## Grade 5 Science, Quarter 1, Unit 1.1

# Properties of Matter

## Overview

**Number of instructional days:** 8 (1 day = 45 minutes)

### Content to be learned

- Use data to explain that regardless of how the parts of an object are arranged, the mass of the whole is always the same as the sum of the masses of its parts.
- Investigate relationships between mass and volume, by comparing the masses of objects of equal volume made of different substances.
- Classify and compare substances using characteristic properties of solids, liquids, and gases.
- Distinguish between solutions, mixtures, and "pure" substances, like compounds and elements.

### Science processes to be integrated

- Use science tools safely and appropriately.
- Measure and compare using science tools.
- Make and record observations and data in order to compare the properties of matter.
- Use properties to classify and draw conclusions about matter.
- Use models to demonstrate processes of change.

### Essential questions

- What are the similarities and differences between mixtures and solutions?
- How do various substances of the same volume compare in terms of mass?
- What is the relationship between the mass of a mixture and the mass of that mixture's component parts?
- What is the relationship between compounds and elements?

# 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 (5-8) INQ+ SAE –3***

*Collect data or use data provided to infer or predict that the total amount of mass in a closed system stays the same, regardless of how substances interact (conservation of matter).*

**PS1 (5-6)–3 Students demonstrate an understanding of conservation of matter by …**

**3a** explaining that regardless of how parts of an object are arranged, the mass of the whole is always the same as the sum of the masses of its parts.

***PS1 (5-8) INQ-1***

*Investigate the relationships among mass, volume and density.*

**PS1 (5-6)-1 Students demonstrate an understanding of characteristic properties of matter by …**

**1a** comparing the masses of objects of equal volume made of different substances.

***PS1 (5-8) INQ+POC –2***

*Given data about characteristic properties of matter (e.g., melting and boiling points, density, solubility) identify, compare, or classify different substances.*

**PS1 (5-6) –2 Students demonstrate an understanding of characteristic properties of matter by …**

**2b** classifying and comparing substances using characteristic properties (e.g., solid, liquid, gas).

***PS1 (5-8) MAS –5***

*Given graphic or written information, classify matter as atom/molecule or element/compound (Not the structure of an atom).*

**PS1 (5-6) – 5 Students demonstrate an understanding of the structure of matter by …**

**5a** distinguishing between solutions, mixtures, and "pure" substances, i.e. compounds and elements.

## Clarifying the Standards

*Prior Learning*

In grades K–2 students demonstrated an understanding of characteristics properties of matter by identifying, comparing, and sorting objects by similar or different physical properties such as size, shape, color, texture, smell, and weight. Students recorded observation and data about physical properties, and used attributes of properties to state why objects are grouped together. Students described properties of solids and liquids as well as identifying and comparing solids and liquids. They used simple tools, such as balances and seesaws, to explore the property of weight.

In grades 3–4, students identified, compared, and sorted objects by similar or different physical properties, and cited evidence to support conclusions about why objects are grouped or not grouped together. They described properties of solids, liquids, and gases, and identified and compared solids, liquids, and gases. Students measured the weight of objects to prove that all matter has weight and used measures of weight to prove that the whole equals the sum of its parts, and they showed that the weight of an object remains the same despite a change in its shape.

*Current Learning*

During this unit of study, students learn that mass is the amount of matter that makes up an object and that a balance is used to measure mass. At the developmental to reinforcement level of instruction, students compare the masses of objects of equal volume made of different substances, and explain that regardless of how parts of an object are arranged, the mass of a whole is always the same as the sum of the masses of its parts. At the developmental level of instruction, students classify and compare substances, such as solids, liquids, and gases, using characteristic properties. At the developmental through the drill-and-practice level of instruction, students distinguish between solutions, mixtures, and “pure” substances.

Through teacher-guided and student-led investigations, students use science tools such as balances, cups, and graduated cylinders to measure and compare properties of matter. Students also need to make and record observations and data in order to compare the properties of matter. They use properties to classify and draw conclusions about matter, as well as use models to demonstrate processes of change. In addition, students will use science tools such as magnets, sieves, filters, and funnels, as well as processes such as evaporation and chromatography, to separate mixtures and solutions into their component parts (“pure” substances).

Students need multiple opportunities using balances to compare the masses of objects with equal volume made of different substances. Students should compare the mass of a variety of solids, such as equal-sized blocks of wood, Styrofoam, and clay. Students should also measure out equal volumes of collections of small solids such as sand, rice, pebbles, and cereal, and then compare the mass of each collection. Finally, students should compare the masses of liquids of equal volume such as water, saltwater, oil, and syrup. These types of investigations should help students understand is that equal volume does not mean equal mass. This lays the foundation for understanding the characteristic property of density, which is addressed in grades 7–8.

In grade 5, students also begin to apply previous understanding of the properties of matter in order to classify and compare given substances based on characteristic properties. They should first review the characteristics of solids, liquids, and gases, and then conduct investigations. For example, students can classify and compare the physical characteristics of water and salt water (high content of salt) in their different states (solid, liquid, and gas). Students should understand that water and salt water each freeze at a certain temperature, become a liquid at a certain temperature, and become a gas at a certain temperature. The focus should be that a given substance, at a certain temperature, naturally occurs as a solid, liquid, or a gas.

Distinguishing between solutions and mixtures is a new concept; therefore, students need many opportunities to explore mixtures and solutions, and various experiences in which to separate them. For example, we can separate collections of socks, buttons, or trail mix by hand. We can separate a sand and water mixture with a funnel and filter. A mixture of iron filings and sand can be separated using a magnet, and a mixture of salt and pepper can be separated by dissolving the salt in water, then using a filter and funnel to separate out the pepper from the saltwater solution. Solutions are special kinds of mixtures that need to be separated through different methods. For example, we can separate salt from a saltwater solution using evaporation, or we can separate black ink (from a permanent marker) into its component colors using chromatography. In addition, students at this grade level should learn that "pure" substances are the individual substances that make up mixtures and solutions (i.e., salt and water are pure substances that make up the saltwater solution).

Working with solutions and mixtures will help students understand that the mass of the parts is equal to the mass of the whole. For example, the students can make a trail mix with a given amount of raisins and Cheerios. They use a balance scale to measure the mass of each part of their mixture, then measure the mass of the mixture. This gives students the opportunity to directly observe that the sum of the individual parts of a mixture is equivalent to the mass of the whole mixture.

*Future Learning*

In grade 6, students will recognize that different substances have properties, which allow them to be identified regardless of sample size, and will differentiate among the characteristics of solids, liquids, and gases. Students will also predict the effects of heating and cooling on the physical state, volume, and mass of a substance.

In grades 7–8, students will measure the mass and volume of regular and irregular objects and using those values as well as the relationship $D=m/v$ to calculate density. They will identify an unknown substance given its characteristic properties, and will classify and compare substances, including solids, liquids, gases, metals, and non-metals, using characteristic properties. They will cite evidence to conclude that the amount of matter before and after undergoing a physical or a chemical change in a closed system remains the same. Students will create diagrams and models that represent the states of matter at the molecular level, and will explain the effect of increased and decreased energy on the motion and arrangement of molecules. They will observe the physical processes of evaporation and condensation, or freezing and melting, and will describe these changes in terms of molecular motion and conservation of mass. Students will use models and diagrams to show the difference between atoms and molecules, and will classify common elements and compounds using symbols and simple chemical formulas. They will interpret the symbols and formulas of simple chemical equations, and will use symbols and chemical formulas to show simple chemical rearrangements that produce new substances. Students also explain that when substances undergo physical changes, the appearance may change but the chemical makeup and chemical properties do not. They will also explain that when substances undergo chemical changes to form new substances, the properties of the new combinations may be very different from those of the old.

## Additional Findings

In grades 3–5, objects and materials can be described by more sophisticated properties, such as conduction of heat and electricity and response to magnets. Students should measure, estimate, and calculate sizes, capacities, and weights. If young children cannot 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 mass doesn't change in spite of striking changes in other properties as long as all the parts, including invisible gases, are accounted for. In addition, students should use magnifiers to inspect substances composed of large collections of particles, such as salt and talcum powder, to discover the unexpected details at smaller scales. They should also observe and describe the behavior of large collections of pieces—powders, marbles, sugar cubes, or wooden blocks, which can, for example, be poured out of a container. Students should consider that the collections might have new properties that the pieces do not (*Benchmarks for Science Literacy*, p. 76).

By the end of grade 5, students should know that no matter how the parts of an object are assembled, the weight of the whole object is always the same as the sum of the parts. Students should also know that when an object is broken into parts, the parts have the same total weight as the original object. In science, we typically define this concept in terms of mass, not weight. Additionally, students should recognize that a new material formed by combining two or more materials will have properties that are different from those of the original material. And students should recognize that many types of things can be made from a small number of basic materials (i.e., substances or elements) (*Benchmarks,* p. 77).

Students cannot understand conservation of matter and weight if they do not understand what matter is, accept weight as an intrinsic property of matter, or distinguish between weight and density. By 5th grade, many students can understand qualitatively that matter is conserved in transforming from solid to liquid. They also start to understand that matter is quantitatively conserved in transforming from solid to liquid, and qualitatively in transforming from solid or liquid to gas—if the gas is visible. Lower elementary students often fail to conserve weight of objects that change shape. When an object's appearance changes in several dimensions, students focus on only one. They cannot imagine a reversed or restored condition and focus mostly on the object's present appearance. The ability to conserve develops gradually. Many students cannot discern weight conservation in some tasks until they are 15 years old. The ability to conserve weight in a task involving transformation from liquid to gas or solid to gas may increase with age (*Atlas of Science Literacy*, Vol. 1, p. 56).

According to the *National Science Education Standards*, in grades 5–8, the focus on student understanding in physical science shifts from properties of objects and materials to the characteristic properties of the substances from which the material are made. In the K–4 years, students learned that objects and materials can be sorted and ordered in terms of their properties. During that process, they learned that some properties, such as size, weight, and shape, can be assigned only to the object while other properties, such as color, texture, and hardness, describe the materials from which objects are made. In grades 5–8, students observe and measure characteristic properties, such as density, solubility, melting point, and boiling point, and use those properties to distinguish and separate one substance form another (*NSES*, p. 149). In addition, characteristic properties are independent of the amount of the substance that is observed (*NSES*, p. 154).

It can be tempting to introduce atoms and molecules so that the particle model of matter can be used as an explanation for the properties of elements and compounds. However, use of such terminology is premature for students in grades 5–8 and can distract from the understanding that can be gained from focusing on the observation and description of macroscopic (or visible) features of substances and of physical changes. At this level, elements and compounds can be defined operationally from their characteristics, but few students can comprehend the idea of atomic and molecular particles (*NSES*, p. 149).

### Grade 5 Science, Quarter 1, Unit 1.2

# Energy

## Overview

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

### Content to be learned

- Differentiate among the properties of various forms of energy.
- Explain how energy can be stored in various ways (e.g., batteries, springs, height in terms of potential energy).
- Describe sound as the transfer of energy through solids, liquids, and gases.
- Identify real-world applications where heat energy is transferred and show the direction that the heat energy flows.

### Science processes to be integrated

- Identify, describe, and compare properties.
- Identify structures and processes within a system.
- Conduct investigations to observe, describe, and explain patterns of change that occur within systems.
- Identify real-world applications.

### Essential questions

- What are some of the properties of the various forms of energy?
- In what ways can energy be stored in an object?
- How do different forms of matter affect the transfer of sound energy?
- What are some real-world examples that show the transfer of heat energy?
- What are some real-world applications that show how heat energy flows?

# 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 (5-8)-SAE+ POC- 6***

*Given a real-world example, show that within a system, energy transforms from one form to another (i.e., chemical, heat, electrical, gravitational, light, sound, mechanical).*

**PS2 (5-6)- 6 Students demonstrate an understanding of energy by…**

**6a** differentiating among the properties of various forms of energy.

**6b** explaining how energy may be stored in various ways (e.g. batteries, springs, height in terms of potential energy).

**6c** describing sound as the transfer of energy through various materials (e.g. solids, liquids, gases).

***PS2 (5-8) INQ+SAE+POC – 7***

*Use data to draw conclusions about how heat can be transferred (convection, conduction, radiation).*

**PS2 (5-6)- 7 Students demonstrate an understanding of heat energy by…**

**7a** identifying real world applications where heat energy is transferred and showing the direction that the heat energy flows.

## Clarifying the Standards

*Prior Learning*

In grades K–2, students demonstrated an understanding of energy by describing observable effects of light using a variety of light sources. They experimented and described how vibrating objects made sound (e.g., guitar strings, seeing salt bounce on drum skin). Students identified the sun as a source of heat energy, and demonstrated when a shadow is created using sunny vs. cloudy days. They also described that the sun warms land and water and that objects change in temperature by adding or subtracting heat.

In grades 3–4, students demonstrated an understanding of energy by experimenting to identify and classify different pitches and volumes of sounds produced by different objects, and they used data to explain what causes sound to have different pitch or volume. Students showed and described that heat can be produced in many ways (e.g. electricity, friction, burning). They drew, diagramed, built, and explained a complete electrical circuit, and they used experimental data to classify a variety of materials as conductors or insulators. Students also investigated 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), and they predicted, described, and investigated how light rays are reflected, refracted, or absorbed. Students described how heat moves from warm objects to cold objects until both objects are the same temperature, and they showed that heat moves from one object to another causing temperature change (e.g. when land heats up it warms the air).

*Current Learning*

At the developmental level through the drill-and-practice level of instruction, grade 5 students demonstrate an understanding of energy by differentiating among the properties of various forms of energy. They explain how energy may be stored in various ways (e.g., batteries, springs, and height in terms of potential energy), and they describe sound as the transfer of energy through various materials (e.g., solids, liquids, and gases). At the developmental to reinforcement level of instruction, students demonstrate an understanding of heat energy by identifying real-world applications where heat energy is transferred and show the direction that the heat energy flows.

As students are learning this content they will conduct investigations to observe, identify, describe, and compare properties of energy, as well as identifying structures, processes, and patterns of change that occur within systems. Further, students identify real-world applications through the use of diagrams and explanations.

In this unit, students build upon their learning from previous grade levels. In grades 3–4, students identified and classified different pitches and volumes of sound. In fifth grade, students described sound as the transfer of energy through different types of matter. They should be provided with multiple concrete experiences listening to sound moving through various solids, liquids, and gases, in order to understand that sound travels through matter and that it transfers better through solids and liquids than it does through gases. Some examples of activities include using funnels to listen to sounds in tubs of water, building and using string-and-cup telephones, tapping an object on a table and listening to the sound as it travels through the air or with your ear directly to the table, and tapping an empty bottle vs. a bottle with a liquid in it.

In order to identify real-world applications where heat energy is transferred and show the direction that the heat energy flows, students can:

- Make a diagram of the heat flow in their house.
- Show how the internal temperature of a parked car increases in the sun.
- Diagram how the heating element in an oven transfers heat energy to the air and food inside the oven.
- Observe and describe how heating the end of a tin foil strip will cause chocolate chips along its length to melt in a predictable pattern. (The heat travels away from the heat source, outward along the foil, as well as up the chocolate chips.)
- Observe and describe how heat moves as you roast a marshmallow. (When toasting a marshmallow, heat moves from the outside to the inside because the heat source is closest to the outside of the marshmallow.)

In order to differentiate between the properties of the various forms of energy, students can use their prior knowledge to brainstorm a list of the properties of electrical, heat, sound, and light energy. They can then use this list to differentiate among the properties of various forms of energy.

Some properties include:

- Electrical energy
  - Travels in a circuit
- Heat energy
  - Transfers from warmer objects to colder objects
  - Travels away from the source of heat in a predictable pattern
  - Is created in a variety of ways (light, friction)
  - Is transferred more easily by some objects/materials (conductors) than by others (insulators)
- Sound energy
  - Travels through matter (better through solids than liquids, and better through liquids than gases)
  - Is created when an object vibrates
  - Can change in pitch and/or volume
- Light energy
  - Travels in a straight line
  - Interacts with objects
  - Can be refracted (bent), reflected, or absorbed.

In order to understand the concept of potential, or stored energy, students will need a variety of hands-on activities using everyday items. Some examples include:

- Rubber bands when stretched have stored energy
- Wind-up toys when wound have stored energy in the internal spring
- Pendulums have potential energy when they are not at the resting position
- A wound-up yoyo has potential energy in the string as well as when it's above the ground
- A spring-loaded toy or a suction cup toy has potential energy
- A slinky has potential energy at the top of the stairs
- Batteries have stored chemical energy

*Future Learning*

Grade 6 does not address any GSEs that focus on the concepts in this unit of study.

In grades 7–8, students will demonstrate an understanding of energy by using a real-world example to explain the transfer of potential energy to kinetic energy. They will construct models to explain the transformation of energy from one form to another (e.g., an electrical circuit changing electrical energy to light energy in a light bulb). Students will explain that while energy may be stored, transferred, or transformed, the total amount of energy is conserved. They will describe the effect of changing voltage in an electrical circuit. Students will design diagrams, models, and analogies to show or describe the motion of molecules for a material in a warmer and cooler state. Further, they will explain the difference among conduction, convection, and radiation, and will create a diagram to explain how heat energy travels in different directions and through different materials by each of these methods.

## Additional Findings

The understanding of energy in grades 5–8 builds on the K–4 experiences with light, heat, sound, electricity, and magnetism. In grades 5–8, students begin to see the connections among those phenomena and to become familiar with the idea that energy is an important property of substances and that most change involves energy transfer. Fundamental concepts and principles that student should understand include that energy is a property of many substances, and is associated with heat, light, electricity, mechanical motion, and sound. Heat moves in predictable ways, flowing from warmer objects to cooler ones, until both reach the same temperature. Light interacts with matter by transmission (including refraction), absorption, or scattering (including reflection) (*National Science Education Standards,* pp. 154–155).

Energy is a major exception to the principle that students should understand ideas before being given labels for them. Children benefit from talking about energy before they are able to define it. It is important to note that three energy-related ideas are very important. One is energy transformation. All physical events involve transferring energy or transforming one form of energy into another. A second idea is the conservation of energy. Whenever energy is reduced in one place, it is increased somewhere else by exactly the same amount. The third idea is that whenever there is a transformation of energy, some of it is likely to go into heat, which spreads around and is therefore not available for use (*Benchmarks for Science Literacy*, p. 81). Therefore, investing much time and effort in developing formal energy concepts can wait. The importance of energy is that it is a useful idea. It helps make sense out of a very large number of things that go on in the physical and biological world (*Benchmarks*, p. 83).

In addition, heat energy itself is a surprisingly difficult idea for students, who thoroughly confound it with the idea of temperature. Much time can be invested in having students memorize definitions—for heat, temperature, transformation, and the like—with little to show for it in the way of understanding (*Benchmarks*, pp. 81–82). Students should, however, be encouraged to look for things and processes that give off heat—lights, radios, television sets, the sun, sawing wood, polishing surfaces, bending things, running motors, people, animals, etc.—and then for those that seem not to give off heat. It is also appropriate to explore how heat spreads from one place to another and what can be done to contain it or shield things from it. Students may believe that cold is transferred rather than heat. They may also believe that some materials are intrinsically warm (blankets) or cold (metals). Objects that keep things warm—such as a sweater or mittens—may be thought to be sources of heat. Only a continuing mix of experiment and discussion is likely to dispel these ideas (*Benchmarks*, p. 83).

By the end of grade 5, students need NOT understand the difference between heat and temperature (*Benchmarks*, p. 83). Students should know that when two objects are rubbed against each other, they both get warmer. In addition, students should understand that many mechanical and electrical devices get warmer when in use. Things that give off light usually give off heat. Students need to recognize that heat can be transferred by contact or from a distance, and that, when warmer things are put with cooler ones, the warmer things cool off and the cooler things warm up until all of the objects are the same temperature. Some materials conduct heat much better than others, and poor conductors can reduce heat loss (e.g., insulators) (*Benchmarks,* p. 84).

According to the research in *Making Sense of Secondary Science*, students tend to mistakenly believe that sound needs an unobstructed pathway in order to travel. Children may envision sound as an invisible object with dimensions, which would need room in order to move. Students often do not understand the idea that air, or some type of matter, is needed for sound transmission. In addition, they rarely suggest a mechanism for sound travel at any age (p. 135).