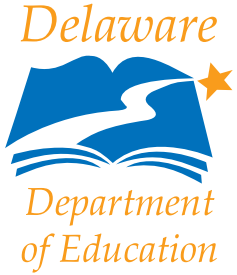

Science Standard 3
Energy and Its Effects
Grade Level Expectations

Science Standard 3
Energy and Its Effects

The flow of energy drives processes of change in all biological, chemical, physical, and geological systems. Energy stored in a variety of sources can be transformed into other energy forms, which influence many facets of our daily lives. The forms of energy involved and the properties of the materials involved influence the nature of the energy transformations and the mechanisms by which energy is transferred. The conservation of energy is a law that can be used to analyze and build understandings of diverse physical and biological systems.

Strand	Grades K-3	Grades 4-5	Grades 6-8	Grades 9-12
The Forms and Sources of Energy Enduring Understanding: Energy takes many forms. These forms can be grouped into types of energy that are associated with the motion of mass (kinetic energy), and types of energy associated with the position of mass and with energy fields (potential energy). Essential Question: How do we know that things have energy?	1. The Sun is a source of energy that lights and warms the Earth. 2. Objects that move (i.e., moving air, moving water) have energy because of their motion. 3. Heat energy is a form of energy that makes things warmer. 4. Electrical energy is a form of energy that is used to operate many of our tools and appliances.	1. Energy from the sun includes visible light, which consists of a combination of different colored light, and components that are not visible, which include infrared and ultraviolet light waves. 2. The energy of a moving object depends on its speed. Faster moving objects have more energy than slower moving objects. 3. Energy can be stored in an elastic material when it is stretched. 4. Sound is a form of energy that is produced by vibrating objects, and can be described by its pitch and its loudness (volume). Sound travels faster through some substances than others. 5. Heat energy raises the object's temperature or changes the state of the object (i.e., solid to liquid, liquid to gas). 6. The energy obtained from electrical outlets is electrical energy that was produced at an electrical power plant.	1. Energy from the Sun takes the form of electromagnetic waves such as infrared, visible, and ultraviolet electromagnetic waves. The radiation from the sun consists of a range of energies in the electromagnetic spectrum. 2. Mechanical energy comes from the motion (kinetic energy) and position (potential energy) of objects. Gravitational potential energy and elastic potential energy are important forms of potential energy that contribute to the mechanical energy of objects. 3. Sound energy is the energy that takes the form of mechanical waves passing through objects or substances. The energy delivered by a wave in a given unit of time is determined by the amplitude and frequency of the wave. 4. Heat energy comes from the random motion of the particles in an object or substance. Temperature is a measure of the motion of the particles.	1. Electromagnetic waves carry a single form of energy called electromagnetic (radiant) energy. 2. An object has kinetic energy because of its linear motion, rotational motion, or both. The kinetic energy of an object can be determined knowing its mass and speed. The object's geometry also needs to be known to determine its rotational kinetic energy. An object can have potential energy when under the influence of gravity, elastic forces or electric forces and its potential energy can be determined from its position. 3. Mechanical waves result from the organized vibrations of molecules in substances. Kinetic energy can be transferred very quickly over large distances by mechanical waves. 4. Thermal (heat) energy is associated with the random kinetic energy of the molecules of a substance.

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		Electrical energy can be generated and then transmitted over great distances. Batteries are portable sources of electrical energy.	The higher the temperature of the material, the greater the motion of the particles. 5. Electrical energy is a form of energy that can be transferred by moving charges through a complete circuit.	5. Magnetic energy and electrical energy are different aspects of a single electromagnetic energy, which results from the motion of electrical charges. 6. Chemical energy is derived from the making and breaking of chemical bonds. 7. Nuclear energy is a form of potential energy that is released when a portion of the mass of the nucleus is converted to energy through nuclear fusion, nuclear fission, or radioactive decay.
Forces and the Transfer of Energy Enduring Understanding: Changes take place because of the transfer of energy. Energy is transferred to matter through the action of forces. Different forces are responsible for the transfer of the different forms of energy. Essential Question: How can energy be transferred from one material to another? What happens to a material when energy is transferred to it?	1. The position of an object gives its location relative to where you are (e.g., above, below, in front, or behind). The motion of an object describes how its position is changing. Pushing or pulling on an object can change its position or motion. 2. When balanced forces act on an object it will remain at rest, but if unbalanced forces act on the object it will begin to move.	1. Force is any push or pull exerted by one object on another. Some forces (e.g., magnetic forces and gravity) can make things move without touching them. 2. The speeds of two or more objects can be compared (i.e., faster, slower) by measuring the distance traveled in a given unit of time, or by measuring the time needed to travel a fixed distance.	1. When the forces acting on an object are balanced, its motion will not change. Unbalanced forces will cause the object's motion to change. Changes in motion depend upon the size and direction of the total unbalanced force exerted on the object. 2. Gravity is a force that acts between masses over very large distances. Near the Earth's surface, gravity pulls objects and substances vertically downward.	1. Forces change the motion of objects. Newton's Laws can be used to predict these changes. 2. Forces are mechanisms that can transfer energy from one object to another. A force acting on an object and moving it through a distance does work on that object and changes its kinetic energy, potential energy, or both. Power indicates the rate at which forces transfer energy to an object or away from it.

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	3. Energy of a moving object can be transferred to other objects (i.e., the energy of moving water can be used to turn a waterwheel). 4. Transferring heat energy to an object will make it feel warmer by raising its temperature and it may cause a change in the object's physical properties.	3. A force must be applied to change the speed of a moving object or change its direction of motion. Larger forces will create greater changes in an object's speed in a given unit of time. 4. Pushing and pulling forces can be used to transfer energy from one object to another. 5. The transfer of heat energy may produce changes in the state of a substance. 6. The energy of electricity is transferred to electrical devices through simple closed circuits (simple series or simple parallel circuits). 7. Some materials allow electricity to flow freely (conductors), while other materials inhibit the flow of electricity (insulators). 8. Some materials are magnetic and can be pushed or pulled by other magnets.	3. Forces can be used to transfer energy from one object to another. Simple machines are used to transfer energy in order to simplify difficult tasks. 4. When energy from the sun is transferred to objects and substances, it can be transformed into a variety of energy forms. 5. Light energy radiates from a source and travels in straight lines. Light is reflected, refracted, transmitted, and absorbed differently by different materials. To see an object, light energy emitted or reflected from the object must enter the eye. 6. The addition or removal of heat energy from a material changes its temperature or its physical state. 7. Heat energy is transported by conduction, convection, and radiation. Heat energy transfers from warmer substances to cooler substances until they reach the same temperature.	3. The momentum of an object can be determined from the object's velocity and it's mass. An impulse represents how much the momentum of an object changes when a force acts on it. The impulse can be used to estimate the size of the force acting on the object. 4. The Law of Conservation of Momentum can be used to predict the outcomes of collisions between objects and can aid in understanding the energy transfers and energy transformations in these collisions. 5. Gravity is a universal force of attraction that each mass exerts on any other mass. The strength of the force depends on the masses of the objects and the distance between them. The force of gravity is generally not important unless at least one of the two masses involved is huge (a star, the Earth or another planet or a moon).

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			8. Electrical systems can be designed to perform a variety of tasks. Series or parallel circuits can be used to transfer electrical energy to devices. Electrical circuits require a complete loop through which the electrical charges can pass. 9. Moving electric charges produce magnetic fields.	6. Electric forces between charged objects are attractive or repulsive. The electric forces between electrons and protons are attractive, determine the structure of atoms, and are involved in all chemical reactions. The electromagnetic forces acting between atoms or molecules are much stronger than the gravitational forces between the same atoms or molecules and are responsible for many common forces such as friction, tensions and supporting forces. 7. Electromagnetic forces are responsible for the physical properties of materials (e.g., the boiling point of a liquid) and the mechanical properties of materials (e.g., surface tension). 8. Electric currents create magnetic fields, and changing magnetic fields induce electric currents. The electric and magnetic forces that result from this interaction are the basis for electric motors, electric generators, and other modern technologies.

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				9. The nuclear forces that hold the nucleus of an atom together are much stronger than the repulsive electric forces acting between the protons that would make the nucleus fly apart, therefore, most atoms have stable nuclei.
Energy Interacting With Materials; the Transformation and Conservation of Energy Enduring Understanding: Energy readily transforms from one form to another, but these transformations are not always reversible. The details of these transformations depend upon the initial form of the energy and the properties of the materials involved. Energy may transfer into or out of a system and it may change forms, but the total energy cannot change.	1. When light hits an object, the light energy can become heat energy.	1. When light strikes an object, the light can reflect off of its surface or pass into the object. The light that passes into the object can pass through it or be absorbed by the material that makes up the object. Light usually refracts when passing from one material into another. 2. When light is absorbed by a material, most of its energy is changed (transformed) into heat energy. Heat energy can also be produced by electrical and mechanical machines and by one object rubbing against another object. 3. Electrical energy in circuits can be changed (transformed) into light, heat, sound, and the energy of motion.	1. Energy can be transformed from one form into another. Energy transformations often take place while energy is being transferred to another object or substance. Energy transformations and energy transfers can be used to explain how energy flows through a physical system (e.g., photosynthesis, weathering, electrical circuits). 2. When a substance absorbs heat energy, or when a different form of energy is absorbed by the substance and is transformed into heat energy, the substance usually expands. The particles within the substance do not expand but the space between the particles increases.	1. Energy cannot be created nor destroyed. Energy can be transferred from one object to another and can be transformed from one form to another, but the total amount of energy never changes. Recognizing that energy is conserved, the processes of energy transformation and energy transfer can be used to understand the changes that take place in physical systems. 2. Most of the changes that occur in the universe involve the transformation of energy from one form to another. Almost all of these energy transformations lead to the production of some heat energy, whether or not heat energy is the desired output of the transformation process.

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Essential Question: What happens to the energy in a system — where does this energy come from, how is it changed within the system, and where does it ultimately go? How does the flow of energy affect the materials in the system?			3. Materials may absorb some frequencies of light but not others. The selective absorption of different wavelengths of white light determines the color of most objects.	3. Waves (e.g., sound and seismic waves, waves in water, and electromagnetic waves) carry energy that can have important consequences when transferred to objects or substances. 4. When waves interact with materials, the energy they transfer often leads to the formation of other forms of energy. These interactions, which depend upon the nature of the material and the wavelength of the waves, can be used to create practical devices (e.g., sonar and ultra sound imaging, solar cells, remote control units, and communication devices). 5. Through reflection and refraction, electromagnetic waves can be redirected to produce concentrated beams or images of their source. 6. When radiant energy is absorbed or emitted by individual atoms or molecules, the changes in energy involve the jump of an electron from one distinct energy level to another.

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				These energy changes, which are characteristic of the atom or molecule, can be used to identify the material.
The Production, Consumption and Application of Energy Enduring Understanding: People utilize a variety of resources to meet the basic and specific needs of life. Some of these resources cannot be replaced. Other resources can be replenished or exist in such vast quantities they are in no danger of becoming depleted. Often the energy stored in resources must be transformed into more useful forms and transported over great distances before it can be helpful to us. Essential Question: What is a "responsible" use of energy? Are there alternative forms of energy that will serve our needs, or better ways of using traditional forms of energy?	1. Moving air, moving water, and sunlight contain energy that can be put to our use.	1. The production of most of the energy that we use in our daily lives comes from energy stored in natural resources. The quantity of these resources is limited, so it is important to conserve our natural resources by using them wisely.	1. Energy sources can be renewable or finite. Most energy used by industrial societies is derived from fossil fuel sources. Such sources are inherently limited on the Earth and are unevenly distributed geographically. Renewable energy sources vary in their availability and ease of use. 2. Technological advances throughout history have led to the discovery and use of different forms of energy, and to more efficient use of all forms of energy. These technological advances have led to increased demand for energy and have had both beneficial and detrimental effects on society. 3. Responsible use of energy requires consideration of energy availability, efficiency of its use, the environmental impact, and possible alternate sources.	1. Demand for energy by society leads to continuous exploration in order to expand supplies of fossil fuels. Nuclear energy is an alternative form of energy. Through the use of fission reactors, nuclear energy is already widely used for the generation of electrical energy. Additional technologies are being developed to increase the use of other alternate energy sources. 2. The increase in energy demand and the new technologies being developed to meet these needs and improve the efficiencies of energy systems have social and environmental consequences. Societal expectations for a sustainable environment will require new, cleaner technologies for the production and use of energy.

Standard 3: Energy and Its Effects, Grade Level Expectations Grades K-3

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Essential Questions: What happens to the energy in a system — where does this energy come from, how is it changed within the system, and where does it ultimately go? How does the flow of energy affect the materials in the system?
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Enduring Understandings: Energy takes many forms. These forms can be grouped into types of energy that are associated with the motion of mass (kinetic energy), and types of energy associated with the position of mass and with energy fields (potential energy).
Enduring Understandings: Changes take place because of the transfer of energy. Energy is transferred to matter through the action of forces. Different forces are responsible for the transfer of the different forms of energy.
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Enduring Understandings: People utilize a variety of resources to meet the basic and specific needs of life. Some of these resources cannot be replenished or exist in such vast quantities they are in no danger of becoming depleted. Often the energy stored in resources must be transformed into more useful forms and transported over great distances before it can be helpful to us.

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Enduring Understandings: Energy takes many forms. These forms can be grouped into types of energy that are associated with the motion of mass (kinetic energy) and types of energy associated with the position of mass and with energy fields (potential energy). Recognize that the Sun warms and lights the Earth. Recognize that air surrounds us and that moving air (wind) has energy that can make things move. Recognize that heat energy can come from the burning of wood.	**Enduring Understandings: Energy takes many forms. These forms can be grouped into types of energy that are associated with the motion of mass (kinetic energy) and types of energy associated with the position of mass and with energy fields (potential energy).** Identify the Sun as the source of energy that warms and lights the Earth. Identify air and water as moving objects that have energy. Observe that heat energy makes things warmer.	**Enduring Understandings: Energy takes many forms. These forms can be grouped into types of energy that are associated with the motion of mass (kinetic energy) and types of energy associated with the position of mass and with energy fields (potential energy).** Identify that objects that move have energy because of their motion. Demonstrate that a hanging mobile has energy because of its motion and the mobile was given this energy by the push of moving air.	**Enduring Understandings: Energy takes many forms. These forms can be grouped into types of energy that are associated with the motion of mass (kinetic energy) and types of energy associated with the position of mass and with energy fields (potential energy).** Identify heat energy as the energy that makes things warmer. Identify electrical energy as a form of energy that is used to operate many of our machines and tools.

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Enduring Understandings: Changes take place because of the transfer of energy. Energy is transferred to matter through the action of forces. Different forces are responsible for the transfer of the different forms of energy. Demonstrate that the position of an object can be above or below, in front of or behind, or to the left or right of another object. Observe that objects move in different ways such as fast, slow, sideways, zigzag, and swaying back and forth. Observe how the air makes the trees and other objects move. Describe how a fast moving wind can make objects move more than a gentle breeze (i.e., trees swaying).	**Enduring Understandings: Changes take place because of the transfer of energy. Energy is transferred to matter through the action of forces. Different forces are responsible for the transfer of the different forms of energy.** Observe the evidence of the force of air pushing on objects and materials such as pinwheels and kites. Compare how the direction and speed (fast, slow) of the moving air affects the motion of the objects. Observe and measure the temperature of hot and cold water. Investigate what happens when hot and cold water are mixed. Record data on a graph and use the data to summarize the results.	**Enduring Understandings: Changes take place because of the transfer of energy. Energy is transferred to matter through the action of forces. Different forces are responsible for the transfer of the different forms of energy**. Investigate how to change an object's movement by giving it a push or pull. Demonstrate that the greater the force, the greater the change in motion of the object. Summarize this understanding through the use of visuals or writing. Demonstrate that when the pushes and pulls acting on an object are balanced, the object will not move. Investigate the conditions necessary for objects to balance. Describe how the object was made to balance.	**Enduring Understandings: Changes take place because of the transfer of energy. Energy is transferred to matter through the action of forces. Different forces are responsible for the transfer of the different forms of energy.** Determine the effect of adding heat energy (warming) or removing heat energy (cooling) on the properties of water as it changes state (gas to liquid to solid, and vice versa). Investigate and describe what happens when an object at a higher temperature is placed in direct contact with an object at a lower temperature. Record data and use the data to describe which way the heat energy is moving between the objects.

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			Demonstrate that energy of motion can be transferred from one object to another (e.g., moving air transfers energy to make a pinwheel spin). Give examples of energy transfer from one object to another. Simulate how bones, muscles, and joints in the human body work to transfer energy to objects, making them move.

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Enduring Understandings: Energy readily transforms from one form to another, but these transformations are not always reversible. The details of these transformations depend upon the initial form of the energy and the properties of the materials involved. Energy may transfer into or out of a system and it may change forms, but the total energy cannot change. Using the sense of touch, recognize that objects placed in direct sunlight feel warmer than objects in the shade.	**Enduring Understandings: Energy readily transforms from one form to another, but these transformations are not always reversible. The details of these transformations depend upon the initial form of the energy and the properties of the materials involved. Energy may transfer into or out of a system and it may change forms, but the total energy cannot change.** Investigate what happens to the temperature of an object when it is placed in direct sunlight. Record data and conclude that the energy in the sunlight was changed into heat energy in the object. Compare what happens when sunlight strikes dark and light colored objects.	**Enduring Understandings: Energy readily transforms from one form to another, but these transformations are not always reversible. The details of these transformations depend upon the initial form of the energy and the properties of the materials involved. Energy may transfer into or out of a system and it may change forms, but the total energy cannot change.** *There are no grade level expectations for this understanding.*	**Enduring Understandings: Energy readily transforms from one form to another, but these transformations are not always reversible. The details of these transformations depend upon the initial form of the energy and the properties of the materials involved. Energy may transfer into or out of a system and it may change forms, but the total energy cannot change.** *There are no grade level expectations for this understanding.*

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All students in **Kindergarten** will be able to:	Building upon the Kindergarten expectations, all students in **Grade 1** will be able to:	Building upon the K-1 expectations, all students in **Grade 2** will be able to:	Building upon the K-2 expectations, all students in **Grade 3** will be able to:
	Draw conclusions that dark colored objects feel warmer and increase more in temperature in sunlight than do light colored objects.		
Enduring Understandings: People utilize a variety of resources to meet the basic and specific needs of life. Some of these resources cannot be replaced. Other resources can be replenished or exist in such vast quantities they are in no danger of becoming depleted. Often the energy stored in resources must be transformed into more useful forms and transported over great distances before it can be helpful to us. Recognize that some people use energy from wood to heat their homes (fireplace) and that this energy is renewable as people replant and grow more trees.	**Enduring Understandings: People utilize a variety of resources to meet the basic and specific needs of life. Some of these resources cannot be replaced. Other resources can be replenished or exist in such vast quantities they are in no danger of becoming depleted. Often the energy stored in resources must be transformed into more useful forms and transported over great distances before it can be helpful to us.** Observe that sunlight can be used to heat the inside of homes and other buildings by allowing the sunlight to pass through windows.	**Enduring Understandings: People utilize a variety of resources to meet the basic and specific needs of life. Some of these resources cannot be replaced. Other resources can be replenished or exist in such vast quantities they are in no danger of becoming depleted. Often the energy stored in resources must be transformed into more useful forms and transported over great distances before it can be helpful to us.** *There are no grade level expectations for this understanding.*	**Enduring Understandings: People utilize a variety of resources to meet the basic and specific needs of life. Some of these resources cannot be replaced. Other resources can be replenished or exist in such vast quantities they are in no danger of becoming depleted. Often the energy stored in resources must be transformed into more useful forms and transported over great distances before it can be helpful to us.** Investigate and describe how moving water and air can be used to make objects and machines, such as a waterwheel and windmill, move.

Standard 3: Energy and Its Effects, Grade Level Expectations Grades 4-5

Essential Question: How do we know that things have energy?
Essential Questions: How can energy be transferred from one material to another? What happens to a material when energy is transferred to it?
Essential Questions: What happens to the energy in a system — where does this energy come from, how is it changed within the system, and where does it ultimately go? How does the flow of energy affect the materials in the system?
Essential Questions: What is a "responsible" use of energy? Are there alternative forms of energy that will serve our needs, or better ways of using traditional forms of energy?

Enduring Understandings: Energy takes many forms. These forms can be grouped into types of energy that are associated with the motion of mass (kinetic energy), and types of energy associated with the position of mass and with energy fields (potential energy).
Enduring Understandings: Changes take place because of the transfer of energy. Energy is transferred to matter through the action of forces. Different forces are responsible for the transfer of the different forms of energy.
Enduring Understandings: Energy readily transforms from one form to another, but these transformations are not always reversible. The details of these transformations depend upon the initial form of the energy and the properties of the materials involved. Energy may transfer into or out of a system and it may change forms, but the total energy cannot change.
Enduring Understandings: People utilize a variety of resources to meet the basic and specific needs of life. Some of these resources cannot be replaced. Other resources can be replenished or exist in such vast quantities they are in no danger of becoming depleted. Often the energy stored in resources must be transformed into more useful forms and transported over great distances before it can be helpful to us.

Building upon the K-3 expectations, all students in **Grade 4** will be able to:	Building upon the K-4 expectations, all students in **Grade 5** will be able to:
Enduring Understandings: Energy takes many forms. These forms can be grouped into types of energy that are associated with the motion of mass (kinetic energy) and types of energy associated with the position of mass and with energy fields (potential energy). Identify, as basic forms of energy; light, heat, sound, electrical, and energy of motion.	**Enduring Understandings: Energy takes many forms. These forms can be grouped into types of energy that are associated with the motion of mass (kinetic energy) and types of energy associated with the position of mass and with energy fields (potential energy).** Identify sunlight as the source of energy needed for plants to make their own food. Observe that sunlight can also warm objects such as the surface of the Earth. Identify that sunlight has three major components; visible, infrared, and ultraviolet, and that the infrared and ultraviolet components cannot be detected by human eyes. Design and implement an investigation to show that white light coming from the sun consists of a variety of component waves that appear to have different colors to our eyes. Record observations of the investigation and use evidence to communicate results. Distinguish ultraviolet from infrared light energy. Although each is invisible to the human eye without the use of technology, describe how the presence of each is detected (i.e., night vision goggles to see infrared energy, sunburn indicates ultraviolet). Observe that sound is produced by vibrating objects and give examples of vibrating objects that produce sound. Observe that volume is a property of sound that determines how loud the sound is, and be able to describe what part of the vibrating object's motion determines the sound it produces.

Standard 3: Energy and Its Effects, Grade Level Expectations Grades 4-5

Essential Question: How do we know that things have energy?
Essential Questions: How can energy be transferred from one material to another? What happens to a material when energy is transferred to it?
Essential Questions: What happens to the energy in a system — where does this energy come from, how is it changed within the system, and where does it ultimately go? How does the flow of energy affect the materials in the system?
Essential Questions: What is a "responsible" use of energy? Are there alternative forms of energy that will serve our needs, or better ways of using traditional forms of energy?

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Building upon the K-3 expectations, all students in **Grade 4** will be able to:	Building upon the K-4 expectations, all students in **Grade 5** will be able to:
	Describe the relationship between the pitch of a sound and the physical properties of the sound source (i.e., length of vibrating object, frequency of vibrations, and tension of vibrating string). Describe how the pitch of sound is different from the volume. Identify that sound energy needs a medium through which to travel. Compare how effectively sound travels through solids, liquids, and air. Demonstrate that vibrations in materials set up wavelike disturbances that spread away from the source. Construct a method to direct sound from the source to the receiver. Identify that the energy of a moving object depends upon its speed. Give examples of how an object's energy of motion increases when the object's speed increases. Describe how energy can be stored in an elastic object or material by stretching it. Use diagrams to describe ways that the energy stored in a stretched object can be used to make objects move.
Enduring Understandings: Changes take place because of the transfer of energy. Energy is transferred to matter through the action of forces. Different forces are responsible for the transfer of the different forms of energy. Identify the basic components (i.e., battery, wires, bulbs, switch) of an electric circuit and understand their function. Draw an example circuit and label the important parts. Relate that circuits must take the form of complete (closed) loops before electrical energy can pass.	**Enduring Understandings: Changes take place because of the transfer of energy. Energy is transferred to matter through the action of forces. Different forces are responsible for the transfer of the different forms of energy.** Use rulers, meter sticks, tapes, and watches to measure the distance objects travel in a given period of time, and how much time it takes for an object to travel a certain distance. Organize the measurements in tables, and construct graphs based on the measurements. Reach qualitative conclusions about the speeds of the objects (faster versus slower).

Standard 3: Energy and Its Effects, Grade Level Expectations Grades 4-5

Essential Question: How do we know that things have energy?
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Essential Questions: What is a "responsible" use of energy? Are there alternative forms of energy that will serve our needs, or better ways of using traditional forms of energy?

Enduring Understandings: Energy takes many forms. These forms can be grouped into types of energy that are associated with the motion of mass (kinetic energy), and types of energy associated with the position of mass and with energy fields (potential energy).
Enduring Understandings: Changes take place because of the transfer of energy. Energy is transferred to matter through the action of forces. Different forces are responsible for the transfer of the different forms of energy.
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Building upon the K-3 expectations, all students in **Grade 4** will be able to:	Building upon the K-4 expectations, all students in **Grade 5** will be able to:
Use diagrams to illustrate ways that two light bulbs can be attached in simple series and in parallel to a battery to make a complete circuit. Explain any differences that will result in the brightness of the bulbs, depending upon the way they are connected to the battery. Test objects for their conductivity and classify the materials based on whether they conduct electricity (conductors) or do not conduct electricity (insulators). Choose which materials would be used to construct a circuit and justify your choices. Demonstrate, through writing and drawing, a variety of ways to construct open, closed, simple parallel and series circuits. List the advantages and/or disadvantages of series and parallel circuits. Use knowledge of electric circuits to explain how a wall switch can be used to "turn on" and "turn off" a ceiling lamp. Observe diagrams or pictures of a variety of circuits and demonstrate how the switch can be used to open or close the circuit. Recognize magnetism as a force that attracts or repels a variety of common materials and identify the physical property of materials that makes them attracted to magnets.	Demonstrate and explain how forces of different sizes and directions can produce different kinds of changes in the motion of an object. Explain how the flow of heat energy contributes to the melting and freezing processes. Describe which way heat energy must flow for liquid water to boil.

Standard 3: Energy and Its Effects, Grade Level Expectations Grades 4-5

Essential Question: How do we know that things have energy?
Essential Questions: How can energy be transferred from one material to another? What happens to a material when energy is transferred to it?
Essential Questions: What happens to the energy in a system — where does this energy come from, how is it changed within the system, and where does it ultimately go? How does the flow of energy affect the materials in the system?
Essential Questions: What is a "responsible" use of energy? Are there alternative forms of energy that will serve our needs, or better ways of using traditional forms of energy?

Enduring Understandings: Energy takes many forms. These forms can be grouped into types of energy that are associated with the motion of mass (kinetic energy), and types of energy associated with the position of mass and with energy fields (potential energy).
Enduring Understandings: Changes take place because of the transfer of energy. Energy is transferred to matter through the action of forces. Different forces are responsible for the transfer of the different forms of energy.
Enduring Understandings: Energy readily transforms from one form to another, but these transformations are not always reversible. The details of these transformations depend upon the initial form of the energy and the properties of the materials involved. Energy may transfer into or out of a system and it may change forms, but the total energy cannot change.
Enduring Understandings: People utilize a variety of resources to meet the basic and specific needs of life. Some of these resources cannot be replaced. Other resources can be replenished or exist in such vast quantities they are in no danger of becoming depleted. Often the energy stored in resources must be transformed into more useful forms and transported over great distances before it can be helpful to us.

Building upon the K-3 expectations, all students in **Grade 4** will be able to:	Building upon the K-4 expectations, all students in **Grade 5** will be able to:
Enduring Understandings: Energy readily transforms from one form to another, but these transformations are not always reversible. The details of these transformations depend upon the initial form of the energy and the properties of the materials involved. Energy may transfer into or out of a system and it may change forms, but the total energy cannot change.	**Enduring Understandings: Energy readily transforms from one form to another, but these transformations are not always reversible. The details of these transformations depend upon the initial form of the energy and the properties of the materials involved. Energy may transfer into or out of a system and it may change forms, but the total energy cannot change.**
Observe that electricity can be transformed into heat, light, and sound as well as the energy of motion. Explain that electrical circuits provide a means of transferring electrical energy from sources such as batteries to devices where it is transformed into heat, light, sound, and the energy of motion.	Observe that light travels in a straight line away from its source until it strikes an object. Observe that when light strikes an object, it can reflect off the object, transmit through the object, be absorbed within the object, or a combination of these phenomena. Give examples of light being reflected, transmitted, and/or absorbed by objects. Using the physical properties of objects, make predictions about how light will behave when it strikes the object. Categorize materials as transparent, translucent, absorbent or reflective based on how they interact with light.
Enduring Understandings: People utilize a variety of resources to meet the basic and specific needs of life. Some of these resources cannot be replaced. Other resources can be replenished or exist in such vast quantities they are in no danger of becoming depleted. Often the energy stored in resources must be transformed into more useful forms and transported over great distances before it can be helpful to us.	**Enduring Understandings: People utilize a variety of resources to meet the basic and specific needs of life. Some of these resources cannot be replaced. Other resources can be replenished or exist in such vast quantities they are in no danger of becoming depleted. Often the energy stored in resources must be transformed into more useful forms and transported over great distances before it can be helpful to us.**
Explain where the electrical energy available at an electric outlet in your home or school comes from. Using books, computers, and other resources, search for ways that people use natural resources to supply energy needs for lighting, heating, and electricity. Report your results by making a poster, written report or oral presentation.	Recognize that solar energy, an inexhaustible source, is an alternative energy source to fossil fuels, an exhaustible source. Using books, computers and other resources, search for ways that we can use sunlight to heat and light our homes, and generate electrical energy. Report your results by making a poster, a written report or an oral presentation.

Standard 3: Energy and Its Effects, Grade Level Expectations Grades 6-8

Essential Question: Why do things have energy?
Essential Questions: How can energy be transferred from one material to another? What happens to a material when it receives energy?
Essential Questions: What happens to the energy in a system — where does this energy come from, how is it changed within the system, and where does it ultimately go? How does the flow of energy affect the materials in the system?
Essential Questions: What is a "responsible" use of energy? Are there alternative forms of energy that will serve our needs, or better ways of using traditional forms of energy?

Enduring Understandings: Energy takes many forms. These forms can be grouped into types of energy that are associated with the motion of mass (kinetic energy) and types of energy associated with the position of mass and energy fields (potential energy).
Enduring Understandings: Changes take place because of the transfer of energy. Energy is transferred to matter through the action of forces. Different forces are responsible for the different forms of energy.
Enduring Understandings: Energy readily transforms from one form to another, but these transformations are not always reversible. The details of these transformations depend upon the initial form of the energy and the properties of the materials involved. Energy may transfer into or out of a system and it may change forms, but the total energy cannot change.

Building upon the K-5 expectations, all students in **Grade 6** will be able to:	Building upon the K-6 expectations, all students in **Grade 7** will be able to:	Building upon the K-7 expectations, all students in **Grade 8** will be able to:
Enduring Understandings: Energy takes many forms. These forms can be grouped into types of energy that are associated with the motion of mass (kinetic energy) and types of energy associated with the position of mass and energy fields (potential energy). List, as basic forms of energy, light, heat, sound, electrical, and energy of motion. Explain that electrical energy is a form of energy that is transferred through circuits to devices that are designed to make use of this form of energy (e.g., lamps, fans, computers, etc.).	**Enduring Understandings: Energy takes many forms. These forms can be grouped into types of energy that are associated with the motion of mass (kinetic energy) and types of energy associated with the position of mass and energy fields (potential energy).** Describe how heat energy when added to a substance, will increase its temperature or change its state. Explain that as more heat energy is added to a substance, the particles' vibrations increase and the spacing between the particles increases, but the size of the particles stays the same.	**Enduring Understandings: Energy takes many forms. These forms can be grouped into types of energy that are associated with the motion of mass (kinetic energy) and types of energy associated with the position of mass and energy fields (potential energy).** Explain that kinetic energy is the energy an object has because of its motion and identify that kinetic energy depends upon the object's speed and mass. Design and carry out investigations to determine how changing the mass of an object or changing its speed changes its kinetic energy. Explain that gravitational potential energy (GPE) is the energy of position (above the Earth's surface) and that it depends on the object's mass and height above the ground. Relate that lifted objects have GPE and that the size of an object's GPE depends on its mass and the vertical distance it was lifted. Make a graph to demonstrate and describe how the GPE changes as the height of an object is increased or decreased. Explain that the mechanical energy of an object is the sum of its kinetic energy and its potential energy at any point in time. Identify the mechanical energy of objects in different circumstances and identify whether the mechanical energy consists of KE, PE or both (i.e., a ball at rest at the top of an incline and in its motion part of the way down the incline, or a model plane driven by a "rubber Band" motor, etc.).

Standard 3: Energy and Its Effects, Grade Level Expectations Grades 6-8

Essential Question: Why do things have energy?
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Essential Questions: What happens to the energy in a system — where does this energy come from, how is it changed within the system, and where does it ultimately go? How does the flow of energy affect the materials in the system?
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Building upon the K-5 expectations, all students in **Grade 6** will be able to:	Building upon the K-6 expectations, all students in **Grade 7** will be able to:	Building upon the K-7 expectations, all students in **Grade 8** will be able to:
		Interpret graphical representations of energy to describe how changes in the potential energy of an object can influence changes in its kinetic energy. Explain that the mechanical energy of an object is a measure of how much the object can change the motion of other objects or materials (e.g.,, a ball (or air) having a large kinetic energy can do more damage than a ball (or air) with less kinetic energy). Use the particle model to explain heat energy as the combined random kinetic energy of particles that make up an object and while the heat energy and temperature of an object are related, they are different quantities. Describe how the motion of water particles in a glass of cold water is different from the motion of water particles in a glass of hot water. Explain that sound energy is mechanical energy that travels in the form of waves. Use the particle model to explain why sound waves must travel through matter, and that sound travels more effectively through solids and liquids than through gases. Model and describe how sound energy travels through solids, liquids, and gases. Use the properties of sound waves and the particle model to describe how the pitch of two waves can be different and how the loudness of two waves can be different.

Standard 3: Energy and Its Effects, Grade Level Expectations Grades 6-8

Essential Question: Why do things have energy?
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Building upon the K-5 expectations, all students in **Grade 6** will be able to:	Building upon the K-6 expectations, all students in **Grade 7** will be able to:	Building upon the K-7 expectations, all students in **Grade 8** will be able to:
		Explain that heat energy and sound energy both make the particles of a substance move. Use models to explain how the particles respond differently to these types of energy. Use models to explain why sound travels much faster through substances than heat energy does. Relate that the sun is the source of almost all of the Earth's energy and that this energy travels to the Earth in the form of electromagnetic waves. Explain that the electromagnetic waves from the sun consist of a range of wavelengths and associated energies. Explain that the majority of the energy from the sun reaches Earth in the form of infrared, visible, and ultraviolet waves. Use diagrams to demonstrate the differences in different types of electromagnetic waves. Plan and conduct an experiment to identify the presence of UV and IR waves in sunlight or other sources of electromagnetic waves. Use evidence to explain the presence of each.

Standard 3: Energy and Its Effects, Grade Level Expectations Grades 6-8

Essential Question: Why do things have energy?
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Building upon the K-5 expectations, all students in **Grade 6** will be able to:	Building upon the K-6 expectations, all students in **Grade 7** will be able to:	Building upon the K-7 expectations, all students in **Grade 8** will be able to:
Enduring Understandings: Changes take place because of the transfer of energy. Energy is transferred to matter through the action of forces. Different forces are responsible for the different forms of energy. Describe the role of electrical charge in circuits by using a model of electrical circuits. Relate that electrical energy carried by charges in a circuit is transferred to devices in the circuit and is usually changed into (transformed) different kinds of energy by these devices (e.g., light bulbs change electrical energy into light and heat energy, motors turn the electrical energy into energy of motion). Trace the flow of energy from electrical energy to other forms of energy, such as light. Express whether energy was transferred, transformed or both. Construct both series and parallel circuits to investigate and describe how multiple devices in series or parallel (bulbs, motors) perform (dim versus bright, fast versus slow). Describe how the way the devices are connected affects the functioning (i.e., dim versus bright) of the device, and relate this to how much electrical energy is received. Conduct investigations on a moving object and make measurements of time and distance traveled and determine the average speed of moving objects.	**Enduring Understandings: Changes take place because of the transfer of energy. Energy is transferred to matter through the action of forces. Different forces are responsible for the different forms of energy.** *There are no grade level expectations for this understanding.*	**Enduring Understandings: Changes take place because of the transfer of energy. Energy is transferred to matter through the action of forces. Different forces are responsible for the different forms of energy.** The force of gravity can act across very large distances of space. Through the force of gravity planets pull on their moons, and pull on each other. The sun pulls on all planets, moons and other celestial bodies in the solar system. Use an understanding of how forces change the motion of objects to explain how gravity is responsible for creating the orbital motion of planets and moons. Explain that the transfer of energy from one object to another is caused by the exertion of a force. Create an energy chain to show how forces can change the mechanical energy of an object. Describe how the distance over which the forces act will influence the amount of energy transferred (and when appropriate, the amount of energy transformed). Give examples of how mechanical energy can be transferred to (or away from) an object, and describe the changes that can take place in the motion of the object because of this energy transfer, (e.g., pulling on a trailer to start it moving or using friction to slow an object and bring it to rest).

Standard 3: Energy and Its Effects, Grade Level Expectations Grades 6-8

Essential Question: Why do things have energy?
Essential Questions: How can energy be transferred from one material to another? What happens to a material when it receives energy?
Essential Questions: What happens to the energy in a system — where does this energy come from, how is it changed within the system, and where does it ultimately go? How does the flow of energy affect the materials in the system?
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Building upon the K-5 expectations, all students in **Grade 6** will be able to:	Building upon the K-6 expectations, all students in **Grade 7** will be able to:	Building upon the K-7 expectations, all students in **Grade 8** will be able to:
Graph and interpret distance versus time graphs for constant speed. Use the graphs to describe how the position of an object changes in a time interval. Describe how the speed of an object depends on the distance traveled and the travel time. Explain how the motion of an object can be described by its position, speed, and direction of motion. Explain that the earth will pull on all objects with a force called gravity that is directed inward toward the center of the Earth. Give examples of objects at rest, and identify the forces that act on an object while it remains at rest (gravity, supportive forces, friction, other pushing or pulling forces). Explain that if the object is not moving, it must have at least two forces acting on it that are balanced. Give examples of moving objects and identify the forces that act on these objects. Select examples where only one force acts on the object and examples where two or more forces act on the object. Explain that unbalanced forces acting on an object will change its speed, direction of motion, or both.		Use diagrams to trace and describe the transfer of energy through a physical system (for example, the erosion effects of water flowing down an unprotected slope). Use the particle model to explain how mechanical waves can transport energy without transporting mass. Give examples that support the transfer of energy without any net transfer of matter. Explain that the frequency and amplitude are two characteristics of waves that determine the mechanical energy carried and delivered by a sound wave per unit of time. Use diagrams to explain how each of these properties will influence the KE of the particles in the substance when a sound wave passes through the substance. The energy delivered by a wave depends on more than just the frequency. Give an example of a high frequency sound wave that delivers small quantities of energy every second and explain how this is possible. Give an example of a low frequency sound wave that delivers large quantities of energy every second and explain how this is possible.

Standard 3: Energy and Its Effects, Grade Level Expectations Grades 6-8

Essential Question: Why do things have energy?
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Enduring Understandings: Energy readily transforms from one form to another, but these transformations are not always reversible. The details of these transformations depend upon the initial form of the energy and the properties of the materials involved. Energy may transfer into or out of a system and it may change forms, but the total energy cannot change.

Building upon the K-5 expectations, all students in **Grade 6** will be able to:	Building upon the K-6 expectations, all students in **Grade 7** will be able to:	Building upon the K-7 expectations, all students in **Grade 8** will be able to:
Conduct investigations to describe how the relative directions of forces simultaneously acting on an object (reinforce or cancel each other) will determine how strongly the combination of these forces influences the motion of the object. Conduct investigations and describe how a force can be directed to increase the speed of an object, decrease the speed of the object or change the direction in which the object moves. Explain that an object that feels the effects of balanced forces may be at rest or may be moving in a straight line with a speed that does not change. Conduct investigations using simple machines to demonstrate how forces transfer energy. Explain that simple machine may change the direction of an applied force (directional advantage) or the size of the force that is applied (mechanical advantage) but that the amount of energy transferred by the simple machine is equal to the amount of energy transferred to the simple machine. Explain that the transfer of energy from one object to another is caused by the exertion of a force.		Use the particle model to explain how heat energy is transferred through solid materials (conduction). Give examples of materials that are good "conductors" of heat energy and examples of materials that are poor conductors of heat energy, and how both types of materials are used in typical homes. Use the particle model to describe the difference between heat energy transfer in solids and heat energy transfer in liquids and gases (i.e., the differences between conduction and convection). Use the particle model to explain why heat energy is always transferred from materials at higher temperatures to materials at lower temperatures. Explain why heat energy transfer ceases when the equilibrium temperature is reached. Explain that when this temperature is reached, the materials are in thermal equilibrium. Conduct simple investigations to demonstrate that heat energy is transferred from one material to another in predictable ways (from materials at higher temperatures to materials at lower temperatures), until both materials reach the same temperature.

Standard 3: Energy and Its Effects, Grade Level Expectations Grades 6-8

Essential Question: Why do things have energy?
Essential Questions: How can energy be transferred from one material to another? What happens to a material when it receives energy?
Essential Questions: What happens to the energy in a system — where does this energy come from, how is it changed within the system, and where does it ultimately go? How does the flow of energy affect the materials in the system?
Essential Questions: What is a "responsible" use of energy? Are there alternative forms of energy that will serve our needs, or better ways of using traditional forms of energy?

Enduring Understandings: Energy takes many forms. These forms can be grouped into types of energy that are associated with the motion of mass (kinetic energy), and types of energy associated with the position of mass and energy fields (potential energy).
Enduring Understandings: Changes take place because of the transfer of energy. Energy is transferred to matter through the action of forces. Different forces are responsible for the different forms of energy.
Enduring Understandings: Energy readily transforms from one form to another, but these transformations are not always reversible. The details of these transformations depend upon the initial form of the energy and the properties of the materials involved. Energy may transfer into or out of a system and it may change forms, but the total energy cannot change.

Building upon the K-5 expectations, all students in **Grade 6** will be able to:	Building upon the K-6 expectations, all students in **Grade 7** will be able to:	Building upon the K-7 expectations, all students in **Grade 8** will be able to:
Use the size of the force and the distance over which the force acts to compare how much energy is transferred into a simple machine to how much energy is transferred out of a simple machine. Design a device that relies on the directional and/or mechanical advantage of a simple machine to perform a task (e.g., lift a weight, move a heavy object). Identify the forces and motions involved, the source of the energy used to complete the task, and how the energy is used by the simple machine.		Explain how the addition or removal of heat energy can change an object's temperature or its physical state. Conduct simple investigations involving changes of physical state and temperature. Relate that there is no change in temperature when a substance is changing state.
Enduring Understandings: Energy readily transforms from one form to another, but these transformations are not always reversible. The details of these transformations depend upon the initial form of the energy and the properties of the materials involved. Energy may transfer into or out of a system and it may change forms, but the total energy cannot change. Show how electrical energy carried by currents in wires can be used to create magnetic fields. Demonstrate how these fields exert magnetic forces on permanent magnets.	**Enduring Understandings: Energy readily transforms from one form to another, but these transformations are not always reversible. The details of these transformations depend upon the initial form of the energy and the properties of the materials involved. Energy may transfer into or out of a system and it may change forms, but the total energy cannot change.** *There are no grade level expectations for this understanding.*	**Enduring Understandings: Energy readily transforms from one form to another, but these transformations are not always reversible. The details of these transformations depend upon the initial form of the energy and the properties of the materials involved. Energy may transfer into or out of a system and it may change forms, but the total energy cannot change.** Identify that energy can exist in several forms, and when it changes from one form into another the process is called energy transformation.

Standard 3: Energy and Its Effects, Grade Level Expectations Grades 6-8

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Explain how these magnetic forces in electric motors are used to change the electrical energy into the energy of motion.		Explain that energy transformation and energy transfer are different processes, and that energy transformations can take place during an energy transfer. Give examples of energy transformations that take place during an energy transfer. Give examples of energy transfers that do not include energy transformations. Give examples of energy transformations that take place without any energy transfer. Use energy chains to trace the flow of energy through physical systems. Indicate the energy transfers and the energy transformations that are involved in the processes (e.g., the lighting of an electric lamp in a region serviced by a hydroelectric (or coal fueled) electric power plant, or the sediment that clouds a stream after a heavy rainfall). Recognize that when light enters an eye, the energy carried by the light waves carries information and allows living things to see. Trace the flow of the energy carried by the light when the light strikes a material and is reflected from, transmitted through, and/or absorbed by the material. Describe the energy transfers and transformations that take place when light energy is absorbed by a material.

Standard 3: Energy and Its Effects, Grade Level Expectations Grades 6-8

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		Conduct investigations to show that materials can absorb some frequencies of electromagnetic waves, but reflect others or allow them to transmit through the material. Use this selective absorption process to explain how objects obtain their color, how materials like sunscreen can serve to protect us from harmful electromagnetic waves, and how selective absorption contributes to the Greenhouse Effect. Trace what happens to the energy from the Sun when it reaches Earth and encounters various materials, such as, atmosphere, oceans, soil, rocks, plants, and animals. Recognize that these materials absorb, reflect and transmit the electromagnetic waves coming from the sun differently. Conduct investigations to determine how the physical properties of materials (e.g., size, shape, color, texture, hardness) can account for the effect the materials have on sunlight and the degree of change observed in the materials (e.g., dark cloth absorbs more heat than light cloth, clear water transmits more light than murky water, and polished materials reflect more light than dull materials).

Standard 3: Energy and Its Effects, Grade Level Expectations Grades 6-8

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Building upon the K-5 expectations, all students in **Grade 6** will be able to:	Building upon the K-6 expectations, all students in **Grade 7** will be able to:	Building upon the K-7 expectations, all students in **Grade 8** will be able to:
		Use the properties of water and soil to explain how uneven heating of Earth's surface can occur. Conduct an investigation that shows how water and soil are heated unequally by sunlight. Describe how this can be used to explain unequal heating of the Earth's surface, producing atmospheric movements that influence weather. Use the particle model to explain why a material expands (takes up more space) as its temperature increases. Recognize that this expansion is due to the increase in the motion of the particles, and that the particles themselves remain the same size.
Enduring Understandings: People utilize a variety of resources to meet the basic and specific needs of life. Some of these resources cannot be replaced. Other resources can be replenished or exist in such vast quantities they are in no danger of becoming depleted. Often the energy stored in resources must be transformed into more useful forms and transported over great distances before it can be helpful to us. Compare the differences in power usage in different electrical devices/appliances. Discuss which devices /appliances (i.e., washer, dryer, refrigerator, electric furnace) are manufactured to require less energy. Select one device/appliance, research different brands and their energy usage, determine which would be the better buy, and report on the findings.	**Enduring Understandings: People utilize a variety of resources to meet the basic and specific needs of life. Some of these resources cannot be replaced. Other resources can be replenished or exist in such vast quantities they are in no danger of becoming depleted. Often the energy stored in resources must be transformed into more useful forms and transported over great distances before it can be helpful to us.** *There are no grade level expectations for this understanding.*	**Enduring Understanding: People utilize a variety of resources to meet the basic and specific needs of life. Some of these resources cannot be replaced. Other resources can be replenished or exist in such vast quantities they are in no danger of becoming depleted. Often the energy stored in resources must be transformed into more useful forms and transported over great distances before it can be helpful to us.** Identify different forms of alternative energy (i.e., solar, wind, ocean waves, tidal and hydroelectric systems). Research and report on the use of this alternative form of energy. Discuss and compare findings to describe the advantages and disadvantages of different kinds of alternative energy.

Standard 3: Energy and Its Effects, Grade Level Expectations Grades 9-12

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Building upon the K-8 expectations, all students in **Grade 9** will be able to:	Building upon the K-9 expectations, all students in **Grade 10** will be able to:	Building upon the K-10 expectations, all students in **Grade 11** will be able to:	Building upon the K-11 expectations, all students in **Grade 12** will be able to:
Enduring Understandings: Energy takes many forms. These forms can be grouped into types of energy that are associated with the motion of mass (kinetic energy) and types of energy associated with the position of mass and energy fields (potential energy). Recognize that electromagnetic energy (radiant energy) is carried by electromagnetic waves. Use diagrams to illustrate the similarities shared by all electromagnetic waves and differences between them. Show how wavelength is used to distinguish the different groups of EM waves (radio waves, microwaves, IR, visible and UV waves, X-rays, and gamma waves).	**Enduring Understandings: Energy takes many forms. These forms can be grouped into types of energy that are associated with the motion of mass (kinetic energy) and types of energy associated with the position of mass and energy fields (potential energy).** *There are no specific grade level expectations for this understanding. They are incorporated into Standards 6.*	**Enduring Understandings: Energy takes many forms. These forms can be grouped into types of energy that are associated with the motion of mass (kinetic energy) and types of energy associated with the position of mass and energy fields (potential energy).** Conduct investigations to identify how the rotational kinetic energy of an object depends on the object's mass, angular speed (rpm), and its geometry (for example; solid and hollow spheres, solid and hollow cylinders, rings). Conduct investigations to show that rolling objects have two kinds of kinetic energy, linear kinetic energy (LKE), and rotational kinetic energy (RKE). For example, a ball released on a ramp from a height, h, will consistently reach the bottom of the ramp with less linear kinetic energy than its GPE at the top of the ramp. The RKE of the rolling object explains the difference.	**Enduring Understandings: Energy takes many forms. These forms can be grouped into types of energy that are associated with the motion of mass (kinetic energy) and types of energy associated with the position of mass and energy fields (potential energy).** Explain that the quantity of radiant energy delivered to a surface every second can be viewed in two different ways. Use the concept of waves to describe that the energy delivered by electromagnetic radiation depends on the amplitude and frequency of the electromagnetic waves. Use the particle model of electromagnetic radiation (energy is carried by packets of electromagnetic energy called photons) to explain that the radiant energy delivered depends on the frequency of the radiation and the number of packets striking the surface per second.

Standard 3: Energy and Its Effects, Grade Level Expectations Grades 9-12

Essential Question: Why do things have energy?
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Building upon the Grade expectations, all students in **Grade 9** will be able to:	Building upon the K-9 expectations, all students in **Grade 10** will be able to:	Building upon the K-10 expectations, all students in **Grade 11** will be able to:	Building upon the K-11 expectations, all students in **Grade 12** will be able to:
Conduct investigations involving moving objects to examine the influence that the mass and the speed have on the kinetic energy of the object. Collect and graph data that supports that the kinetic energy depends linearly upon the mass, but nonlinearly upon the speed. Recognize that the kinetic energy of an object depends on the square of its speed, and that $KE = \frac{1}{2} mv^2$. Collect and graph data that shows that the potential energy of an object increases linearly with the weight of an object (mg) and with its height above a pre-defined reference level, h. (GPE = mgh). Conduct investigations and graph data that indicate that the energy stored in a stretched elastic material increases nonlinearly with the extent to which the material was stretched.		Explain that when a chemical reaction takes place and energy is released, the reaction results in molecules that have a lower chemical energy and if energy must be added for a chemical reaction to take place, the molecules that result from that reaction have higher chemical energy. Recognize that nuclear energy takes the form of mass, and that energy is released from a nuclear reaction as a consequence of the annihilation of mass. Explain why large amounts of energy are released when small amounts of mass are annihilated ($E = mc^2$).	

Standard 3: Energy and Its Effects, Grade Level Expectations Grades 9-12

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Recognize that the energy stored in a stretched elastic material is proportional to the square of the stretch of the material, and a constant that reflects the elasticity of the material. (Elastic PE = ½ kx^2) Explain that heat energy represents the total random kinetic energy of molecules of a substance. Recognize that chemical energy is the energy stored in the bonding of atoms and molecules. Describe the differences between nuclear energy and chemical energy, that chemical energy is derived from the energy of the electrons that move around the nucleus, while nuclear energy is associated with the protons and neutrons in the nucleus.			

Standard 3: Energy and Its Effects, Grade Level Expectations Grades 9-12

Essential Question: Why do things have energy?
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Enduring Understanding: Changes take place because of the transfer of energy. Energy is transferred to matter through the action of forces. Different forces are responsible for the different forms of energy. Recognize that electromagnetic waves transfer energy from one charged particle to another. Use graphics or computer animations to illustrate this transfer process. Give everyday examples of how society uses these transfer processes (for example, communication devices such as radios and cell phones). Use diagrams to illustrate how the motion of molecules when a mechanical wave passes through the substance is different from the motion associated with their random kinetic energies.	**Enduring Understanding: Changes take place because of the transfer of energy. Energy is transferred to matter through the action of forces. Different forces are responsible for the different forms of energy.** *There are no specific grade level expectations for this understanding. They are incorporated into Standards 2 and 6.*	**Enduring Understanding: Changes take place because of the transfer of energy. Energy is transferred to matter through the action of forces. Different forces are responsible for the different forms of energy.** Use the inverse square law to describe how the force of gravity changes over long distances (for example, describe the forces acting on the Voyager Space Probes as they moved through the solar system). Conduct investigations to determine the relative sizes of static and kinetic frictional forces acting between two surfaces. Conduct investigations to determine what variables (mass, normal force, surface area, surface texture, etc.) influence the size of frictional forces that act between two objects.	**Enduring Understanding: Changes take place because of the transfer of energy. Energy is transferred to matter through the action of forces. Different forces are responsible for the different forms of energy.** *There are no grade level expectations for this understanding.*

Standard 3: Energy and Its Effects, Grade Level Expectations Grades 9-12

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Use diagrams or models to explain how mechanical waves can transport energy without transporting matter. Reflect on why mechanical waves will pass through some states of matter better than others. Recognize that the gravitational force is a universal force of attraction that acts between masses, but this force is only significant when one (or both) of the objects is massive (for example, a star, planet or moon). Explain that as objects move away from the surface of a planet or moon, the gravitational pull on the object will decrease. Use examples to illustrate that near the surface of a planet or moon, the gravitational force acting on an object remains nearly constant.		Give examples in which static friction is a force of propulsion, initiating the motion of an object. Use force diagrams to illustrate the forces acting on the object during this propulsion process. Use force diagrams to describe how static friction can prevent an object (that is subject to another force) from moving. Draw force diagrams to illustrate the action of friction when it acts to slow-down an object. Use an energy argument to describe how friction slows down a moving object. Describe the factors that contribute to the size of an electric force acting between charged particles (i.e., the size of an electric force depends upon the size of the charges involved and the distance between the charges). Recognize that the electric force is an inverse square force like the gravitational force.	

Standard 3: Energy and Its Effects, Grade Level Expectations Grades 9-12

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Recognize that on Earth, the object would have to be moved several hundred miles above the surface before the decrease in the force of gravity would become detectable. Explain the difference between the mass of an object and its weight. Identify that near the surface of the Earth, the gravitational force acting on the object (its weight) depends only on its mass, and that this force can be simply calculated from knowledge of the mass ($F_G = mg$). Conduct investigations to determine the behavior of elastic materials. Graph the data and identify the relationship between the extent of the stretch and the size of the elastic force (i.e., $F_{elastic} = kx$ where x = stretch).		Use a sketch of this force to describe how its influence changes as the distance between the charges increases. Recognize that the gravitational forces acting between objects the size of people or even large trucks is negligible compared to their weight (for example, F_{Grav} acting between two people standing 1m apart on the Earth's surface is less than one billionth the size of their weight). Also recognize that gravitational forces between particles at the molecular level are completely negligible when compared to electric forces that act between these particles ($F_{Grav}/F_{electric}<10^{-30}$). Describe how many of the forces acting between objects (friction and normal forces) and acting within objects (tensions, compressions and elastic forces) are manifestations of the electromagnetic forces that act between atoms and molecules in substances.	

Standard 3: Energy and Its Effects, Grade Level Expectations Grades 9-12

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Describe the role that forces play when energy is transferred between interacting objects and explain how the amount of energy transferred can be calculated from measurable quantities. Give examples of common forces transferring energy to (or away from) objects. For example; a pulling force can transfer energy to an object (when the object is pulled along a floor), a pushing force can transfer energy away from an object (to slow its motion), and friction and air resistance always transfer kinetic energy away from moving objects. Identify that "work" is the process by which a force transfers energy to an object, and use measured quantities to make calculations of the work done by forces (W = energy transferred = F·D).		Use diagrams or models to show how the electric forces acting between molecules can explain the presence of these forces. Use diagrams to show the similarities between the magnetic field of a permanent magnet and the magnetic field created by an electric coil. Conduct investigations to show how forces acting between permanent magnets and conducting coils carrying electric currents can be used to create electric motors. Use diagrams to show how magnets and rotating coils can be used to create electric currents. Use vector diagrams to illustrate the forces that act within the nucleus. Recognize that the stability of a nucleus depends upon the repulsive electric forces acting between the protons and the attractive nuclear forces acting between all protons and neutrons in the nucleus.	

Standard 3: Energy and Its Effects, Grade Level Expectations Grades 9-12

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Conduct investigations to determine what factors influence whether a force transfers energy to an object or away from the object, and how the direction of the force (relative to the direction of motion) influences the quantity of energy transferred by the force. Recognize that power is a quantity that tells us how quickly energy is transferred to an object or transferred away from the object. Give examples that illustrate the differences between power, force and energy (for example, the energy needed to propel a vehicle is stored in the chemical energy of the fuel. Static friction is the force that propels the vehicle, and the power of the vehicle's engine helps to determine how quickly the vehicle can speed up …. and how quickly its engine uses fuel!).		Use examples of mechanical or chemical systems to explain that the stability of an object is linked to the object's energy, and that stability can be used as an indicator how likely it is that an object will undergo a physical, chemical, or nuclear change. Identify mid-sized nuclei as the most stable nuclei, and use the concept of stability to explain the basics of nuclear fission, fusion, and radioactive decay. Use models and diagrams to illustrate the differences between fission, fusion and radioactive decay. Use vector diagrams to illustrate how the total force is determined from a group of individual forces. Make vector diagrams of objects moving with a constant velocity, identifying all of the forces acting on the object (for example, a car moving along a straight highway, an aircraft in flight, an elevator ascending at constant speed, etc.).	

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Use models and diagrams to illustrate the structure of the atom. Include information regarding the distribution of electric charge and mass in the atom. Identify the forces that are responsible for the stability of the atom, and which parts of the atom exert and feel these forces. Recognize that there are attractive forces acting within the nucleus that are different from electric forces, and that these forces are responsible for the stability of the nucleus.		Reflect on how forces can collectively act on the object and not change its motion (basis of Newton's 1st Law). Conduct investigations to reach qualitative and quantitative conclusions regarding the effects of the size of the total force and the object's mass on its resulting acceleration (Newton's 2nd Law, $a = F_{total}/m$). Observe how the direction of the acceleration relates to the direction of the total force. Use examples to illustrate the differences between mass and force and explain why only forces can change the motion of objects. Explain why an object with a large mass is usually more difficult to start moving than an object with a smaller mass.	

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		Use Newton's Second Law to calculate the acceleration of objects that are subject to common forces (for example, gravity, constant pushing or pulling forces and/or friction). Use vector diagrams to show how the direction of the acceleration (relative to the direction of the velocity) can be used to determine if the speed of the object will increase or decrease, and if the direction of motion will change. Describe what the size of the acceleration of an object indicates about the object's motion (how quickly the object's velocity will change). Give examples of objects having large accelerations (motorcycles starting from rest, vehicles stopping abruptly, cars negotiating sharp curves), and objects having small accelerations (tractor trailers starting from rest, large ships slowing down, and vehicles traveling on long gradual curves on highways).	

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		Conduct investigations to show that the acceleration due to gravity is the same for all objects near the surface of the earth. Use graphical analysis to determine the acceleration due to gravity from experimental data. Use algebraic relationships that relate the acceleration of an object to its speed and position to make predictions about the motion of objects as they move along straight and circular paths. Conduct investigations (or demonstrate) that under a variety of conditions when two objects collide they exert equal sized forces on each other. Use Newton's 2nd Law to explain why these two objects may react differently to equal sized forces. Use vector diagrams and Newton's 3rd Law to explain how a bathroom scale indirectly indicates your weight.	

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		Recognize that momentum of an object is a property of its motion that can be calculated from its mass and its velocity ($P = mv$), and that only forces can change the momentum of an object. Conduct investigations to determine the relationship between the force acting on an object and the change it produces in the object's momentum (i.e., the impulse) ($\Delta P = F_{avg} \cdot \Delta t$). Use the concept of impulse ($I = F_{avg} \cdot \Delta t$) to make estimates of average forces when the change in an object's momentum is known. For example, explain why collision forces will be reduced when the barriers are flexible (increasing Δt decreases F_{avg}), or how the severity of the injury to a falling athlete will be influenced by the surface the athlete lands on (i.e., turf, hard ground, concrete, etc.).	

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Describe that forces transfer energy from one object to another through a process called “work”. Explain how calculating the work done by a force helps us make qualitative and quantitative predictions regarding the motion of objects. Use mathematics, graphing calculators and/or graphing analysis programs to investigate the work done by individual forces.

Give examples of forces doing work to transfer energy to a rotating object (increasing its rotational speed), or doing work to transfer energy away from a rotating object (decreasing its rotational speed).</td><td></td></tr>
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		Describe how the concept of torque is used to explain (and calculate) the rotational effect that forces have when they act on objects. Conduct investigations to identify the factors that determine the torque produced by a force (Torque = force · lever distance). (For example, what conditions must be met to ensure that the sum of all torques acting on an object is zero, leaving the object in rotational equilibrium?).	

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Use energy chains to trace the flow of energy through physical systems. Indicate the source of the energy in each example, and trace the energy until it leaves the system or adopts a form in the system that neither changes nor is transferred. Make qualitative estimates of all the forms of the energy involved and reflect on the consequences of the energy transfers and transformations that take place. For example, trace the flow of the radiant energy carried by sunlight that strikes the roof of a home. Reflect on how the color of the roof (light vs. dark) will have an impact on the ability to heat and cool the house, and possibly the functional lifetime of the roofing materials themselves.		Give specific examples of how wave interference occurs in earth systems for both mechanical waves and electromagnetic waves. For example, in the case of mechanical waves, demonstrate regions of high volume (constructive interference) and low volume "dead spots" (destructive interference) in the space surrounding two speakers. Or consider the effect that wave interference has on the impact of seismic waves produced by earthquakes. In the case of EM waves, observe the colored patterns (fringes) on a soap bubble or in a thin layer of oil on a puddle of water. Describe how wave interference is used to create useful devices, such as noise cancellation devices (mechanical waves), window coatings to selectively transmit or reflect IR waves, diffraction gratings for spectroscopy, and lasers (EM waves).	Use diagrams to show how concave reflecting devices and convex lenses can be used to collect and focus EM waves. Recognize that the characteristics of these devices are different for different groups of EM waves (radio waves, microwaves, infrared waves, visible waves, etc.). Create light ray diagrams to illustrate how converging devices are used to collect and focus waves in scientific devices (e.g., telescopes and microscopes).

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Use diagrams and energy chains to illustrate examples of the selective absorption of mechanical waves in natural phenomena and give examples of how the selective absorption of mechanical waves is used to conduct investigations in medicine, industry and science (for example ultrasound imagery, detecting the epicenter of earthquakes, testing structures for defects, and conducting explorations of the earth's crust and mantle). Explain that what happens to electromagnetic waves that strike a substance (reflection, transmission, absorption) depends on the wavelength of the waves and the physical properties of the substance. Investigate how radio waves, microwaves, infrared waves, visible waves and ultraviolet waves behave when they strike different substances.		Explain why the Law of Conservation of Energy must be expanded to the Law of the Conservation of Mass/Energy when nuclear energy is involved in a process. Use the concept of stability to explain why energy is released during a fission process and during a fusion process. Use diagrams and energy chains to illustrate and explain the flow and transformations of energy that occur in fission and fusion processes, and during radioactive decay.	

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Record how effectively different materials reflect, absorb and transmit different kinds of EM waves. Draw conclusions based on this data and the physical properties of the substances (e.g., some substances absorb visible waves, but not radio waves. Other materials absorb UV waves, but not visible waves). Give examples that illustrate how the selective absorption of EM waves explains physical phenomena. For example; how X-rays can be used to detect broken bones beneath the skin and how coating on eyeglasses and sunglasses protect the eyes by permitting visible waves to pass but absorb UV waves. Use energy chains to trace the flow of energy in a selective absorption process (e.g., sunburn, Greenhouse Effect, microwave cooking).			

Standard 3: Energy and Its Effects, Grade Level Expectations Grades 9-12

Essential Question: Why do things have energy?
Essential Questions: How can energy be transferred from one material to another? What happens to a material when it receives energy?
Essential Questions: What happens to the energy in a system — where does this energy come from, how is it changed within the system, and where does it ultimately go? How does the flow of energy affect the materials in the system?
Essential Questions: What is a "responsible" use of energy? Are there alternative forms of energy that will serve our needs, or better ways of using traditional forms of energy?

Enduring Understandings: Energy takes many forms. These forms can be grouped into types of energy that are associated with the motion of mass (kinetic energy), and types of energy associated with the position of mass and energy fields (potential energy).
Enduring Understandings: Changes take place because of the transfer of energy. Energy is transferred to matter through the action of forces. Different forces are responsible for the different forms of energy.
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Use energy chains to trace the flow of energy through systems involving sliding friction and air resistance (for example, the braking action in vehicles or bicycles or a vehicle rolling to rest). Explain that through the action of resistive forces (friction and air resistance) mechanical energy is transformed into heat energy, and because of the random nature of heat energy, transforming all of the heat energy back into mechanical energy (or any other organized form of energy) is impossible. Give examples where organized forms of energy (GPE, elastic PE, the KE of large objects) are transformed into heat energy but the reverse transformations are not possible. Reflect on why organized forms of energy are more useful than disorganized forms (heat energy).			

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Enduring Understanding: People utilize a variety of resources to meet the basic and specific needs of life. Some of these resources cannot be replaced. Other resources can be replenished or exist in such vast quantities they are in no danger of becoming depleted. Often the energy stored in resources must be transformed into more useful forms and transported over great distances before it can be helpful to us. Research the factors that contribute to the energy efficiency of cars and trucks. Examine the role that the power of the engine and the weight and physical size and shape of the vehicle have on the fuel efficiency of the vehicle. Identify and report on the sources of the fuels currently used by vehicles and alternative fuels being developed.	**Enduring Understanding: People utilize a variety of resources to meet the basic and specific needs of life. Some of these resources cannot be replaced. Other resources can be replenished or exist in such vast quantities they are in no danger of becoming depleted. Often the energy stored in resources must be transformed into more useful forms and transported over great distances before it can be helpful to us.** *There are no grade level expectations for this understanding.*	**Enduring Understanding: People utilize a variety of resources to meet the basic and specific needs of life. Some of these resources cannot be replaced. Other resources can be replenished or exist in such vast quantities they are in no danger of becoming depleted. Often the energy stored in resources must be transformed into more useful forms and transported over great distances before it can be helpful to us.** Use energy chains to describe the flow of energy in a nuclear-fueled electric power facility. Indicate the source of energy of the facility, how and where energy leaves the facility, and in which parts of the facility energy transformations take place. Compare and contrast the energy diagram of the nuclear-fueled power plant to a comparable energy diagram for a fossil-fueled electric power plant.	**Enduring Understanding: People utilize a variety of resources to meet the basic and specific needs of life. Some of these resources cannot be replaced. Other resources can be replenished or exist in such vast quantities they are in no danger of becoming depleted. Often the energy stored in resources must be transformed into more useful forms and transported over great distances before it can be helpful to us.** *There are no grade level expectations for this understanding.*

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		Prepare a written report, a poster, or a computer-based presentation that explains the advantages and disadvantages of using fossil fuels, nuclear fuel, and alternative energy sources to generate electrical energy.	