulators.
- Predict, describe, and investigate how light rays are reflected, refracted, or absorbed.
- Investigate observable effects of light using a variety of light sources.

Science processes to be integrated

- Conduct experiments; collect, and record data.
- Use science processes to make predictions, conduct investigations, and diagram findings.
- Use or build models to demonstrate understanding of the interaction between structures and processes within a system.
- Make predictions based on given examples or illustrations.

Essential questions

- What makes an object either a conductor or an insulator? Explain.
- What are some ways that heat can be produced?
- What happens when light comes into contact with objects?
- What are some of the characteristics of light energy?
- What effects can be observed in an electrical circuit?

Written Curriculum

Grade-Span Expectations

PS 2 - Energy is necessary for change to occur in matter. Energy can be stored, transferred, and transformed, but cannot be destroyed.

PS2 (K-4) SAE -4

Given a specific example or illustration (e.g., simple closed circuit, rubbing hands together), predict the observable effects of energy (i.e., light bulb lights, a bell rings, hands warm up (e.g., a test item might ask, "what will happen when…?").

PS2 (3-4)-4 Students demonstrate an understanding of energy by…

4c describing or showing that heat can be produced in many ways (e.g. electricity, friction, burning).

4d drawing, diagramming, building, and explaining a complete electrical circuit.

4e using experimental data to classify a variety of materials as conductors or insulators

PS2 (K-4) SAE – 5

Use observations of light in relation to other objects/substances to describe the properties of light (can be reflected, refracted, or absorbed).

PS2 (3-4)-5 Students demonstrate an understanding of energy by…

5a investigating observable effects of light using a variety of light sources (e.g., light travels in a straight line until it interacts with an object, blocked light rays produce shadows).

5b predicting, describing, and investigating how light rays are reflected, refracted, or absorbed.

Clarifying the Standards

Prior Learning

In grades K–2, students identified the sun as a source of heat energy and described that the sun warms land and water. Students described that objects change in temperature by adding or subtracting heat. They described the observable effects of light using a variety of sources, including both natural and manmade light, and demonstrated when shadows are created using sunny versus cloudy days. Students also experimented and described how vibrating objects make sound.

In grade 3, students showed that heat moves from one object to another, causing a change in temperature, and they described how heat energy moves from warm objects to cold objects until both are the same temperature. Students experimented to identify and classify different pitches and volumes of sounds produced by different objects. They used data to explain what causes sound to have different pitch or volume, and used experimental data to classify a variety of materials as conductors or insulators.

Current Learning

During this unit of study, students in grade 4 participate in experiments in order to learn about the characteristics of electrical and light energy, and to extend their understanding of the transfer and transformation of energy. At the developmental level of instruction, students describe or show that heat can be produced in many ways, such as through electricity, friction, and burning.

When given a specific example or illustration, students predict the observable effects of electrical energy. They draw, diagram, build, and explain a complete electrical circuit in order to show the interactions between the structures (batteries, bulbs, and wires) and the processes (flow of electrical energy, transformation of chemical energy in the battery to electrical energy, to light energy) within a simple system. After testing a variety of materials in order to observe how they interact within an electrical circuit, students use their experimental data to classify these materials as either conductors or insulators.

Students should look for similarities and differences among the materials tested in the circuit in order to describe the properties that make an object either a conductor or an insulator. As an extension to their learning, when building and diagramming electrical circuits, students should be given opportunities to build series and parallel circuits in order to understand how changes in the structure of the system can affect the system. These concepts are new to students, and are only addressed in this grade level. Therefore, these concepts should be taught at the developmental level through the drill-and-practice level of instruction.

Also at the developmental level through the drill-and-practice level of instruction, students investigate the observable effects of light using a variety of light sources, and they predict, describe, and investigate how light rays are reflected, refracted, or absorbed. Students need the opportunity to explore the interaction of light with a wide variety of materials in order to directly observe these phenomena. While conducting investigations, students should observe that light travels in a straight line until it interacts with objects. When light interacts with materials, some or all of the light can be reflected, bouncing off the surface of the object, or the light can be absorbed in various degrees, creating shadows. If light travels through different mediums, such as water, it can be bent or refracted.

To help students develop a conceptual understanding of light reflection, have them drop rubber balls on a flat, smooth surface. The balls will bounce straight back up, mimicking the reflection of light from a smooth surface. However, when students drop the rubber balls onto a rough surface, they bounce off in different directions. This mimics the behavior of light when it interacts with a rough surface (i.e., the light rays scatter when reflected off a rough surface). In order to observe the refraction, or bending, of light, for each group of students, prepare a shoebox with two slits on one end. If students shine a flashlight at the shoebox, they observe that the light travels through the slits in a straight line. If a clear plastic cup is placed inside the box, the light travels through the plastic cup with little to no change in direction. However, if the cup is filled with water, students will actually see the light refract, or bend, as it passes through the water in the cup. They will observe the rays of light cross as they pass beyond the cup of water. To show absorption, have students shine a flashlight at different kinds of materials, such as cardboard, construction paper, wax paper, clear plastic wrap, zipper bags, and laminating film. Students should observe varying degrees of light passing through and/or absorption of light, leading to the understanding that the materials can be classified as transparent, translucent, or opaque.

Keep in mind that students at this grade level are more capable of collecting quantitative data, but should continue to collect and record qualitative data as well. Students need to focus on demonstrating, conducting, and building, in addition to diagramming and explaining.

Students have been exposed to these vocabulary words, and after this unit of study, will further understand them: electricity, circuit, closed circuit, open circuit, friction, reflected, refracted, absorbed, transparent, translucent, and opaque.

Future Learning

In grades 5–6, students will differentiate among the properties of various forms of energy. They will explain how energy may be stored in various ways (e.g., batteries), and will describe sound as the transfer of energy through various materials (e.g., solids, liquids, and gases). Students will also identify real-world applications where heat energy is transferred, and will show the direction that the heat energy flows.

Additional Findings

During the elementary grades, investing much time and effort in developing formal energy concepts can wait. Students should know that energy is important because it is useful. It helps make sense out of a very large number of things that go on in the physical, biological, and engineering worlds. One aspect of energy that elementary students can understand is heat, which is produced almost everywhere. In their science and technology activities, students should be alerted to look for things and processes that give off heat such as lights, radios, television sets, the sun, sawing wood, polishing surfaces, bending things, people, animals, etc.—and then those that do not seem to give off heat. By the end of grade 5, students should know that things that give off light often also give off heat (*Benchmarks for Science Literacy*, pp. 83–84).

Physical science in grades K–4 includes topics that give students a chance to increase their understanding of the objects and events that they encounter daily. By experimenting with light, heat, electricity, and magnetism, students begin to understand that phenomena can be observed, measured, and controlled in various ways. In most children's minds, electricity begins at a source and goes to a target. This mental model can be seen in students' first attempts to light a bulb using a battery and wire by attaching a wire to a bulb. Repeated activities will help students develop an idea of a circuit late in the K–4 grade span and begin to grasp the effect of more than one battery. Some fundamental concepts include that light travels in a straight line until it strikes an object. They will understand that light can be reflected by a mirror, refracted by a lens, or absorbed by the object; and heat can be produced in many ways. Electricity in circuits can produce light, heat, sound, and magnetic effects, and electrical circuits require a complete loop through which an electrical current can pass (*National Science Education Standards*, pp. 123, 126–127).

The majority of elementary students and some middle-school students who have not received any systematic instruction about light tend to identify light with its source (e.g., light is in the bulb), or its effects (e.g., patch of light). They do not have an awareness of light as something that travels from one place to another. As a result, these students have difficulties explaining the direction and formation of shadows, and the reflection of light by objects. For example, some students simply note the similarity of shape between the object and the shadow or say that the object hides the light. Middle-school students often accept that mirrors reflect light but, at least in some situations, reject the idea that ordinary objects reflect light (*Benchmarks*, pp. 338–339).

Most students' introduction to learning about electricity involves using a battery, wire, and a 1.25V bulb to make the bulb light. Students usually have certain established ideas about how batteries and bulbs work. Students' ideas about electricity generally indicate a source-consumer model in which the battery gives energy to the bulb. In practice, this model underlies the common examples of circuits that are built by children in the 8–12 age range in their initial attempts to light the bulb. Furthermore, it seems that

many strategies designed to help students understand electricity actually introduce and reinforce problems (*Making Sense of Secondary Science*, p. 117). In their earliest experiences with batteries, students often think of a battery as a unipolar "giver" of electricity. Students generally think of the battery as a store of electricity or energy. They see it as delivering a constant current in a closed circuit instead of maintaining a constant voltage. Students tend to have little knowledge of voltage (*Making Sense*, p. 121).

Students usually think of a circuit as a series of happenings as electricity leaves the battery, travels through components, and returns to the battery. This can prevent them from thinking of the circuit as a complete system and doesn't allow them to think of the interactions when a change in one place affects the whole circuit (*Making Sense*, pp. 121–122). Students' spatial abilities can affect their use of circuit diagrams. If one circuit has been rotated as to have a different spatial arrangement, students may not see it as identical to the first circuit. When students were asked whether a circuit diagram would "work" in practice, they more often judged symmetrical diagrams to be functioning that non-symmetric ones (*Making Sense,* p. 124).