Model Curriculum
Grade 3
Physical Science (PS)

Topic: Matter and Forms of Energy
This topic focuses on the relationship between matter and energy. Matter has specific properties and is found in all substances on Earth. Heat is a familiar form of energy that can change the states of matter.

Content Statement
All objects and substances in the natural world are composed of matter.

Matter takes up space and has mass*.

*While mass is the scientifically correct term to use in this context, the NAEP 2009 Science Framework (page 27) recommends using the more familiar term "weight" in the elementary grades with the distinction between mass and weight being introduced at the middle school level. In Ohio, students will not be assessed on the differences between mass and weight until Grade 6.

Content Elaboration
Prior Concepts Related to Matter
PreK-2: Objects are things that can be seen or felt. Properties of objects may be described, measured and sorted. The physical properties of water change as observed in weather. Air has mass* and takes up space (ESS).

Grade 3 Concepts:
Objects are composed of matter and matter has observable properties. Matter is anything that has mass and takes up space. All solids, liquids and gases are made of matter.

Volume is a measure of the amount of space an object takes up. Volumes of liquids can be measured in metric units with a beaker or graduated cylinder. Weight is a measure of gravity (how strongly Earth's gravity pulls the object toward Earth). Weight is measured using a scale. For any given location, the more matter there is in an object, the greater the weight. Opportunities to investigate and experiment with different methods of measuring weight and liquid volume must be provided.

Objects are made of smaller parts, some too small to be seen even with magnification. Matter continues to exist, even when broken into pieces too tiny to be visible.

Notes: Atomic and subatomic nature of matter is not appropriate at this grade. Math standards at this grade limit volume measurements to liquids measured to the nearest whole number. This document follows the recommendations of the NAEP 2009 Science Framework (see page 27) for dealing with the concepts of mass and weight.

Future Application of Concepts
Grades 4-5: The mass and total amount of matter remains the same when it undergoes a change, including phase changes. The sum of the mass of the parts of an object is equal to the weight (mass) of the entire object.
Grades 6-8: The atomic model is introduced. Properties are explained by the arrangement of particles.

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Expectations for Learning: Cognitive Demands
This section provides definitions for Ohio's science cognitive demands, which are intrinsically related to current understandings and research about how people learn. They provide a structure for teachers and assessment developers to reflect on plans for teaching science, to monitor observable evidence of student learning, and to develop summative assessment of student learning of science.

Visions into Practice: Classroom Examples

This section provides examples of tasks that students may perform; this includes guidance for developing classroom performance tasks. It is not an all-inclusive checklist of what should be done, but is a springboard for generating innovative ideas.

Designing Technological/ Engineering Solutions using Science Concepts	Demonstrating Science Knowledge	Interpreting and Communicating Science Concepts	Recalling Accurate Science
Draw conclusions to characterize types of matter based on observations made from experimental evidence.			
Investigate the parts of a (classroom-made) lava lamp exhibit when various conditions (e.g., temperature, size of bottle) are changed and record the results. Compare how the findings can apply to a real-world scenario (e.g., responding to an oil spill in different climates or parts of the world). **Note:** This is ***not*** a kit. For directions on constructing the lava lamp, visit http://www.sciencebob.com/experiments/lavalamp.php 	Given three different items, measure as many properties for each item as possible. Record the measurements for each item on a separate index card. Switch samples with another group and identify which set of measurements belong with which item. 	Distinguish between weight and volume. Represent the differences in words and visual models. 	Name observable differences between the three states of matter. 
		Investigate an ice balloon and the various conditions that affect the rate at which the ice melts, using the Ice Balloon Investigation. 	Recognize that matter continues to exist when broken into pieces too tiny to be visible.

Instructional Strategies and Resources

This section provides additional support and information for educators. These are strategies for actively engaging students with the topic and for providing hands-on, minds-on observation and exploration of the topic, including authentic data resources for scientific inquiry, experimentation and problem-based tasks that incorporate technology and technological and engineering design. Resources selected are printed or Web-based materials that directly relate to the particular Content Statement. It is not intended to be a prescriptive list of lessons.

- *Essential Science for Teachers: Physical Science: Session 1: Matter*, a video on demand produced by Annenberg, explores the concept of matter with elementary children and teachers. The segment includes defining matter and exploring properties and states of matter. It incorporates interviews with children and classroom segments to identify common misconceptions and gives teaching strategies to address these misconceptions. While the segment on plasma is interesting, it is content beyond this grade level.

Common Misconceptions

- From a time of 3:15 to 16:40, this video on demand produced by Annenberg shows individual interviews with children that highlight common misconceptions about what is matter (e.g., air is not matter) and ways that this can be addressed in the classroom.
- Kind (2004) cites that students think matter has no permanent aspect. When matter disappears from sight (e.g., when sugar dissolves in water), it ceases to exist.
- Students often think of solids at matter, but not liquids and gases (AAAS, 1993).
- Kind (2004, p.8) cites that children do not reason consistently. They may use sensory reasoning on some occasions and logical reasoning on others. Sensory experience dominates in cases where matter is not visible.
- Students often think that:
  - Measurement is only linear.
  - Any quantity can be measured as accurately as you want.
  - Some objects cannot be measured because of their size or inaccessibility.
  - The five senses are infallible.
  - Gases are not matter because most are invisible.
  - Gases do not have mass.
  - Air and oxygen are the same gas.
  - Helium and hot air are the same gas.
  - Materials can only exhibit properties of one state of matter.
  - Melting/freezing and boiling/condensation are often understood only in terms of water.
  - Steam is visible water gas molecules.
  - Materials can only exhibit properties of one state of matter.
  - Melting and dissolving are confused.
  - Dew formed on the outside of glass comes from the inside of the glass.
  - Gases are not matter because most are invisible.
  - Weight and volume, which both describe an amount of matter, are the same property.
  - Steam is water vapor over boiling water.

Diverse Learners

Strategies for meeting the needs of all learners including gifted students, English Language Learners (ELL) and students with disabilities can be found at this site. Resources based on the Universal Design for Learning principles are available at www.cast.org.

Classroom Portals

These are windows into the classroom through webcasts, podcasts or video clips to exemplify and model classroom methods of teaching science using inquiry.

Starting at a time of 9:55 on this video on demand produced by Annenberg, children test a mixture of unknown powders to identify what is in the mixture. Children use data and procedures from previous investigations to solve the problem. Jean, an inclusion teacher, talks about classroom management and organization for messy lab activities and the benefits of cooperative learning. The video shows how the teacher helped students who were having difficulties. Notice that the students are asked continually to support their claims with evidence.

Jean, an inclusion teacher, helps third-grade students who are having difficulties during classroom inquiry activities in this video on demand, produced by Annenberg. She has been trying to develop multi-sensory approaches to learning science to help a diversity of students, including ESL, inclusion students and other special needs students. Jean talks about classroom management and organization for messy lab activities and the benefits of cooperative learning. The video shows how an inclusion teacher can be used in this lesson.

Select Video 10, *Linda–Grades 2-4*, to see a resource teacher who models inquiry-based science lessons in her large urban district. Although not all of the content is directly aligned to this content statement, the strategies could be applied to any content.

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Model Curriculum
Grade 3
Physical Science (PS)

Topic: Matter and Forms of Energy

This topic focuses on the relationship between matter and energy. Matter has specific properties and is found in all substances on Earth. Heat is a familiar form of energy that can change the states of matter.

Content Statement

Matter exists in different states, each of which has different properties.

The most common states of matter are solids, liquids and gases.

Shape and compressibility are properties that can distinguish between the states of matter.

One way to change matter from one state to another is by heating or cooling.

Content Elaboration

Prior Concepts Related to Matter

PreK-2: Materials can be sorted by properties. The physical properties of water change as observed in weather (ESS).

Grade 3 Concepts:

Gases, liquids and solids are different states of matter that have different properties. Liquids and solids do not compress into a smaller volume as easily as do gases. Liquids and gases flow easily, but solids do not flow easily. Solids retain their shape and volume (unless a force is applied). Liquids assume the shape of the part of the container that it occupies (retaining its volume). Gases assume the shape and volume of its container.

Heating may cause a solid to melt to form a liquid, or cause a liquid to boil or evaporate to form a gas. Cooling may change a gas into a liquid or cause a liquid to freeze and form a solid.

Conducting experiments or investigations that demonstrate phase changes, such as the melting or freezing of substances other than water (e.g., vinegar, vegetable oil, sugar, butter), must be used to reinforce the concept that materials other than water also go through phase changes.

Note 1: Purdue University provides a table that can help in differentiating the properties of solids, gases and liquids. Teaching about the atomic structure as related to the phases is not appropriate for this grade level.

Note 2: Only solids, liquids and gases are appropriate at this grade, even though other phases have been identified. The differences between boiling and evaporation are not dealt with at this grade.

Future Application of Concepts

Grades 4-5: The amount of mass* and matter remains the same during phase changes.
Grades 6-8: Atomic theory is introduced. Properties of solids, liquids and gases are related to the spacing and motion of particles. Thermal energy and temperature are related to the motion of particles.

*While mass is the scientifically correct term to use in this context, the NAEP 2009 Science Framework (page 27) recommends using the more familiar term "weight" in the elementary grades with the distinction between mass and weight being introduced at the middle school level. In Ohio, students will not be assessed on the differences between mass and weight until Grade 6.

Expectations for Learning: Cognitive Demands

This section provides definitions for Ohio's science cognitive demands, which are intrinsically related to current understandings and research about how people learn. They provide a structure for teachers and assessment developers to reflect on plans for teaching science, to monitor observable evidence of student learning, and to develop summative assessment of student learning of science.

Visions into Practice: Classroom Examples

This section provides examples of tasks that students may perform; this includes guidance for developing classroom performance tasks. It is not an all-inclusive checklist of what should be done, but is a springboard for generating innovative ideas.

Designing Technological/ Engineering Solutions using Science Concepts	Demonstrating Science Knowledge	Interpreting and Communicating Science Concepts	Recalling Accurate Science
Draw conclusions to characterize types of matter based on observations made from experimental evidence.			
Investigate the parts of a (classroom-made) lava lamp exhibit when various conditions are changed and record the results. Consider how the findings can apply to a real-world scenario (e.g., responding to an oil spill in different climates or parts of the world). **Note:** For directions on constructing the lava lamp, visit http://www.sciencebob.com/experiments/lavalamp.php	Predict the fastest way for ice to form. Design an investigation to determine what parameters ensure the fastest formation (e.g., change temperature of the starting water using cold, room-temperature and very hot water, condition the starting water with salt or sugar, change the starting water by adding food coloring).	Explain why which data sets (e.g., descriptions of various physical properties) match given substances focusing on specific states of matter.	Recognize three different states of matter.

Instructional Strategies and Resources

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- *Essential Science for Teachers: Physical Science: Session 1: Matter*, a video on demand produced by Annenberg, explores the concept of matter with elementary children and teachers. The segment includes defining matter and exploring properties and states of matter. It incorporates interviews of children and classroom segments to identify common misconceptions and gives teaching strategies to address these misconceptions. While the segment on plasma is interesting, it is content beyond this grade level.
- *Solids and Liquids*, an interactive simulation from BBC Schools, has children determine the melting point of different substances to observe the properties of liquids and solids.
- *Changing State* is an interactive simulation from BBC Schools that allows students to heat and cool water and to observe phase changes. The optional section dealing with heating the gas further is not aligned to this content statement.
- *Gases Around Us* is an interactive simulation from BBC Schools that demonstrates that gases expand to fill a container.

Common Misconceptions

- *Essential Science for Teachers: Physical Science: Session 1: Matter*, a video on demand produced by Annenberg, explores the concept of matter with elementary children and teachers. The segment from a time of 7:00 to 16:40 shows individual student interviews that highlight common misconceptions about states of matter (e.g., air is not matter) and ways that they can be addressed in the classroom.
- Children often think that:
  - Measurement is only linear.
  - Any quantity can be measured as accurately as you want.
  - Some objects cannot be measured because of their size or inaccessibility.
  - The five senses are infallible.
  - Gases are not matter because most are invisible.
  - Gases do not have mass.
  - Air and oxygen are the same gas.
  - Helium and hot air are the same gas.
  - Materials can only exhibit properties of one state of matter.
  - Melting/freezing and boiling/condensation are often understood only in terms of water.
  - Steam is visible water gas molecules.
  - Materials can only exhibit properties of one state of matter.
  - Melting and dissolving are confused.
  - Dew formed on the outside of glass comes from the inside of the glass.
  - Gases are not matter because most are invisible.
  - Weight and volume, which both describe an amount of matter, are the same property.
  - Steam is the visible cloud of water vapor over boiling water.
- One study showed that some children, ages 5-13, tend to associate solids with rigid materials (Stavy & Stachel, 1984). They regard powders as liquids and any non-rigid materials, such as a sponge or a cloth, as being somewhere in between a solid and liquid (Driver, Squires, Rushworth & Wood-Robinson, 1994).
- Children can classify liquids more easily than they can solids, perhaps because liquids are less varied in their physical characteristics (Kind, 2004).

- Students' explanation of powders as liquids is often "because they can be poured." Reasons for non-rigid objects being neither solid nor liquid are because they "are soft," "crumble," or "can be torn." Children characterized the state of matter of a material according to its macroscopic appearance and behavior with the result that solids are associated with hardness, strength and an inability to bend (Driver et al., 1994).
- Students' understanding of boiling comes before their understanding of evaporation (Keeley, 2005). Driver (1994) states that from a sample of students ages 6-8, 70 percent understood that when water boils, vapor comes from it and that the vapor is made of water; the same students did not recognize that when a wet surface dries, the water turns to water vapor.
- Because students confuse heat and temperature as being the same, they believe that the longer something is heated, the hotter it gets and the boiling point increases the longer it is allowed to boil (Driver et al., 1994).

Diverse Learners

Strategies for meeting the needs of all learners including gifted students, English Language Learners (ELL) and students with disabilities can be found at this site. Resources based on the Universal Design for Learning principles are available at www.cast.org.

Classroom Portals

These are windows into the classroom through webcasts, podcasts or video clips to exemplify and model classroom methods of teaching science using inquiry.

Beginning at a time of about 0:50, this video on demand produced by Annenberg explores the properties of gases, liquids and solids. Students observe phase changes of water from ice to steam, discuss what they know so far, test the properties of *Oobleck* to classify its state. Notice the questioning strategy: *What do you think about that?* and *Give me reasons for your thinking.*

Ingrid, a first-grade teacher, has children explore the properties of solids, liquids and gases through playful explorations. Before the activities, she conducts a class discussion and journal writing to determine what the children already know. After the activities, she surveys children's thoughts about their experiences in a class discussion to come to a consensus about the important properties of solids, liquids and gases.

Essential Science for Teachers: Physical Science Session 1: Matter is another video on demand produced by Annenberg. It explores the concept of matter with elementary children and teachers. The segment from a time of 32:40 to 54:40 shows individual interviews with children about states of matter. Classroom activities show that categories between the states of matter are not always clear-cut. Demonstrations show the differences between liquids and gases.

Jean, a veteran teacher who feels ill prepared to teach science, is featured on this video on demand produced by Annenberg. The beginning of the video shows her leading a classroom lesson in which students explore different states of matter. Notice her questioning strategy: *What do you think about that?* and *Give me reasons for your thinking.* The remainder of the video does not align to this standard but shows how she develops multi-sensory approaches to learning science to help a diversity of students, including ESL, inclusion students and other special needs students. Jean talks about classroom management and organization for messy lab activities and the benefits of cooperative learning. The video also shows how an inclusion teacher can be used in this lesson.

Select Video 10, *Linda–Grades 2-4*, to see a resource teacher who models inquiry-based science lessons for teachers in her large urban district. Although not all of the content is directly aligned to this content statement, the strategies could be applied to any content.

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Content Statement

Heat, electrical energy, light, sound and magnetic energy are forms of energy.

There are many different forms of energy. Energy is the ability to cause motion or create change.

Note: The different forms of energy that are outlined at this grade level should be limited to familiar forms of energy that a student is able to observe.

Content Elaboration

Prior Concepts Related to Sound, Energy and Motion

PreK-2: Vibrations are associated with sound. An object is in motion when its position is changing. Forces change the motion of an object. Sunlight is the principal source of energy on Earth and warms Earth's land, air and water (ESS). Weather changes occur due to changes in energy (ESS). Living things require energy (LS). Plants get energy from sunlight (LS).

Grade 3 Concepts:

Examples of energy causing motion or creating change include a falling rock causing a crater to form on the ground, heating water causing water to change into a gas, light energy from the sun contributing to plant growth, electricity causing the blades of a fan to move, electrically charged objects causing movement in uncharged objects or other electrically charged objects, sound from a drum causing rice sitting on the drum to vibrate, and magnets causing other magnets and some metal objects to move.

Investigations (3-D or virtual) must be used to demonstrate the relationship between different forms of energy and motion.

Note 1: It is not appropriate at this grade level to explore the different types of energy in depth or use wave terminology when discussing energy. These will be developed at later grades.

Note 2: There often is confusion between the concepts of force and energy. Force can be thought of as a push or pull between two objects and energy as the property of an object that can cause change. If forces actually push or pull something over a distance, then there is an exchange of energy between the objects. The differences between force and energy will be developed over time and are not appropriate for this grade level.

	Note 3: The word “heat” is used loosely in everyday language, yet it has a very specific scientific meaning. Usually what is called heat is actually “thermal or radiant energy.” An object has thermal energy due to the random movement of the particles that make up the object. Radiant energy is that which is given off by objects through space (e.g., warmth from a fire, solar energy from the sun). “Heating” is used to describe the transfer of thermal or radiant energy to another object or place. Differentiating between these concepts is inappropriate at this grade. This document uses the same conventions as noted in the NAEP 2009 Science Framework (see page 29) where “heat” is used in lower grades. However, the word “heat” has been used with care so it refers to a *transfer* of thermal or radiant energy. The concept of thermal energy, as it relates to particle motion, is introduced in grade 6. **Future Application of Concepts** **Grades 4-5:** Processes of energy transfer and transformation are introduced. Heat, electrical energy, light and sound are explored in more detail. **Grades 6-8:** Energy is classified as kinetic or potential. The concepts of conservation of energy and thermal energy as it relates to particle motion are introduced.

Expectations for Learning: Cognitive Demands

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Designing Technological/ Engineering Solutions using Science Concepts	Demonstrating Science Knowledge	Interpreting and Communicating Science Concepts	Recalling Accurate Science
Investigate ways a pot of warm water can cause motion or create change.			
	Explore ways that a pot of warm water can cause change (e.g., warm water can cause butter to melt, pouring water on a sand structure can cause the structure to change shape). 	Explain how warm water can cause motion or create change. 	Recognize that energy can cause motion or create change. 
Design, construct and test a small boat or aircraft that can move in different directions (or against the flow of air/water) in nature. Document the forms of energy and resulting motion as the boat or aircraft is being demonstrated to an authentic audience. 		Explain how a magnet can cause motion or create change. Examples of possible answers include: a magnet can cause other magnets and some metallic items to move toward it, a magnet can cause other magnets to move away from it. 	Identify objects with energy in the environment (e.g., moving water, windmill, water wheel, sunlight) and determine what types of energy they have. 

Instructional Strategies and Resources

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- *Science in Focus: Energy* is a series of videos on demand produced by Annenberg to help teachers understand children's preconceptions about energy and what is important to understand about energy. Some of the content, like forces and work, are not directly related to this content statement. However, teachers need a good understanding of the differences and relationships between these important concepts.
- Write and illustrate a children's book about energy. Use observable forms of magnetic energy, electrical energy, light, sound and heat. Include descriptions and illustrations. Share the finished product with students at a different grade level.
- Combine and integrate the ESS grade 3 Energy Resources section. Building a solar oven can be used to illustrate that light energy can cause changes in temperature.

Common Misconceptions

- Do not use resources that claim "free energy" or "perpetual motion machines" since these perpetuate myths that violate the law of conservation of energy. These are especially common when dealing with magnetic energy.
- Students do not realize that light, heat and sound are forms of energy and can cause things to happen.
- Energy is a thing, an object or something that is tangible.
- Energy is confined to some particular origin, such as what we get from food or what the electric company sells.
- Energy is a thing. This is a fuzzy notion, probably because of the way we talk about the amount of energy; it is difficult to imagine an amount of an abstraction.
- The terms "energy" and "force" are interchangeable.
- Heat is a substance.
- Heat is not energy.
- *Science in Focus: Energy* is a series of videos on demand produced by Annenberg dealing with energy. This segment deals with heat. The video series is designed to make teachers aware of common student misconceptions. While not all the concepts addressed are appropriate to be taught at this grade level, being aware of them can help avoid perpetuating common misconceptions.

Diverse Learners

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Classroom Portals

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