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?	A. The Sun is a source of energy that lights and warms the Earth. **Level: Essential** B. Objects that move (i.e., moving air, moving water) have energy because of their motion. **Level: Important** C. Heat energy is a form of energy that makes things warmer. **Level: Important** D. Electrical energy is a form of energy that is used to operate many of our tools and appliances. **Level: Compact**	A. 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. **Level: Compact** B. The energy of a moving object depends on its speed. Faster moving objects have more energy than slower moving objects. **Level: Essential** C. Energy can be stored in an elastic material when it is stretched. **Level: Important** D. 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. **Level: Compact** E. Heat energy raises the object's temperature or changes the state of the object (i.e., solid to liquid, liquid to gas). **Level: Important** F. The energy obtained from electrical outlets is electrical energy that was produced at an electrical power plant.	A. 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. **Level: Essential** B. 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. **Level: Essential** C. 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. **Level: Important** D. 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. **Level: Important**	A. Electromagnetic waves carry a single form of energy called electromagnetic (radiant) energy. **Level: Essential** B. 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. **Level: Essential** C. Mechanical waves result from the organized vibrations of molecules in substances. Kinetic energy can be transferred very quickly over large distances by mechanical waves. **Level: Essential** D. Thermal (heat) energy is associated with the random kinetic energy of the molecules of a substance. **Level: Essential**

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The Forms and Sources of Energy *(Continued from previous page)*		Electrical energy can be generated and then transmitted over great distances. Batteries are portable sources of electrical energy. **Level: Compact**	The higher the temperature of the material, the greater the motion of the particles. E. Electrical energy is a form of energy that can be transferred by moving charges through a complete circuit. **Level: Essential**	E. Magnetic energy and electrical energy are different aspects of a single electromagnetic energy, which results from the motion of electrical charges. **Level: Compact** F. Chemical energy is derived from the making and breaking of chemical bonds. **Level: Essential** G. 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. **Level: Compact**
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?	A. 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. **Level: Important** B. 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. **Level: Important**	A. 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. **Level: Essential** B. 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. **Level: Essential**	A. 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. **Level: Essential** B. Gravity is a force that acts between masses over very large distances. Near the Earth's surface, gravity pulls objects and substances vertically downward. **Level: Important**	A. Forces change the motion of objects. Newton's Laws can be used to predict these changes. **Level: Essential** B. 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. **Level: Essential**

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Forces and the Transfer of Energy *(Continued from previous page)*	C. 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). **Level: Important** D. 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. **Level: Important**	C. 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. **Level: Essential** D. Pushing and pulling forces can be used to transfer energy from one object to another. **Level: Important** E. The transfer of heat energy may produce changes in the state of a substance. **Level: Important** F. The energy of electricity is transferred to electrical devices through simple closed circuits (simple series or simple parallel circuits). **Level: Essential** G. Some materials allow electricity to flow freely (conductors), while other materials inhibit the flow of electricity (insulators). **Level: Essential** H. Some materials are magnetic and can be pushed or pulled by other magnets. **Level: Compact**	C. 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. **Level: Essential** D. When energy from the sun is transferred to objects and substances, it can be transformed into a variety of energy forms. **Level: Essential** E. 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. **Level: Important** F. The addition or removal of heat energy from a material changes its temperature or its physical state. **Level: Important** G. Heat energy is transported by conduction, convection, and radiation. Heat energy transfers from warmer substances to cooler substances until they reach the same temperature. **Level: Essential**	C. The momentum of an object can be determined from the object's velocity and it's mass. **Level: Essential** 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. **Level: Important** D. 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. **Level: Essential** E. 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). **Level: Important**

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Forces and the Transfer of Energy *(Continued from previous page)*			H. 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. **Level: Important** I. Moving electric charges produce magnetic fields. **Level: Compact**	F. 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. **Level: Important** G. 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). **Level: Compact** H. 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. **Level: Essential**

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Forces and the Transfer of Energy *(Continued from previous page)*				I. 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. **Level: Compact**
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. 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?	A. When light hits an object; the light energy can become heat energy. **Level: Compact**	A. 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. **Level: Compact** B. 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. **Level: Compact** C. Electrical energy in circuits can be changed (transformed) into light, heat, sound, and the energy of motion. **Level: Compact**	A. 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). **Level: Essential** B. 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. **Level: Essential**	A. 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. **Level: Essential** B. 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. **Level: Essential**

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Energy Interacting With Materials; the Transformation and Conservation of Energy *(Continued from previous page)*			C. 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. **Level: Compact**	C. 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. **Level: Essential** D. 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). **Level: Important** E. Through reflection and refraction, electromagnetic waves can be redirected to produce concentrated beams or images of their source. **Level: Important** F. 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. **Level: Compact**

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Energy Interacting With Materials; the Transformation and Conservation of Energy *(Continued from previous page)*				These energy changes, which are characteristic of the atom or molecule can be used to identify the material. **Level: Important**
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?	A. Moving air, moving water, and sunlight contain energy that can be put to our use. **Level: Important**	A. 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. **Level: Compact**	A. 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. **Level: Compact** B. 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. **Level: Compact** C. Responsible use of energy requires consideration of energy availability, efficiency of its use, the environmental impact, and possible alternate sources. **Level: Compact**	A. 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. **Level: Essential** B. 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. **Level: Essential**