Physical Science

Pacing Guide and Unpacked Standards

GROVEPORT MADISON
SCHOOLS

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Groveport Madison Science Pacing Guide

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RST.9-10.10 Read, comprehend & respond to science/technical texts.</td><td rowspan="7">WHST.6-8.1 (a,b,c,d,e,f) Write arguments to support claims & thesis.
WHST.6-8.2 (a,b,c,d,e,f) Write informative/explanatory texts. WHST.6-8.4 Develop, organize & produce clear and coherent writing.
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WHST.6-8.7 Conduct short research projects.
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WHST.6-8.9 Support analysis & draw evidence from informational text.
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• Fusion in stars</td></tr>
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Ohio's New Learning Standards - Clear Learning Targets

PS.M.1

Study of Matter: Classification of Matter
Hetero vs. Homogenous, Properties of Matter, States of matter and its changes

Essential Understandings:

- Matter can be classified in broad categories such as homogeneous and heterogeneous, or classified according to its composition or by its chemical (reactivity) and physical properties (e.g., color solubility, odor, hardness, density, melting point and boiling point, viscosity, and malleability). Solutions are homogenous mixtures of a solute dissolved in a solvent. The amount of a solid solute that can dissolve in a solvent generally increases as the temperature increases since the particles have more kinetic energy to overcome the attractive forces between them. Water is often used as a solvent since so many substances will dissolve in water. Physical properties can be used to separate the substances in mixtures, including solutions.

- Phase changes can be represented by graphing the temperature of a sample vs. the time it has been heated. Investigations must include collecting data during heating, cooling and solid-liquid-solid phase changes. At times, the temperature will change steadily, indicating a change in the motion of the particles and the kinetic energy of the substance. However, during a phase change, the temperature of a substance does not change, indicating there is no change in kinetic energy. Since the substance continues to gain or lose energy during phase changes, these changes in energy are potential and indicate a change in the position of the particles. When heating a substance, a phase change will occur when the kinetic energy of the particles is great enough to overcome the attractive forces between the particles; the substance then melts or boils. Conversely, when cooling a substance, a phase change will occur when the kinetic energy of the particles is no longer great enough to overcome the attractive forces between the particles; the substance then condenses or freezes. Phase changes are examples of changes that can occur when energy is absorbed from the surroundings (endothermic) or released into the surroundings (exothermic).

- When thermal energy is added to a solid, liquid or gas, most substances increase in volume because the increased kinetic energy of the particles causes an increased distance between the particles. This results in a change in density of the material. Generally, solids have greater density than liquids, which have greater density than gases due to the spacing between the particles. The density of a substance can be calculated from the slope of a mass vs. volume graph. Differences in densities can be determined by interpreting mass vs. volume graphs of the substances.

Vocabulary

Calculate
Determine
Describe
Graph
Conduct
Interrupt
Categorize
Homogeneous
Heterogeneous
Chemical (Reactivity)
Physical Properties
Solutions
Solute
Solvent
Phase Changes
Kinetic Energy
Endothermic
Exothermic

Essential Skills:	The students can categorize matter as either homogeneous or heterogeneous in nature. The students can calculate the density of a substance using a formula and a mass vs. volume graph. The students can determine quantitatively the physical properties of a substance (including density, melting point, boiling point, viscosity, hardness, and solubility) The students can describe a substance qualitatively by odor, color, malleability, reactivity, & flammability. The students can use a particle model to describe the flow of energy as a substance heats or cools The students can graph the changes in phase for substances using given data. The students can conduct an investigation that focuses on the change from solid to liquid to gas state of a substance. The students can interpret phase changes at the atomic level as change in the KE and strength of attraction between atoms The students can explain the difference between an endothermic reaction and exothermic reactions.

Misconceptions

- Students may think that models are physical copies of the real thing, failing to recognize models as conceptual representations. (AAAS, 1993)
- Students know models can be changed, but at the high school level, they may be limited by thinking that a change in a model means adding new information or that changing a model means replacing a part that was wrong. (AAAS, 1993)
- Students often do not believe models can duplicate reality. (AAAS, 1993)
- Students often think that breaking bonds releases energy. (Ross, 1993)
- When multiple models are presented, they tend to think there is one "right one". (AAAS, 1993)

Instructional Strategies and Resources

The Rutherford experiment is a simulation that shows high-speed particles bombarding a thin foil.
While the simulation is not to scale, it does provide a dynamic visual to help students understand what is happening at the atomic level that explains the experimental evidence.

Career Connections

http://www.collegexpress.com/interests/science-and-engineering/articles/studying-sciences/science-majors-and-potential-jobs/

Prior Knowledge	**Future Knowledge**
Elementary School: Introduction of matter. **Middle School:** Continuing on prior elementary knowledge middle school expanded the concept of matter and explored, the differences in the physical properties of solids, liquids, and gases, elements, compounds, mixtures, molecules, kinetic and potential energy and the particulate nature of matter.	The study of atoms will be continued in chemistry this will include but not be limited to: electron configuration, molecular shapes, and bond angles.

Ohio's New Learning Standards - Clear Learning Targets

PS.M.2	**Study of Matter: Atoms** **Models of the atom, ions, Isotopes**	**Vocabulary** Understand Recognize Explain Identify Compare Demonstrate Examine Atom Atomic Number Protons Isotopes Neutrons Electrons Mass Nucleus Mass Numbers Anions Cations

Essential Understandings:

- **NOTE: Content introduced in middle school, where the atom was introduced as a small, indestructible sphere, is further developed in the physical science syllabus.** Over time, technology was introduced that allowed the atom to be studied in more detail. The atom is composed of protons, neutrons and electrons that have measurable properties, including mass and, in the case of protons and electrons, a characteristic charge. When bombarding thin gold foil with atomic-sized, positively charged, high-speed particles, a few of the particles were deflected slightly from their straight-line path. Even fewer bounced back toward the source. This evidence indicates that most of an atom is empty space with a very small positively charged nucleus. This experiment and other evidence indicate the nucleus is composed of protons and neutrons, and electrons that move about in the empty space that surrounds the nucleus. **NOTE: Additional experimental evidence that led to the development of other historic atomic models will be addressed in the chemistry syllabus.**

- All atoms of a particular element have the same atomic number; an element may have different isotopes with different mass numbers. Atoms may gain or lose electrons to become anions or cations. Atomic number, mass number, charge and identity of the element can be determined from the numbers of protons, neutrons and electrons. Each element has a unique atomic spectrum that can be observed and used to identify an element. **NOTE: Atomic mass and explanations about how atomic spectra are produced are addressed in the chemistry syllabus.**

Essential Skills:	The students can understand that an atom consists of different particles with a measurable mass and specific electrical charge (neutron is 0). The students can recognize technology has allowed us to study the atom in greater detail over time. The students can explain the process scientists used to determine that atoms are mostly space. The students can explain that all atoms of an element have the same atomic number. The students can compare isotopes of an element by their protons, neutrons, and electrons. The students can identify an element, its mass and charge by its number of protons, neutrons, and electrons. The students can demonstrate that atoms may become ions by gaining or losing electrons. The students can examine the spectra of several common atoms to determine that each element has a unique pattern of light emitted.

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Instructional Strategies and Resources

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Ohio’s New Learning Standards: Science - Clear Learning Targets

<table>
<tr><td>PS.M.3</td><td>Study of Matter:
Periodic Trends of the Elements
Periodic law, Representative groups</td><td rowspan="2"><u>Vocabulary</u>

Describe
Identify
Explain
Periodic Law
Groups
Periodic Table
Periods
Metals
Nonmetals
Metalloids
Families
Alkali Metals
Alkaline Earth Metals
Halogens
Noble Gasses</td></tr>
<tr><td colspan="2"><u>Essential Understandings:</u>
NOTE: Content from the middle school level, specifically the properties of metals and nonmetals and their positions on the periodic table, is further expanded in this course. When elements are listed in order of increasing atomic number, the same sequence of properties appears over and over again; this is the periodic law. The periodic table is arranged so that elements with similar chemical and physical properties are in the same group or family. Metalloids are elements that have some properties of metals and some properties of nonmetals. Metals, nonmetals, metalloids, periods and groups or families including the alkali metals, alkaline earth metals, halogens and noble gases can be identified by their position on the periodic table.
Elements in Groups 1, 2 and 17 have characteristic ionic charges that will be used in this course to predict the formulas of compounds. NOTE: Other trends in the periodic table (e.g., atomic radius, electronegativity, ionization energies) are found in the chemistry syllabus.</td></tr>
<tr><td><u>Essential Skills:</u></td><td colspan="2">The students can describe how elements are organized on the periodic table.
The students can describe distinguishing characteristics of halogens, alkali metals, alkaline earth metals, and noble gases.
The students can identify and describe metalloids.
The students can explain what is the same among all elements in a group
The students can identify elements that belong in the same period.
The students can identify physical and chemical properties of elements based on their location on the periodic table.</td></tr>
</table>

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Ohio's New Learning Standards - Clear Learning Targets

PS.M.4	**Study of Matter:** **Bonding and Compounds** **Ionic and covalent bonding, nomenclature**	**Vocabulary** Determine Ion Three dimensional Lattice Covalent bond Bonding Atoms Elements Molecular Compound

Essential Understandings:

- In this course, the chemical joining of atoms is studied in more detail. Atoms may be bonded together by losing, gaining or sharing electrons to form molecules or three-dimensional lattices. An ionic bond involves the attraction of two oppositely charged ions, typically a metal cation and a nonmetal anion formed by transferring electrons between the atoms. An ion attracts oppositely charged ions from every direction, resulting in the formation of a three-dimensional lattice. Covalent bonds result from the sharing of electrons between two atoms, usually nonmetals. Covalent bonding can result in the formation of structures ranging from small individual molecules to three-dimensional lattices (e.g., diamond). The bonds in most compounds fall on a continuum between the two extreme models of bonding: ionic and covalent.

- Using the periodic table to determine ionic charge, formulas of ionic compounds containing elements from groups 1, 2, 17, hydrogen and oxygen can be predicted. Given a chemical formula, a compound can be named using conventional systems that include Greek prefixes where appropriate. Prefixes will be limited to represent values from one to 10**.** Given the name of an ionic or covalent substance, formulas can be written. **NOTE: Naming organic molecules is beyond this grade level and is reserved for an advanced chemistry course. Prediction of bond types from electronegativity values, polar covalent bonds, writing formulas and naming compounds that contain polyatomic ions or transition metals will be addressed in the chemistry syllabus.**

Essential Skills:	The students can compare and contrast ionic bonding with covalent bonding. The students can show how ions with different charges can form 3-D lattices. The students can use the periodic table to predict what formula will result when two elements bond (Groups 1,2, 17, and oxygen) The students can define and illustrate Ionic and Covalent bonds. The students can name a compound by its chemical formula based on the bonding. The students can give a compound's name, determine the formula.

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Prior Knowledge	Future Knowledge
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Ohio's New Learning Standards - Clear Learning Targets

PS.M.5

Study of Matter: Reactions of Matter
Chemical reactions, Nuclear reactions

Vocabulary

Demonstrate
Identify
Explain
Understand
Explore
Read and Interrupt
Reactants
Products
Thermal Energy
Nuclear Reactions
Radioactive Decay
Radiation
Radioactive Isotopes
Half-life
Nuclear Fission
Nuclear Fusion

Essential Understandings:

- In this course, conservation of matter is expressed by writing balanced chemical equations. At this level, reactants and products can be identified from an equation and simple equations can be written and balanced given either the formulas of the reactants and products or a word description of the reaction. **NOTE: Stoichiometric relationships beyond the coefficients ina balanced equation and classification of types of chemical reactions are addressed in the chemistry syllabus.**

- During chemical reactions, thermal energy is either transferred from the system to the surroundings (exothermic) or transferred from the surroundings to the system (endothermic). Since the environment surrounding the system can be large, temperature changes in the surroundings may not be detectable.

- While chemical changes involve changes in the electrons, nuclear reactions involve changes to the nucleus and involve much larger energies than chemical reactions. The strong nuclear force is the attractive force that binds protons and neutrons together in the nucleus. While the nuclear force is extremely weak at most distances, over the very short distances present in the nucleus the force is greater than the repulsive electrical forces among protons. When the attractive nuclear forces and repulsive electrical forces in the nucleus are not balanced, the nucleus is unstable. Through radioactive decay, the unstable nucleus emits radiation in the form of very fast-moving particles and energy to produce a new nucleus, thus changing the identity of the element. Nuclei that undergo this process are said to be radioactive. Radioactive isotopes have several medical applications. The radiation they release can be used to kill undesired cells (e.g., cancer cells). Radioisotopes can be introduced into the body to show the flow of materials in biological processes.

- For any radioisotope, the half-life is unique and constant. Graphs can be constructed that show the amount of a radioisotope that remains as a function of time and can be interpreted to determine the value of the half-life. Half-life values are used in radioactive dating.

- Other examples of nuclear processes include nuclear fission and nuclear fusion. Nuclear fission involves splitting a large nucleus into smaller nuclei, releasing large quantities of energy. Nuclear fusion is the joining of smaller nuclei into a larger nucleus accompanied by the release of large quantities of energy. Nuclear fusion is the process responsible for formation of all the elements in the universe beyond helium and the energy of the sun and the stars.

NOTE: Further details about nuclear processes including common types of nuclear radiation, predicting the products of nuclear decay, mass-energy equivalence and nuclear power applications are addressed in the chemistry and physics syllabi.	

Essential Skills:	The students can demonstrate that matter is conserved in a balanced chemical equation The students can identify reactants and products of a balanced chemical equation. The students can determine if given chemical equations are balanced or not The students can explain that thermal energy can be transferred from the system (exothermic) during a chemical reaction. The students can explain that thermal energy can be transferred to the system (endothermic) during a chemical reaction. The students can understand that all thermal energy in the system is not large enough to be detected, though it is present. The students can understand that the nuclear forces which bind protons and neutrons together are very strong over short distances. The students can explain that nuclear reactions involve changes in a nucleus, requiring much more energy than a chemical reaction. The students can identify that the stability of a nucleus is a result of a balance of attractive nuclear forces and repulsive electrical forces within the nucleus. The students can explore how radioactive isotopes are used in the medical field to kill undesired cells in the body. The students can read a graph of the half-life of any radioisotope and interpret time which can be used in radioactive dating. The students can explain the difference between nuclear fusion (the process that is responsible for formation of elements and energy in stars) and nuclear fission (the process that splits a larger nucleus into smaller nuclei and releases neutrons).

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Criteria for Success (Performance Level Descriptors)

Limited: Given a phase change graph, identify the temperature of the melting and/or boiling point; Given elemental properties, classify elements in the same group; Given a chemical name for a compound, identify the elements involved; Recognize that electrons can be lost, gained, or shared when atoms bond; Given a chemical equation, identify the reactants and products.

Basic: Describe, using properties, the difference between homogenous and heterogeneous matter; Given a phase change graph, identify where the phase changes occur; Given data, determine values for various atomic properties (e.g., atomic number, mass number); Distinguish between the isotopes and

ions of an element and describe properties of elements based on their position in the periodic table; Determine the chemical names of simple compounds given their formulas (or vice versa); Given a pair of elements, determine the formula of a compound between them and/or whether the bond would be covalent or ionic; Describe endothermic or exothermic reactions. **Proficient:** Use one designated property (e.g., solubility, density, boiling/melting point) to separate a mixture; Interpret phase change graphs to identify changes in kinetic and/or potential energy; Create a diagram or model atoms, ions, isotopes, and various chemical bonds; Balance chemical equations; Describe properties of elements that lead to radioactive decay, interpret half-life graphs and produce a graph from half-life data. **Accelerated:** Predict how unknown elements react when given properties; Given an ionic formula with an unknown, identify ionic charge and/or the elemental group and its location on the periodic table (e.g., XF2); Describe the changes in motion and relative position of particles when given data or graphs (e.g., phase change graphs); Given half-life data of radioactive elements, evaluate which elements are appropriate for various applications and justify this using evidence. **Advanced:** Design a solution to a real-world problem involving mixtures that need to be separated based on more than one property (e.g., solubility, density, boiling/melting point).

Prior Knowledge **Elementary School:** Introduction of matter. **Middle School:** Continuing on prior elementary knowledge middle school expanded the concept of matter and explored, the differences in the physical properties of solids, liquids, and gases, elements, compounds, mixtures, molecules, kinetic and potential energy and the particulate nature of matter.	**Future Knowledge** The study of atoms will be continued in chemistry this will include but not be limited to: electron configuration, molecular shapes, and bond angles.

Ohio's New Learning Standards - Clear Learning Targets

PS.EW.1	**Energy and Waves:** **Conservation of Energy** **Quantifying kinetic energy, Quantifying gravitational potential energy,**	**<u>Vocabulary</u>** Draw Identify Demonstrate Apply Calculate Create Joules Gravitational Potential Energy Conservation of Energy Force (F) Displacement Energy Transformation Thermal Energy
<u>Essential Understandings:</u> • Energy content learned in middle school, specifically conservation of energy and the basic differences between kinetic and potential energy is elaborated on and quantified in this course. Energy has no direction and has units of Joules (J). Kinetic energy, *Ek*, can be mathematically represented by $E_k = ½mv^2$. Gravitational potential energy, *Eg*, can be mathematically represented by $E_g = mgh$, The amount of energy of an object is measured relative to a reference that is considered to be at a point of zero energy. The reference may be changed to help understand different situations. Only the change in the amount of energy can be measured absolutely. The conservation of energy and equations for kinetic and gravitational potential energy can be used to calculate values associated with energy (i.e., height, mass, speed) for situations involving energy transfer and transformation. Opportunities to quantify energy from data collected in experimental situations (e.g., a swinging pendulum, a car travelling down an incline) must be provided.		

<u>Essential Skills:</u>	The students can draw diagrams to indicate that energy radiates out in all directions from a source. The students can identify that the units for energy and work are the Joule (J) The students can demonstrate that Kinetic Energy can be calculated mathematically using the formula $E_k=½mv^2$. The students can demonstrate that Potential Energy can be calculated mathematically using the formula $E_g=mgh$. The students can apply the transfer of energy, while conserving energy, in everyday situations such as a car traveling down an incline. The students can calculate work (W) using the following formula: W=**FΔx** The students can create a pie or bar graph that shows the transformation of energy in a scenario. The students can demonstrate the ability to complete equations for work, kinetic energy, and potential energy and tie them with the law of conservation of energy to solve problems. The students can identify that during an energy transformation, some energy is transferred to thermal energy; which is more spread out and less useful for doing work.

Misconceptions

- Potential energy is a thing that objects hold (like cereal stored in a closet).
- The only type of potential energy is gravitational.
- Doubling the velocity of a moving object will double its kinetic energy.
- Stored energy is something that causes energy later; it is not energy until it has been released.
- Objects do not have any energy if they are not moving.
- Energy is a thing that can be created and destroyed.
- Energy is literally lost in many energy transformations.
- Gravitational potential energy depends only upon the height of an object.
- Energy can be changed completely from one form to another with no loss of useful energy.

Instructional Strategies and Resources

- "Waves, Light, and Sound" from The Physics Zone links to many animations of waves that can be used with absent students or students who need more reinforcement. Simulations also may be good to slow down some of the phenomena that students observe in class so they can make observations that are more detailed. Some of the simulations can only be accessed by members, but many of the simulations have unrestricted access.

Modeling workshops are available nationally that help teachers develop a framework for incorporating guided inquiry in their instruction.

Career Connections: http://www.collegexpress.com/interests/science-and-engineering/articles/studying-sciences/science-majors-and-potential-jobs/

Prior Knowledge	**Future Knowledge**
Elementary: Concepts introduced at the elementary level are: heat, electrical energy, light, sound, and magnetic energy are all forms of energy; energy can be transformed. **Middle School:** Concepts of conservation of energy as well as transformation and transfer of energy.	The concepts taught in the Physical Science course will be elaborated on in Physics.

Ohio's New Learning Standards: Science Clear Learning Targets

PS.EW.2	**Energy and Waves:** **Transfer and Transformation of Energy** **(including work)**	**Vocabulary/** Draw Identify Demonstrate Apply Calculate Create Force (F) Displacement Work Energy Transformation Conservation of Energy Conduction Convection Radiation Thermal Energy Kinetic Energy Potential Energy Law of Conservation of Energy
Essential Understandings: • In middle school, concepts of energy transfer and transformation were addressed, including conservation of energy, conduction, convection and radiation, the transformation of electrical energy, and the dissipation of energy into thermal energy. Work also was introduced as a method of energy transfer into or out of the system when an outside force moves an object over a distance. In this course, these concepts are further developed. As long as the force, **F**, and displacement, Δx, are in the same direction, work, W, can be calculated from the equation $W = F\Delta x$. Energy transformations for a phenomenon can be represented through a series of pie graphs or bar graphs. Equations for work, kinetic energy and potential energy can be combined with the law of conservation of energy to solve problems. When energy is transferred from one system to another, some of the energy is transformed to thermal energy. Since thermal energy involves the random movement of many trillions of subatomic particles, it is less able to be organized to bring about further change. Therefore, even though the total amount of energy remains constant, less energy is available for doing useful work.		

Essential Skills:	The students can draw diagrams to indicate that energy radiates out in all directions from a source. The students can identify that the units for energy and work are the Joule (J) The students can demonstrate that Kinetic Energy can be calculated mathematically using the formula $E_k=½mv^2$. The students can demonstrate that Potential Energy can be calculated mathematically using the formula $E_g=mgh$. The students can apply the transfer of energy, while conserving energy, in everyday situations such as a car traveling down an incline. The students can calculate work (W) using the following formula: $W=\mathbf{F\Delta x}$ The students can create a pie or bar graph that shows the transformation of energy in a scenario. The students can demonstrate the ability to complete equations for work, kinetic energy, and potential energy and tie them with the law of conservation of energy to solve problems. The students can identify that during an energy transformation, some energy is transferred to thermal energy; which is more spread out and less useful for doing work.

Misconceptions

- Potential energy is a thing that objects hold (like cereal stored in a closet).
- The only type of potential energy is gravitational.
- Doubling the velocity of a moving object will double its kinetic energy.
- Stored energy is something that causes energy later; it is not energy until it has been released.
- Objects do not have any energy if they are not moving.
- Energy is a thing that can be created and destroyed.
- Energy is literally lost in many energy transformations.
- Gravitational potential energy depends only upon the height of an object.
- Energy can be changed completely from one form to another with no loss of useful energy.

Instructional Strategies and Resources

- "Waves, Light, and Sound" from The Physics Zone links to many animations of waves that can be used with absent students or students who need more reinforcement. Simulations also may be good to slow down some of the phenomena that students observe in class so they can make observations that are more detailed. Some of the simulations can only be accessed by members, but many of the simulations have unrestricted access.

Modeling workshops are available nationally that help teachers develop a framework for incorporating guided inquiry in their instruction.

Career Connections: http://www.collegexpress.com/interests/science-and-engineering/articles/studying-sciences/science-majors-and-potential-jobs/

Prior Knowledge	**Future Knowledge**
Elementary: Concepts introduced at the elementary level are: heat, electrical energy, light, sound, and magnetic energy are all forms of energy; energy can be transformed. **Middle School:** Concepts of conservation of energy as well as transformation and transfer of energy.	The concepts taught in the Physical Science course will be elaborated on in Physics

Ohio's New Learning Standards - Clear Learning Targets

PS.EW.3

Energy and Waves: Waves
Refraction, Reflection, Diffraction, Absorption, Superposition, Radiant energy, Electromagnetic spectrum, Doppler shift

Essential Understandings:

- As addressed in middle school, waves transmit energy from one place to another, can transfer energy between objects and can be described by their speed, wavelength, frequency and amplitude. The relationship between speed, wavelength and frequency also was addressed in middle school Earth and Space Science as the motion of seismic waves through different materials is studied.
- In elementary and middle school, reflection and refraction of light were introduced, as was absorption of radiant energy by transformation into thermal energy. In this course, these processes are addressed from the perspective of waves and expanded to include other types of energy that travel in waves. When a wave encounters a new material, the new material may absorb the energy of the wave by transforming it to another form of energy, usually thermal energy. Waves can be reflected off solid barriers or refracted when a wave travels form one medium into another medium. Waves may undergo diffraction around small obstacles or openings. When two waves traveling through the same medium meet, they pass through each other then continue traveling through the medium as before. When the waves meet, they undergo superposition, demonstrating constructive and destructive interference. Sound travels in waves and undergoes reflection, refraction, interference and diffraction. In the physics syllabus, many of these wave phenomena will be studied further and quantified.
- Radiant energy travels in waves and does not require a medium. Sources of light energy (e.g., the sun, a light bulb) radiate energy continually in all directions. Radiant energy has a wide range of frequencies, wavelengths and energies arranged into the electromagnetic spectrum. The electromagnetic spectrum is divided into bands: radio (lowest energy), microwaves, infrared, visible light, X-rays and gamma rays (highest energy) that have different applications in everyday life. Radiant energy of the entire electromagnetic spectrum travels at the same speed in a vacuum. Specific frequency, energy or wavelength ranges of the electromagnetic spectrum are not required. However, the relative positions of the different bands, including the colors of visible light, are important (e.g., ultraviolet has more energy than microwaves).
- Radiant energy exhibits wave behaviors including reflection, refraction, absorption, superposition and diffraction, depending in part on the nature of the medium. For opaque objects (e.g., paper, a chair, an apple), little if any radiant energy is transmitted into the new material. However the radiant energy can be absorbed, usually increasing the thermal energy of the object and/or the radiant energy can be reflected. For rough objects, the reflection in all directions forms a diffuse reflection and for smooth shiny objects, reflections can result in clear images. Transparent materials transmit

Vocabulary

Explain
Describe
Demonstrate
Compare
Understand
Waves
Superposition
Destructive Interference
Reflection
Refraction
Interference
Diffraction
Radiant Energy
Wavelength
Absorbed
Doppler Shift
Electromagnetic Spectrum
Constructive Interference

• most of the energy through the material but smaller amounts of energy may be absorbed or reflected. • Changes in the observed frequency and wavelength of a wave can occur if the wave source and the observer are moving relative to each other. When the source and the observer are moving toward each other, the wavelength is shorter and the observed frequency is higher; when the source and the observer are moving away from each other, the wavelength is longer and the observed frequency is lower. This phenomenon is called the Doppler shift and can be explained using diagrams. This phenomenon is important to current understanding of how the universe was formed and will be applied in later sections of this course. Calculations to measure the apparent change in frequency or wavelength are not appropriate for this course.	
<u>Essential Skills:</u>	The students can explain that waves are a transfer of energy in a variety of forms (thermal, light, sound…). The students can described waves by their speed, wavelength, frequency, and amplitude The students can explain the physical properties of waves (reflection, superposition, diffraction, refraction, and constructive and destructive interference). The students can demonstrate understanding of Radiant Energy and the electromagnetic spectrum by providing examples, i.e.: microwaves, visible, gamma The students can compare the relative energy, frequency, and wavelength of radio, visible light, ultraviolet, and x-rays. The students can explain that the speed of all forms of radiant energy is the same and requires no medium, much faster than the speed of sound (a mechanical wave). The students can explain that Radiant Energy exhibits behaviors such as transmission, reflection, refraction, absorption, superposition, and diffraction depending on the nature of the medium. The students can understand that when Radiant Energy is absorbed in an opaque medium that object will increase in thermal energy. The students can demonstrate understanding of the Doppler Effect through a diagram.

Misconceptions

- Potential energy is a thing that objects hold (like cereal stored in a closet).
- The only type of potential energy is gravitational.
- Doubling the velocity of a moving object will double its kinetic energy.
- Stored energy is something that causes energy later; it is not energy until it has been released.
- Objects do not have any energy if they are not moving.
- Energy is a thing that can be created and destroyed.
- Energy is literally lost in many energy transformations.
- Gravitational potential energy depends only upon the height of an object.
- Energy can be changed completely from one form to another with no loss of useful energy.

Instructional Strategies and Resources • "Waves, Light, and Sound" from The Physics Zone links to many animations of waves that can be used with absent students or students who need more reinforcement. Simulations also may be good to slow down some of the phenomena that students observe in class so they can make observations that are more detailed. Some of the simulations can only be accessed by members, but many of the simulations have unrestricted access. Modeling workshops are available nationally that help teachers develop a framework for incorporating guided inquiry in their instruction.	
Career Connections: http://www.collegexpress.com/interests/science-and-engineering/articles/studying-sciences/science-majors-and-potential-jobs/	
Prior Knowledge **Elementary:** Concepts introduced at the elementary level are: heat, electrical energy, light, sound, and magnetic energy are all forms of energy; energy can be transformed. **Middle School:** Concepts of conservation of energy as well as transformation and transfer of energy.	**Future Knowledge** The concepts taught in the Physical Science course will be elaborated on in Physics

Ohio's New Learning Standards - Clear Learning Targets		
PS.EW.4	**Energy and Waves:** **Thermal Energy**	**Vocabulary** Explain Understand Demonstrate Thermal Conductivity Thermal Energy Transfer Thermal Insulators Thermal Radiation
Essential Understandings: • Processes of heat transfer, including conduction, convection and radiation, are studied. In other sections of this course, the role of thermal energy during heating, cooling and phase changes are explored conceptually and graphically. In this course, rates of thermal energy transfer and thermal equilibrium are introduced. • Thermal conductivity depends on the rate at which thermal energy is transferred from one end of a material to another. Thermal conductors have a high rate of thermal energy transfer and thermal insulators have a slow rate of thermal energy transfer. The rate at which thermal radiation is absorbed or emitted by a system depends on its temperature, color, texture and exposed surface area. All other things being equal, in a given amount of time, black rough surfaces absorb more thermal energy than smooth white surfaces. An object or system is continually absorbing and emitting thermal radiation. If the object or system absorbs more thermal energy than it emits and there is no change in phase, the temperature increases. If the object or system emits more thermal energy than is absorbed and there is no change in phase, the temperature decreases. For an object or system in thermal equilibrium, the amount of thermal energy absorbed is equal to the amount of thermal energy emitted; therefore, the temperature remains constant. In chemistry, changes in thermal energy are quantified for substances that change their temperature.		
Essential Skills:	The students can explain how particles in matter move relative to their temperature. The students can explain that thermal conductivity depends on the rate at which thermal energy transfers from one end of a material to another. The students can understand that the rate that thermal energy is absorbed is dependent upon the physical properties of that object. The students can demonstrate understanding of thermal equilibrium with a phase diagram.	

Misconceptions

- Potential energy is a thing that objects hold (like cereal stored in a closet).
- The only type of potential energy is gravitational.
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Instructional Strategies and Resources

- "Waves, Light, and Sound" from The Physics Zone links to many animations of waves that can be used with absent students or students who need more reinforcement. Simulations also may be good to slow down some of the phenomena that students observe in class so they can make observations that are more detailed. Some of the simulations can only be accessed by members, but many of the simulations have unrestricted access.

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Prior Knowledge	**Future Knowledge**
Elementary: Concepts introduced at the elementary level are: heat, electrical energy, light, sound, and magnetic energy are all forms of energy; energy can be transformed. **Middle School:** Concepts of conservation of energy as well as transformation and transfer of energy.	The concepts taught in the Physical Science course will be elaborated on in Physics

Ohio's New Learning Standards - Clear Learning Targets

PS.EW.5

Energy and Waves: Electricity
Movement of Electrons, Current, Electric Potential (voltage), Resistors and Transfer Energy

Essential Understandings:

- In earlier grades, these concepts were introduced: electrical conductors and insulators; and a complete loop are needed for an electrical circuit that may be parallel or in a series. In this course, circuits are explained by the flow of electrons, and current, voltage and resistance are introduced conceptually to explain what was observed in middle school. The differences between electrical conductors and insulators can be explained by how freely the electrons flow throughout the material due to how firmly electrons are held by the nucleus.

- By convention, electric current is the rate at which positive charge flows in a circuit. In reality, it is the negatively charged electrons that are actually moving. Current is measured in amperes (A), which is equal to one coulomb of charge per second (C/s). In an electric circuit, the power source supplies the electrons already in the circuit with electric potential energy by doing work to separate opposite charges. For a battery, the energy is provided by a chemical reaction that separates charges on the positive and negative sides of the battery. This separation of charge is what causes the electrons to flow in the circuit. These electrons then transfer energy to other objects and transform electrical energy into other forms (e.g., light, sound, heat) in the resistors. Current continues to flow, even after the electrons transfer their energy. Resistors oppose the rate of charge flow in the circuit. The potential difference or voltage across an energy source is a measure of potential energy in Joules supplied to each coulomb of charge. The volt (V) is the unit of potential difference and is equal to one Joule of energy per coulomb of charge (J/C). Potential difference across the circuit is a property of the energy source and does not depend upon the devices in the circuit. These concepts can be used to explain why current will increase as the potential difference increases and as the resistance decreases. Experiments, investigations and testing (3-D or virtual) must be used to construct a variety of circuits, and measure and compare the potential difference (voltage) and current. Electricity concepts are dealt with conceptually in this course. Calculations with circuits will be addressed in the physics syllabus.

Vocabulary

Explain
Identify
Demonstrate
Construct
Circuits
Current
Voltage
Resistance
Electrical Insulators
Amperes
Resistors
Voltage
Electrical Conductors
Electric Potential
Energy

Essential Skills:	The students can explain conductors, insulators and resistors in terms of how electrons move within a substance. The students can identify that current is measured in amperes with the units of one coulomb charge per second. The students can explain that a power source supplies the electrons already in a circuit with electrical potential energy. The students can demonstrate through a diagram that a chemical reaction in a battery is responsible for the flow of electrons. The students can construct a variety of circuits, measuring the voltage and current The students can explain that current will increase as the potential difference increases or as resistance decreases.

Misconceptions

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- The only type of potential energy is gravitational.
- Doubling the velocity of a moving object will double its kinetic energy.
- Stored energy is something that causes energy later; it is not energy until it has been released.
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Instructional Strategies and Resources

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Criteria for Success (Performance Level Descriptors)

Limited: Calculate for gravitational potential energy and kinetic energy; Identify the portion of the electromagnetic spectrum that has the lowest frequency, wavelength, or energy; Recognize the properties of an object that affect absorption and radiation rates of thermal energy; Recognize that electrons flow through a circuit.

Basic: Recognize when work is done on an object; Compare relative energies, frequencies and wavelengths of the different bands of the electromagnetic spectrum, including the colors of visible light; Explain the dissipations of energy from systems due to transformation into thermal energy; Describe the origin, motion and energy of electrons in circuits.

Proficient: Given a real-world scenario, calculate values involving work or values involving conservation of energy in a closed system; Describe the characteristics and behaviors (e.g., superposition/interference, diffraction) of waves as a form of energy transfer; Compare radiant energy interactions between objects with differing characteristics that influence the rate of thermal absorption and emission (e.g., temperature, color, texture, exposed surface area in the system); Describe the relationships between voltage, current, and resistance in circuits.

Accelerated: Calculate gravitational potential energy when the reference point is not the ground or lowest level; Given a real-world scenario, calculate values involving both work and conservation of energy in a closed system; Create a model to visually represent diffraction, superposition, constructive and

destructive interference, or a change in wavelength due to the Doppler effect; Given a real-world scenario, recommend specific design features that relate to thermal energy absorption and emission (e.g., temperature, color, texture, exposed surface area in the system); Explain observed changes in current and voltage in a circuit in terms of electrons and energy transfer; Design and/or evaluate a circuit to meet real-world conditions and constraints. **Advanced:** Plan an experiment to determine values related to energy transformation and energy transferred through work on a system; Design or improve a system that involves work and energy transformation that meets certain constraints (e.g., height, speed, force, displacement).

Prior Knowledge **Elementary:** Concepts introduced at the elementary level are: heat, electrical energy, light, sound, and magnetic energy are all forms of energy; energy can be transformed. **Middle School:** Concepts of conservation of energy as well as transformation and transfer of energy.	**Future Knowledge** The concepts taught in the Physical Science course will be elaborated on in Physics

Ohio’s New Learning Standards - Clear Learning Targets

PS.FM.1

Force and Motion: Motion
Introduction to one-dimensional vectors, Displacement, Velocity (constant/average/instantaneous), Graphs (position vs. time/velocity vs. time)

Essential Understandings:

- The motion of an object depends on the observer’s frame of reference and is described in terms of distance, position, displacement, speed, velocity, acceleration and time. Position, displacement, velocity, and acceleration are all vector properties (magnitude and direction). All motion is relative to whatever frame of reference is chosen, for there is no motionless frame from which to judge all motion. The relative nature of motion will be addressed conceptually, not mathematically. Non-inertial reference frames are excluded. Motion diagrams can be drawn and interpreted to represent the position and velocity of an object. NOTE: Showing the acceleration on motion diagrams will be reserved for physics.

- The displacement, or change in position of an object is a vector quantity that can be calculated by subtracting the initial position from the final position ($\Delta x = x_f - x_i$). Displacement can be positive or negative depending upon the direction of motion. Displacement is not always equal to the distance travelled. Examples should be given where the distance is not the same as the displacement.

- Velocity is a vector property that represents the rate at which position changes. Average velocity can be calculated by dividing displacement (change in position) by the elapsed time ($v_{avg} = (x_f - x_i)/(t_f - t_i)$). Velocity may be positive or negative depending upon the direction of motion and is not always equal to the speed. Provide examples of when the average speed is not the same as the average velocity. Objects that move with constant velocity have the same displacement for each successive time interval. While speeding up or slowing down and/or changing direction, the velocity of an object changes continuously, from instant to instant. The speed of an object at any instant (clock reading) is called instantaneous speed. An object may not travel at this instantaneous speed for any period of time or cover any distance with that particular speed, especially if the speed is continually changing.

- Acceleration is a vector property that represents the rate at which velocity changes. Average acceleration can be calculated by dividing the change in velocity divided by elapsed time ($a_{avg} = (v_f - v_i)/(t_f - t_i)$). At this grade level, it should be noted that acceleration can be positive or negative, but specifics about what kind of motions produce positive or negative accelerations will be addressed in the physics syllabus. The word “deceleration” should not be used because students tend to associate a negative sign of acceleration only with slowing down. Objects that have no acceleration can either be standing still or be moving with constant velocity (speed and direction). Constant acceleration occurs when the change in an object’s instantaneous velocity is the same for equal successive time intervals.

Vocabulary

Explain Draw Demonstrate
Calculate Interrupt
Understand
Identify
Create
Distance
Position
Displacement
Speed
Time
Velocity
Instantaneous Velocity
Acceleration
Constant Acceleration
Time
Vector Properties
Positive Slope
Negative Slope

- Motion can be represented by position vs. time and velocity vs. time graphs. Specifics about the speed, direction, and change in motion can be determined by interpreting such graphs. For physical science, graphs will be limited to positive x-values and show only uniform motion involving constant velocity or constant acceleration. Motion must be investigated by collecting and analyzing data in the laboratory. Technology can enhance motion exploration and investigation through video analysis, the use of motion detectors, and graphing data for analysis.

- Objects that move with constant velocity and have no acceleration form a straight line (not necessarily horizontal) on a position vs. time graph. Objects that are at rest will form a straight horizontal line on a position vs. time graph. Objects that are accelerating will show a curved line on a position vs. time graph. Velocity can be calculated by determining the slope of a position vs. time graph. Positive slopes on position vs. time graphs indicate motion in a positive direction. Negative slopes on position vs. time graphs indicate motion in a negative direction. While it is important that students can construct graphs by hand, computer graphing programs or graphing calculators can also be used so more time can be spent on graph interpretation and analysis.

- Constant acceleration is represented by a straight line (not necessarily horizontal) on a velocity vs. time graph. Objects that have no acceleration (at rest or moving at constant velocity) will have a straight horizontal line for a velocity vs. time graph. Average acceleration can be by determining the slope of a velocity vs. time graph. The details about motion graphs should not be taught as rules to memorize, but rather as generalizations that can be developed from interpreting the graphs.

<u>Essential Skills:</u>	The students can explain why two different frames of reference would describe motion differently. The students can draw motion diagrams that represent position and velocity of an object (known as a vector). The students can demonstrate that displacement can be calculated via ($\Delta x = x_f - x_i$) and is not always equal to distance traveled. The students can calculate velocity (through experimentation) using the following formula ($v_{avg} = (x_f - x_i)/(t_f - t_i)$). The students can interpret acceleration of an object based on the calculation of velocity for an object at various points. The students can understand that acceleration (calculated ($a_{avg} = (v_f - v_i)/(t_f - t_i)$) can be positive or negative. The students can identify instantaneous velocity at any given point during a speed exploration activity. The students can create a position vs. time graph based on collected data. The students can interpret acceleration of an object on a position vs. time graph by understanding the slope of the line.

Misconceptions

- If the speed is constant, then there is no acceleration.
- High velocities coincide with large accelerations and low velocities coincide with small accelerations.

Instructional Strategies and Resources

- “Forces in 1 Dimension” is an interactive simulation that allows students to explore the forces at work when trying to push a filing cabinet. An applied force is created and the resulting friction force and total force acting on the cabinet are then shown. Forces vs. time, position vs. time, velocity vs. time, and acceleration vs. time graphs can be shown as can force diagrams representing all the forces (including gravitational and normal forces).
- “Motion Diagrams” is a tutorial from Western Kentucky University that shows how to draw motion diagrams for a variety of motions. It includes an animated physlet. Motion diagrams in physical science will only show position and velocity and will not show acceleration.
- The Physics Classroom supports this tutorial on one-dimensional motion that gives a thorough explanation of acceleration, including an animation to use with students who may still be having difficulties with acceleration.

  Modeling workshops are available nationally that help teachers develop a framework for incorporating guided inquiry in their instruction.

Career Connections: http://www.collegexpress.com/interests/science-and-engineering/articles/studying-sciences/science-majors-and-potential-jobs/

Prior Knowledge	Future Knowledge
Elementary School: Force and motion is introduced. **Middle School:** Force and motion is developed further. Speed is dealtwith conceptually, mathematically and graphically. The concept that forces have both magnitude and direction can be represented with a force diagram that forces can be added to find a net force and that forces may affect motion is also addressed.	Showing the acceleration on motion diagrams will be reserved for Physics

Ohio's New Learning Standards - Clear Learning Targets

PS.FM.2

Force and Motion: Forces
Force diagrams, Types of forces (gravity, friction, normal, tension),
Field model for forces at a distance

Essential Understandings:

- Force is a vector quantity, having both magnitude and direction. The (SI) unit of force is a Newton. One Newton of net force will cause a 1 kg object to experience an acceleration of 1 m/s^2. A Newton also can be represented as $kg{\cdot}m/s^2$. The opportunity to measure force in the lab must be provided (e.g., with a spring scale or a force probe). Normal forces and tension forces are introduced conceptually at this level. These forces and other forces are introduced in prior grades (friction, drag, contact, gravitational, electric and magnetic) and can be used as examples of forces that affect motion. Gravitational force (weight) can be calculated from mass, but all other forces will only be quantified from force diagrams that were introduced in middle school. In physical science, only forces in one dimension (positive and negative) will be addressed. The net force can be determined by one-dimensional vector addition. More quantitative study of friction forces, universal gravitational forces, elastic forces and electrical forces will be addressed in the physics syllabus.

- Friction is a force that opposes sliding between two surfaces. For surfaces that are sliding relative to each other, the force on an object always points in a direction opposite to the relative motion of the object. In physical science, friction will only be calculated from force diagrams. Equations for static and kinetic friction are found in the physics syllabus.

- A normal force exists between two solid objects when their surfaces are pressed together due to other forces acting on one or both objects (e.g., a solid sitting on or sliding across a table, a magnet attached to a refrigerator). A normal force is always a push directed at right angles from the surfaces of the interacting objects. A tension force occurs when a non-slack rope, wire, cord or similar device pulls on another object. The tension force always points in the direction of the pull.

- In middle school, the concept of a field as a region of space that surrounds objects with the appropriate property (mass for gravitational fields, charge for electric fields, and a magnetic object for magnetic fields) was introduced to explain gravitational, magnetic and electrical forces that occur over a distance. The field concept is further developed in physical science. The stronger the field, the greater the force exerted on objects placed in the field. The field of an object is always there, even if the object is not interacting with anything else. The gravitational force (weight) of an object is proportional to its mass. Weight, ***Fg,*** can be calculated from the equation $\boldsymbol{F_g} = m\,\boldsymbol{g}$, where ***g*** is the gravitational field strength of an object which is equal to *9.8 N/kg* (m/s^2) on the surface of Earth.

Vocabulary

Demonstrate
Compare
Identify
Draw
Show
Explain
Calculate
Forces
Friction
Drag
Contact
Gravitational
Electric
Magnetic
Normal Force
Newton

Essential Skills:	The students can demonstrate through laboratory exercise that a Newton is a unit of force that can be measured and represented as $kg{\cdot}m/s^2$. The students can compare the magnitude and direction of forces acting on an object in a force diagram The students can identify the normal force in several situations The students can draw tension as a force that acts in the direction of pull when a cord or spring is in contact with an object. The students can show in a diagram that for surfaces sliding relative to each other, the friction force on an object will always point in a direction opposite to the relative motion of that object. The students can explain how magnetic and electric fields that are stronger exert a greater force on an object within the field. The students can identify that a field exists even if it is not exerting a force on another object. The students can calculate weight as the gravitational force on an object using **Fg** = m **g**

Misconceptions

- If the speed is constant, then there is no acceleration.
- High velocities coincide with large accelerations and low velocities coincide with small accelerations.

Instructional Strategies and Resources

- "Forces in 1 Dimension" is an interactive simulation that allows students to explore the forces at work when trying to push a filing cabinet. An applied force is created and the resulting friction force and total force acting on the cabinet are then shown. Forces vs. time, position vs. time, velocity vs. time, and acceleration vs. time graphs can be shown as can force diagrams representing all the forces (including gravitational and normal forces).
- "Motion Diagrams" is a tutorial from Western Kentucky University that shows how to draw motion diagrams for a variety of motions. It includes an animated physlet. Motion diagrams in physical science will only show position and velocity and will not show acceleration.
- The Physics Classroom supports this tutorial on one-dimensional motion that gives a thorough explanation of acceleration, including an animation to use with students who may still be having difficulties with acceleration.

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Prior Knowledge	**Future Knowledge**
Elementary School: Force and motion is introduced. **Middle School:** Force and motion is developed further. Speed is dealt with conceptually, mathematically and graphically. The concept that forces have both magnitude and direction can be represented with a force diagram, that forces can be added to find a net force and that forces may affect motion is also addressed.	Showing the acceleration on motion diagrams will be reserved for Physics

Ohio's New Learning Standards - Clear Learning Targets

PS.FM.3

Force and Motion: Dynamics
Objects at rest, Objects moving with constant velocity, Accelerating objects

Vocabulary

Explain
Define
Determine
Identify
Force
Motion

Essential Understandings:

- An object does not accelerate (remains at rest or maintains a constant speed and direction of motion) unless an unbalanced net force acts on it. The rate at which an object changes its speed or direction (acceleration) is proportional to the vector sum of the applied forces (net force, Fnet) and inversely proportional to the mass ($\boldsymbol{a} = \boldsymbol{F_{net}}/m$). When the vector sum of the forces (net force) acting on an object is zero, the object does not accelerate. For an object that is moving, this means the object will remain moving without changing its speed or direction. For an object that is not moving, the object will continue to remain stationary. These laws will be applied to systems consisting of a single object upon which multiple forces act. Vector addition will be limited to one dimension. While both horizontal and vertical forces can be acting on an object simultaneously, one of the dimensions must have a net force of zero.

- A force is an interaction between two objects. Both objects in the interaction experience an equal amount of force, but in opposite directions. Interacting force pairs are often confused with balanced forces. Interacting force pairs can never cancel each other out because they always act on different objects. Naming the force (e.g., gravity, friction) does not identify the two objects involved in the interacting force pair. Objects involved in an interacting force pair can be easily identified by using the format "A acts on B so B acts on A." For example, the truck hits the sign therefore the sign hits the truck with an equal force in the opposite direction. Earth pulls the book down so the book pulls Earth up with an equal force. The focus of the content is to develop a conceptual understanding of the laws of motion to explain and predict changes in motion, not to name or recite a memorized definition.
  NOTE: In the physics syllabus, all laws will be applied to systems of many objects.

Essential Skills:	The students can explain that an object at rest will stay at rest, and an object in motion will remain in motion until unbalanced forces act on that object. The students can define force as an interaction between two objects. The students can determine if an object will accelerate by examining the magnitude and direction of the forces acting on the object. The students can identify interaction force pairs, i.e. The Force of Object A on B, The Force of Object B on A.

Misconceptions

- If the speed is constant, then there is no acceleration.
- High velocities coincide with large accelerations and low velocities coincide with small accelerations.

Instructional Strategies and Resources

- "Forces in 1 Dimension" is an interactive simulation that allows students to explore the forces at work when trying to push a filing cabinet. An applied force is created and the resulting friction force and total force acting on the cabinet are then shown. Forces vs. time, position vs. time, velocity vs. time, and acceleration vs. time graphs can be shown as can force diagrams representing all the forces (including gravitational and normal forces).
- "Motion Diagrams" is a tutorial from Western Kentucky University that shows how to draw motion diagrams for a variety of motions. It includes an animated physlet. Motion diagrams in physical science will only show position and velocity and will not show acceleration.
- The Physics Classroom supports this tutorial on one-dimensional motion that gives a thorough explanation of acceleration, including an animation to use with students who may still be having difficulties with acceleration.

Modeling workshops are available nationally that help teachers develop a framework for incorporating guided inquiry in their instruction.

Career Connections: http://www.collegexpress.com/interests/science-and-engineering/articles/studying-sciences/science-majors-and-potential-jobs/

Criteria for Success (Performance Level Descriptors)

Limited: Interpret a free-body diagram to identify normal and tension forces; Recall that interactive force pairs are equal in magnitude but act in opposite directions.

Basic: Recall that interactive force pairs can never cancel each other; Interpret a free-body diagram to determine forces, including normal (for surfaces at any angle) and tension forces; For problems involving mass, weight and gravitational field strength, calculate one when given the other two; Calculate distance, displacement, average velocity, and acceleration based on graphical and tabular motion data;

Proficient: Represent, analyze and interpret data from diagrams, graphs, charts, and tables related to position vs. time, velocity vs. time, acceleration, and motion; Calculate force, mass or acceleration using values drawn from tables, graphs and free-body diagrams; Identify or describe interactive force pairs, and compare their magnitudes and directions.

Accelerated: In a real-world scenario, construct a free-body diagram using information from motion vs. time graphs (or vice versa); Given a real-world context, interpret position vs. time, velocity vs. time and/or motion data to create a scenario that describes possible forces responsible for the motion (or vice versa).

Advanced: Design or critique solutions to engineering problems involving forces and motion; Design an experiment to measure the velocity of objects in a real-world scenario; Design an experiment using dynamics to determine a specific force in a given system of forces (e.g., friction force from spring scale).

Prior Knowledge	**Future Knowledge**
Elementary School: Force and motion is introduced. **Middle School:** Force and motion is developed further. Speed is dealt with conceptually, mathematically and graphically. The concept that forces have both magnitude and direction can be represented with a force diagram, that forces can be	Showing the acceleration on motion diagrams will be reserved for Physics.

added to find a net force and that forces may affect motion is also addressed.	

Ohio's New Learning Standards - Clear Learning Targets

PS.U.1

The Universe:
History of the Universe

Vocabulary

Recognized
Describe
Big Bang Model
Visual telescope
Radio telescope
X-ray telescope
Electromagnetic Spectrum

Essential Understandings:

- The Big Bang Model is a broadly accepted theory for the origin and evolution of our universe. It postulates that 12 to 14 billion years ago, the portion of the universe seen today was only a few millimeters across (NASA).
- According to the "big bang" theory the contents of the known universe expanded explosively into existence from a hot, dense state 13.7 billion years ago (NAEP 2009). After the big bang, the universe expanded quickly (and continues to expand) and then cooled down enough for atoms to form. Gravity pulled the atoms together into gas clouds that eventually became stars, which comprise young galaxies. Foundations for the big bang model can be included to introduce the supporting evidence for the expansion of the known universe (for example, Hubble's Law and red shift, or cosmic microwave background radiation). A discussion of Hubble's Law and red shift is found in the *Galaxy formation* section, below.
- Technology provides the basis for many new discoveries related to space and the universe. Visual, radio, and x-ray telescopes collect information from across the entire electromagnetic spectrum; computers are used to manage data and complicated computations; space probes send back data and materials from remote parts of the solar system; and accelerators provide subatomic particles energies that simulate conditions in the stars and in the early history of the universe before stars formed.

Essential Skills:	
	The students can know the age of the universe to be 13.7 billion years old. The students can list 3 evidences for the big bang. The students can recognize that the Big Bang Model is broadly accepted for explaining how the Universe began. The students can state Hubble's Law and how it provides evidence for the Big Bang. The students can provide evidence through technology that the universe is still expanding (x-ray, radio telescope, and computers) that use the electromagnetic spectrum. The students can describe how particle accelerators are used to create energies in the early universe and how they are used to make inferences on the big bang and the interior of stars.

Misconceptions

- NASA provides general student misconceptions pertaining to the universe and the big bang theory.
- Students' understanding of the magnitude of the universe needs to developed where they can make sense of how large is a billion or a million. Keely, Eberle & Tugel (2005) suggests teaching the notion of scale with familiar objects that students can see, like the moon and sun. Gradually introduce the nearby planets and then planets further away.(p.182)

Instructional Strategies and Resources

- A collection of videos is provided by NASA about the James Webb Telescope – the largest space-based observatory ever built to date. From galaxy evolution to planetary formation, the Webb telescope will equip scientists to see far beyond previous endeavors.
- Investigate the star life cycle with interactive media or gain an overview of astronomical spectroscopy in studies of stellar spectra.
- It is important to keep the evidence supporting the big bang model at the grade 9-10 level. Students should understand where the evidence for the theory is found and the importance of data that support the expansion of the universe. This article provides a higher level of detail than is required for this course, but sections of the article are helpful and appropriate in understanding the foundational support.
- NASA provides science modules to support teaching about red shift and Doppler effects from a cosmology viewpoint. There also are NASA documents that can assist in teaching about stellar evolution.
- Use an interactive HR Diagram to explore different patterns that can exist on the chart and the evolution of specific types of stars.
- Astronomy: Eliciting Student Ideas is a workshop produced by Annenberg that uses constructivism by examining student beliefs on what causes the seasons and their explanations for the phases of the moon that are explored in the video-on-demand "A Private Universe."
- Dying stars and Birth of Elements is a computer-based exercise where high school students analyze realistically simulated X-ray spectra of a supernova remnant and determine the abundances of various elements in them. In the end, they will find that the elements necessary for life on Earth – the iron in their blood, the calcium in their bones – are created in these distant explosions.
- "A Star is Born... but How?" and "Stars" are two tutorials on the Windows to the Universe from the National Earth Science Teachers Association that give details about star formation.
- Exploring Mars is a video produced by Annenberg that shows students in a grade 11 integrated science class who explore how the Mars landscape may have formed.

Career Connections: http://www.collegexpress.com/interests/science-and-engineering/articles/studying-sciences/science-majors-and-potential-jobs/

Prior Knowledge	Future Knowledge
Elementary School: Observations of the sky and space are the foundation for developing a deeper knowledge of the solar system. In late elementary school, the parts of the solar system are introduced, including characteristics of the sun and planets, orbits, and celestial bodies. **Middle School:** Energy, waves, gravity and density are emphasized in the physical sciences and characteristics and patterns within the solar system are found.	No further information on the universe will be taught

Ohio's New Learning Standards - Clear Learning Targets

<table>
<tr><td colspan="2">PS.U.2

The Universe:
Galaxies</td><td rowspan="2"><u>Vocabulary/</u>

Explain
Classify
Describe
Provide
Galaxy
Spiral Galaxy
Red Shift
Milky Way
Hubble Law</td></tr>
<tr><td colspan="2"><u>Essential Understandings:</u>
A galaxy is a group of billions of individual stars, star systems, star clusters, dust, and gas bound together by gravity. There are billions of galaxies in the universe, and they are classified by size and shape. The Milky Way is a spiral galaxy. It has more than 100 billion stars and a diameter of more than 100,000 light years. At the center of the Milky Way is a bulge of stars, from which are spiral arms of gas, dust, and most of the young stars. The solar system is part of the Milky Way galaxy.
Hubble's Law states that galaxies that are farther away have a greater red shift, so the speed at which a galaxy is moving away is proportional to its distance from the Earth. Red shift is a phenomenon due to Doppler shifting, so the shift of light from a galaxy to the red end of the spectrum indicates that the galaxy and the observer are moving farther away from one another. Doppler shifting is also found in the Energy and Waves section of this course.</td></tr>
<tr><td><u>Essential Skills:</u></td><td colspan="2">The students can explain the formation of stars from clouds as gravity continued to pull in additional matter.
The students can classify a galaxy by shape and size
The students can describe what makes up a galaxy, held together by gravity.
The students can provide evidence through technology that the universe is still expanding (x-ray, radio telescope, and computers) that use the electromagnetic spectrum.</td></tr>
<tr><td colspan="3">Misconceptions
NASA provides general student misconceptions pertaining to the universe and the big bang theory.
Students' understanding of the magnitude of the universe needs to developed where they can make sense of how large is a billion or a million. Keely, Eberle & Tugel (2005) suggests teaching the notion of scale with familiar objects that students can see, like the moon and sun. Gradually introduce the nearby planets and then planets further away.(p.182)</td></tr>
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Instructional Strategies and Resources

- A collection of videos is provided by NASA about the James Webb Telescope – the largest space-based observatory ever built to date. From galaxy evolution to planetary formation, the Webb telescope will equip scientists to see far beyond previous endeavors.
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Career Connections: http://www.collegexpress.com/interests/science-and-engineering/articles/studying-sciences/science-majors-and-potential-jobs/

Prior Knowledge	**Future Knowledge**
Elementary School: Observations of the sky and space are the foundation for developing a deeper knowledge of the solar system. In late elementary school, the parts of the solar system are introduced, including characteristics of the sun and planets, orbits, and celestial bodies. **Middle School:** Energy, waves, gravity and density are emphasized in the physical sciences and characteristics and patterns within the solar system are found.	No further information on the universe will be taught

Ohio's New Learning Standards - Clear Learning Targets

PS.U.3	**The Universe: Stars** **Formation: Stages of evolution, Fusion in stars**	**Vocabulary**

Essential Understandings:

- Early in the formation of the universe, stars coalesced out of clouds of hydrogen and helium and clumped together by gravitational attraction into galaxies. When heated to a sufficiently high temperature by gravitational attraction, stars begin nuclear reactions, which convert matter to energy and fuse the lighter elements into heavier ones. These and other fusion processes in stars have led to the formation of all the other elements. (NAEP 2009). All of the elements, except for hydrogen and helium, originated from the nuclear fusion reactions of stars (College Board Standards for College Success, 2009).
- Stars are classified by their color, size, luminosity and mass. A Hertzprung-Russell diagram must be used to estimate the sizes of stars and predict how stars will evolve. Most stars fall on the main sequence of the H-R diagram, a diagonal band running from the bright hot stars on the upper left to the dim cool stars on the lower right. A star's mass determines the star's place on the main sequence and how long it will stay there. Patterns of stellar evolution are based on the mass of the star. Stars begin to collapse as the core energy dissipates. Nuclear reactions outside the core cause expansion of the star, eventually leading to the collapse of the star. **NOTE: Names of stars and naming the evolutionary stage of a star from memory will not be assessed. The emphasis is on the interpretation of data (using diagrams and charts) and the criteria and processes needed to make those determinations.**

Vocabulary

Describe
Classify
Understand
Explain
Predict
Explain
Hertzprung-Russell Diagram
Red Shift
Fusion
Luminosity

Essential Skills:	
	The students can describe how lighter elements are fused into heavier ones in stars The students can classify a star on the basis of mass, color, size, and luminosity The students can understand how to read a Hertzprung-Russell (H-R) diagram The students can explain why the Sun is considered a main sequence star based on its location on the H-R Diagram. The students can predict how a star will evolve. The students can explain how and when stars collapse

Misconceptions

- NASA provides general student misconceptions pertaining to the universe and the big bang theory.
- Students' understanding of the magnitude of the universe needs to developed where they can make sense of how large is a billion or a million. Keely, Eberle & Tugel (2005) suggests teaching the notion of scale with familiar objects that students can see, like the moon and sun. Gradually introduce the nearby planets and then planets further away.(p.182)

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- Astronomy: Eliciting Student Ideas is a workshop produced by Annenberg that uses constructivism by examining student beliefs on what causes the seasons and their explanations for the phases of the moon that are explored in the video-on-demand "A Private Universe."
- The Quantum Mechanical Universe is a video produced by Annenberg about a current look at where we have been and a peek into the future.
- Dying stars and Birth of Elements is a computer-based exercise where high school students analyze realistically simulated X-ray spectra of a supernova remnant and determine the abundances of various elements in them. In the end, they will find that the elements necessary for life on Earth – the iron in their blood, the calcium in their bones – are created in these distant explosions.
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Criteria for Success (Performance Level Descriptors)

Limited: Recognize that the universe is expanding; Recognize that galaxies moving away from Earth have an observed redshift; Recall that fusion occurs in stars; Recall that the Hertzsprung-Russell (HR) diagram provides information about stars.
Basic: Identify information provided by a Hertzsprung-Russell diagram; Recall a major difference between nuclear fission and fusion.
Proficient: Explain how redshift provides information about the distances of galaxies and how this can be used as evidence for the Big Bang model of the universe; Interpret a Hertzsprung-Russell diagram in terms of mass, luminosity, temperature, and evolutionary stages of the main sequence stars; Explain the role of fusion in stars in the formation of elements.
Accelerated: Compare and interpret spectroscopic data indicating the Doppler shift of various galaxies to determine relative motion and distances.
Advanced: Relate red and blue shift to relative galaxy motion and distance by constructing a shifted spectrum.

Prior Knowledge	Future Knowledge
Elementary School: Observations of the sky and space are the foundation for developing a deeper knowledge of the solar system. In late elementary school, the parts of the solar system are introduced,	No further information on the universe will be taught

including characteristics of the sun and planets, orbits, and celestial bodies. **Middle School:** Energy, waves, gravity and density are emphasized in the physical sciences and characteristics and patterns within the solar system are found.	

Common Core Standards for Literacy in Science – Reading Standards 9-10

Key Ideas and Details:
CCSS.ELA-LITERACY.RST.9-10.1
Cite specific textual evidence to support analysis of science and technical texts, attending to the precise details of explanations or descriptions.
CCSS.ELA-LITERACY.RST.9-10.2
Determine the central ideas or conclusions of a text; trace the text's explanation or depiction of a complex process, phenomenon, or concept; provide an accurate summary of the text.
CCSS.ELA-LITERACY.RST.9-10.3
Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks, attending to special cases or exceptions defined in the text.

Craft and Structure:
CCSS.ELA-LITERACY.RST.9-10.4
Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to *grades 9-10 texts and topics*.
CCSS.ELA-LITERACY.RST.9-10.5
Analyze the structure of the relationships among concepts in a text, including relationships among key terms (e.g., *force, friction, reaction force, energy*).
CCSS.ELA-LITERACY.RST.9-10.6
Analyze the author's purpose in providing an explanation, describing a procedure, or discussing an experiment in a text, defining the question the author seeks to address.

Integration of Knowledge and Ideas:
CCSS.ELA-LITERACY.RST.9-10.7
Translate quantitative or technical information expressed in words in a text into visual form (e.g., a table or chart) and translate information expressed visually or mathematically (e.g., in an equation) into words.
CCSS.ELA-LITERACY.RST.9-10.8
Assess the extent to which the reasoning and evidence in a text support the author's claim or a recommendation for solving a scientific or technical problem.
CCSS.ELA-LITERACY.RST.9-10.9
Compare and contrast findings presented in a text to those from other sources (including their own experiments), noting when the findings support or contradict previous explanations or accounts.

Range of Reading and Level of Text Complexity:
CCSS.ELA-LITERACY.RST.9-10.10
By the end of grade 10, read and comprehend science/technical texts in the grades 9-10 text complexity band independently and proficiently.

Common Core Standards for Literacy in Science – Writing Standards 9-10

Text Types and Purposes:

CCSS.ELA-LITERACY.WHST.9-10.1
Write arguments focused on *discipline-specific content*.
CCSS.ELA-LITERACY.WHST.9-10.1.A
Introduce precise claim(s), distinguish the claim(s) from alternate or opposing claims, and create an organization that establishes clear relationships among the claim(s), counterclaims, reasons, and evidence.
CCSS.ELA-LITERACY.WHST.9-10.1.B
Develop claim(s) and counterclaims fairly, supplying data and evidence for each while pointing out the strengths and limitations of both claim(s) and counterclaims in a discipline-appropriate form and in a manner that anticipates the audience's knowledge level and concerns.
CCSS.ELA-LITERACY.WHST.9-10.1.C
Use words, phrases, and clauses to link the major sections of the text, create cohesion, and clarify the relationships between claim(s) and reasons, between reasons and evidence, and between claim(s) and counterclaims.
CCSS.ELA-LITERACY.WHST.9-10.1.D
Establish and maintain a formal style and objective tone while attending to the norms and conventions of the discipline in which they are writing.
CCSS.ELA-LITERACY.WHST.9-10.1.E
Provide a concluding statement or section that follows from or supports the argument presented.
CCSS.ELA-LITERACY.WHST.9-10.2
Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes.
CCSS.ELA-LITERACY.WHST.9-10.2.A
Introduce a topic and organize ideas, concepts, and information to make important connections and distinctions; include formatting (e.g., headings), graphics (e.g., figures, tables), and multimedia when useful to aiding comprehension.
CCSS.ELA-LITERACY.WHST.9-10.2.B
Develop the topic with well-chosen, relevant, and sufficient facts, extended definitions, concrete details, quotations, or other information and examples appropriate to the audience's knowledge of the topic.
CCSS.ELA-LITERACY.WHST.9-10.2.C
Use varied transitions and sentence structures to link the major sections of the text, create cohesion, and clarify the relationships among ideas and concepts.
CCSS.ELA-LITERACY.WHST.9-10.2.D
Use precise language and domain-specific vocabulary to manage the complexity of the topic and convey a style appropriate to the discipline and context as well as to the expertise of likely readers.
CCSS.ELA-LITERACY.WHST.9-10.2.E
Establish and maintain a formal style and objective tone while attending to the norms and conventions of the discipline in which they are writing.
CCSS.ELA-LITERACY.WHST.9-10.2.F
Provide a concluding statement or section that follows from and supports the information or explanation presented (e.g., articulating implications or the significance of the topic).
CCSS.ELA-LITERACY.WHST.9-10.3
(See note; not applicable as a separate requirement)

Production and Distribution of Writing:

CCSS.ELA-LITERACY.WHST.9-10.4
Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.

CCSS.ELA-LITERACY.WHST.9-10.5
Develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach, focusing on addressing what is most significant for a specific purpose and audience.
CCSS.ELA-LITERACY.WHST.9-10.6
Use technology, including the Internet, to produce, publish, and update individual or shared writing products, taking advantage of technology's capacity to link to other information and to display information flexibly and dynamically.

Research to Build and Present Knowledge:
CCSS.ELA-LITERACY.WHST.9-10.7
Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.
CCSS.ELA-LITERACY.WHST.9-10.8
Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the usefulness of each source in answering the research question; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and following a standard format for citation.
CCSS.ELA-LITERACY.WHST.9-10.9
Draw evidence from informational texts to support analysis, reflection, and research.

Range of Writing:
CCSS.ELA-LITERACY.WHST.9-10.10
Write routinely over extended time frames (time for reflection and revision) and shorter time frames (a single sitting or a day or two) for a range of discipline-specific tasks, purposes, and audiences.