PUBLIC SCHOOLS OF EDISON TOWNSHIP

OFFICE OF CURRICULUM AND INSTRUCTION

Science Grade 8

Length of Course:	Term
Elective/Required:	Required
Schools:	Middle Schools
Eligibility:	Grade 8
Credit Value:	N/A
Date Approved:	August 23, 2022

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Modifications will be made to accommodate IEP mandates for classified students

Statement of Purpose

In July 2011, the National Research Council (NRC) of the National Academy of Sciences developed *A Framework for K-12 Science Education*. This guidance provides a sound, evidence-based foundation for standards by drawing on current scientific research - including research on the methods in which students learn science effectively - and identifies the science all students in grade K-12 should know.
The NRC's Framework describes a vision of what it means to be proficient in science; it rests on a view of science as both a body of knowledge and an evidence-based, model and theory building enterprise that continually extends, refines, and revises understanding. It presents three dimensions that will be combined to form each standard:

Dimension 1: Practices
Practices describe behaviors that scientists engage in as they investigate and build models and theories about the natural world. They also include the key set of engineering practices that engineers use as they design and build models and systems. The NRC uses the term "practices" instead of a term like "skills" to emphasize that engaging in scientific investigation requires not only skill but also knowledge that is specific to each practice. Part of the NRC's intent is to better explain and extend what is meant by "inquiry" in science and the range of cognitive, social, and physical practices that it requires.

Although engineering design is similar to scientific inquiry, there are significant differences. For example, scientific inquiry involves the formulation of a question that can be answered through an investigation, while engineering design involves the formulation of a problem that can be solved through design. Emphasizing the engineering aspects of the Next Generation Science Standards will clarify for students the relevance of science, technology, engineering, and mathematics to everyday life.

Dimension 2: Cross Cutting Concepts
The Cross Cutting Concepts have application across all domains of science and, as such, are a way of linking different domains together. They include:

- Patterns, similarity, and diversity;
- Cause and effect;
- Scale, proportion, and quantity;
- Systems and system models;
- Energy and matter;
- Structure and function; and
- Stability and change.

The Framework emphasizes that these concepts need to be made explicit for students because they provide an organizational schema for inter-relating knowledge from various science fields into a coherent and scientifically-based view of the world.

Dimension 3: Disciplinary Core Ideas

Disciplinary Core Ideas have the power to focus K-12 science curriculum, instruction, and assessment on the most important aspects of science. To be considered core, the ideas meet at least two of the following criteria (and, ideally, all four):

- Have broad importance across multiple sciences or engineering disciplines, or be a key organizing concept of a single discipline;
- Provide a key tool for understanding or investigating more complex ideas and solving problems;
- Relate to the interests and life experiences of students or be connected to societal or personal concerns that require scientific or technological knowledge; and/or
- Be teachable and learnable over multiple grades at increasing levels of depth and sophistication.

Disciplinary Core Ideas are grouped in four domains: the physical sciences, the life sciences, the earth and space sciences; and engineering, technology, and applications of science. Adopted by the State Board of Education in 2014, as the Next Generation Science Standards, they were renamed as the New Jersey Student Learning Standards for Science (NJSLS-S) in May 2016.

The goal of the 8th grade Science curriculum is to produce students who have gained sufficient knowledge of the practices, crosscutting concepts, and core ideas of science and engineering to engage in public discussions on science-related issues, to be critical consumers of scientific information related to their everyday lives, and to continue to learn about science throughout their lives. Students will be exposed to a “3D” approach to learning which intertwines the cross cutting concepts, scientific practices and disciplinary core ideas.

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Course Objectives

The student will be able to:

- NJSLS/MS-PS2-1: Apply Newton's Third Law to design a solution to a problem involving the motion of two colliding objects
- NJSLS/MS-PS2-2: Plan an investigation to provide evidence that the change in an object's motion depends on the sum of the forces on the object and the mass of the object.
- NJSLS/MS-PS2-3: Ask questions about data to determine the factors that affect the strength of electric and magnetic forces.
- NJSLS/MS-PS2-4: Construct and present arguments using evidence to support the claim that gravitational interactions are attractive and depend on the masses of interacting objects.
- NJSLS/MS-PS2-5: Conduct an investigation and evaluate the experimental design to provide evidence that fields exist between objects exerting forces on each other even though the objects are not in contact.
- NJSLS/MS-PS1-1: Develop models to describe the atomic composition of simple molecules and extended structures.
- NJSLS/MS-PS1-2: Analyze and interpret data on the properties of substances before and after the substances interact to determine if a chemical reaction has occurred.
- NJSLS/MS-PS1-3: Gather and make sense of information to describe that synthetic materials come from natural resources and impact society.
- NJSLS/MS-PS1-4: Develop a model that predicts and describes changes in particle motion, temperature, and state of a pure substance when thermal energy is added or removed.
- NJSLS/MS-PS1-5: Develop and use a model to describe how the total number of atoms does not change in a chemical reaction and thus mass is conserved.
- NJSLS/MS-PS1-6: Undertake a design project to construct, test, and modify a device that either releases or absorbs thermal energy by chemical processes.
- NJSLS/MS-PS3-1: Construct and interpret graphical displays of data to describe the relationships of kinetic energy to the mass of an object and to the speed of an object.
- NJSLS/MS-PS3-2: Develop a model to describe that when the arrangement of objects interacting at a distance changes, different amounts of potential energy are stored in the system.
- NJSLS/MS-PS3-3: Apply scientific principles to design, construct, and test a device that either minimizes or maximizes thermal energy transfer.
- NJSLS/MS-PS3-4: Plan an investigation to determine the relationships among the energy transferred, the type of matter, the mass, and the change in the

average kinetic energy of the particles as measured by the temperature of the sample.

- NJSLS/MS-PS3-5: Construct, use, and present arguments to support the claim that when the kinetic energy of an object changes, energy is transferred to or from the object.
- NJSLS/MS-PS4-1: Use mathematical representations to describe a simple model for waves that includes how the amplitude of a wave is related to the energy in a wave.
- NJSLS/MS-PS4-2: Develop and use a model to describe that waves are reflected, absorbed, or transmitted through various materials.
- NJSLS/MS-PS4-3: Integrate qualitative scientific and technical information to support the claim that digitized signals are a more reliable way to encode and transmit information than analog signals.
- NJSLS/ETS1-1: Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.
- NJSLS/ETS1-2: Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.
- NJSLS/ETS1-3: Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success.
- NJSLS/ETS1-4: Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved

Timeline

First Marking Period Units:

Unit 1: Structure and Properties of Matter

Unit 2: Changes in Matter

Second Marking Period Units:

Unit 3: Chemical Reactions

Unit 4: Forces and Motion

Third Marking Period Units

Unit 5: Types of Forces

Unit 6: Forms of Energy

Fourth Marking Period Units

Unit 7: Thermal Energy

Unit 8: Energy and Waves

Grade 8 Unit 1: Structure and Properties of Matter **Approximate Instructional Days: 20**

Unit Summary
Essential Questions: How is it that everything is made of stardust? Students build understandings of what occurs at the atomic and molecular scale. Students apply their understanding that pure substances have characteristic properties and are made from a single type of atom or molecule. They also provide molecular level accounts to explain states of matter and changes between states. The crosscutting concepts of *cause and effect*, *scale, proportion and quantity*, *structure and function*, *interdependence of science, engineering, and technology*, and *the influence of science, engineering and technology on society and the natural world* provide a framework for understanding the disciplinary core ideas. Students demonstrate grade appropriate proficiency in *developing and using models*, and *obtaining, evaluating, and communicating information*. Students are also expected to use the scientific and engineering practices to demonstrate an understanding of the core ideas.
Student Learning Objectives
Develop models to describe the atomic composition of simple molecules and extended structures. ***[Clarification Statement: Emphasis is on developing models of molecules that vary in complexity. Examples of simple molecules could include ammonia and methanol. Examples of extended structures could include sodium chloride or diamonds. Examples of molecular-level models could include drawings, 3D ball and stick structures, or computer representations showing different molecules with different types of atoms. The substructure of atoms and the periodic table are learned in high school chemistry.] [Assessment Boundary: Assessment does not include valence electrons and bonding energy, discussing the ionic nature of subunits of complex structures, or a complete depiction of all individual atoms in a complex molecule or extended structure.]*** **(MS-PS1-1)**
Analyze and interpret data on the properties of substances before and after the substances interact to determine if a chemical reaction has occurred. ***[Clarification Statement: Examples of reactions could include burning sugar or steel wool, fat reacting with sodium hydroxide, and mixing zinc with hydrogen chloride.] [Assessment Boundary: Assessment is limited to analysis of the following properties: density, melting point, boiling point, solubility, flammability, and odor.]*** **(MS-PS1-2)**
Possible Student Misconceptions (based on research):
Middle school students may think everything that exists is matter, including heat, light, and electricity. Alternatively, they may believe that matter does not include liquids and gasses or that they are weightless materials. With specially designed instruction, some middle school students can learn the scientific notion of matter. Middle-school and high-school students are deeply committed to a theory of continuous matter. Although some students may think that substances can be divided up into small particles, they do not recognize the particles as building blocks, but as formed as basically continuous substances under certain conditions. Students at the beginning of middle school may be at different points in their conceptualization of a "theory" of matter. Although some 5th graders may start seeing weight as a fundamental property of all matter, many students in 6th and 7th grade still appear to think of weight simply as "felt weight" -- something whose weight they can't feel is considered to have no weight at all. Accordingly, some students believe that if one keeps dividing a piece of Styrofoam, one would soon obtain a piece that weighed nothing. Students of all ages show a wide range of beliefs about the nature and behavior of particles. They lack an appreciation of the very small size of particles; attribute macroscopic properties to particles; believe there must be something in the space between particles; have difficulty in appreciating the intrinsic motion of particles in solids, liquids and gasses; and have problems in conceptualizing forces between particles. Despite these difficulties, there is some evidence that carefully designed instruction carried out over a long period of time may help middle-school students develop correct ideas about particles (NSDL, 2015).
Unit Sequence

Part A - Essential Question: ***What is the universe made of?***

Concepts/ Enduring Understanding

- Substances are made from different types of atoms.
- Atoms are the basic units of matter.
- Substances combine with one another in various ways.
- Molecules are two or more atoms joined together.
- Atoms form molecules that range in size from two to thousands of atoms.
- Molecules can be simple or very complex.
- Solids may be formed from molecules, or they may be extended structures with repeating subunits (e.g., crystals).

Formative Assessment

Students who understand the concepts are able to:

- Develop a model of a simple molecule.
- Use the model of the simple molecule to describe its atomic composition.
- Develop a model of an extended structure.
- Use the model of the extended structure to describe its repeating subunits.

Recommended Activities/ Assessments

- Brief introduction to parts of an atom and periodic table basics.
- Activities to identify the types and number of atoms in the given molecule
- Introduction to models
- Make molecular level models (3D ball and stick structures, drawings showing different molecules with different types of atoms)
- Activities to identify the types and number of atoms in the given molecule
- District Unit 1 Common Assessment

Resources

- McGraw Hill iScience Textbook- Chapter 9 Lesson 1 (pages 315-316, 320-321)
- McGraw Hill iScience Textbook- Chapter 10 Lesson 1 (pages 348-349)
- McGraw Hill iScience Textbook- Chapter 11 Lesson 2 (pages 390-394)
- McGraw Hill iScience Textbook- Chapter 12 Lesson 1 (pages 422-423, 425-426)
- Discovery Ed Techbook - Structure and Properties of Matter (1.4)

Part B - Essential Question: ***Is it possible to tell if two substances physically mixed or if they are chemically combined with each other?***

Concepts/ Enduring Understanding

- Each pure substance has characteristic physical and chemical properties (for any bulk quantity under given conditions) that can be used to identify it.
- Physical properties can be measured or observed without changing the matter into something else.
- Chemical properties describe the ability of matter to react or combine with other matter to form a new substance.
- Substances react chemically in characteristic ways.
- In a chemical process, the atoms that make up the original substances are regrouped into different molecules; these new substances have different properties from those of the reactants.
- The analysis of data on the properties of products and reactants can be used to determine whether a chemical process has occurred.
- Density, melting point, boiling point, solubility, flammability, and odor are characteristic properties that can be used to identify a pure substance.
- Macroscopic patterns are related to the nature of the atomic-level structure of a substance.

Note: Emphasis on chemical and physical properties, not details about types of chemical reactions.

Formative Assessment

Students who understand the concepts are able to:

- Analyze and interpret data to determine the properties of matter, and whether they are physical or chemical properties.
- Organize given data about the characteristic physical and chemical properties (e.g., density, melting point, boiling point, solubility, flammability, odor) of pure substances before and after they interact.
- Analyze the data to identify patterns (i.e., similarities and differences), including the changes in physical and chemical properties of each substance before and after the interaction (e.g., before the interaction, a substance burns, while after the interaction, the resulting substance does not burn).
- Support their interpretation of the data by describing that the change in the properties of substances is related to the rearrangement of atoms in the reactants and products in a chemical reaction (e.g., when a reaction has occurred, atoms from the substances present before the interaction must have been rearranged into new configurations, resulting in the properties of new substances).

Recommended Activities/Assessments

- Data analysis activity to identify patterns (physical and chemical properties)
- District MP 1 Benchmark Assessment

Resources

- McGraw Hill iScience Textbook- Chapter 7 Lesson 2 & 4 (pages 239-245, 256-259)
- McGraw Hill iScience Textbook- Chapter 12 Lesson 1 (pages 418-421, 424-426)
- McGraw Hill iScience Textbook- Chapter 13 Lesson 1 (pages 452-457)

• Discovery Education- Structure and Properties of Matter (1.4)
Common Core Standards Alignment

ELA/Literacy	Mathematics	Technology	Career Ready Practice
Cite specific textual evidence to support analysis of science and technical texts, attending to the precise details of explanations or descriptions.(MS-PS1-2) **RST.6-8.1** Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table). (MS-PS1-1),(MS-PS1-2) **RST.6-8.7**	Reason abstractly and quantitatively. (MS-PS1-1),(MS-PS1-2) **MP.2** Model with mathematics. (MS-PS1-1) **MP.4** Use ratio and rate reasoning to solve real-world and mathematical problems. (MS-PS1-1),(MS-PS1-2) **6.RP.A.3** Use numbers expressed in the form of a single digit times an integer power of 10 to estimate very large or very small quantities, and to express how many times as much one is than the other. (MS-PS1-1) **8.EE.A.3** Display numerical data in plots on a number line, including dot plots, histograms, and box plots. (MS-PS1-2) **6.SP.B.4** Summarize numerical data sets in relation to their context. (MS-PS1-2) **6.SP.B.5**	8.1.8.A.1 Demonstrate knowledge of a real world problem using digital tools	CRP8. Utilize critical thinking to make sense of problems and persevere in solving them.

Next Generation Science Standards and Foundations for the Unit **The performance expectations above were developed using the following elements from A Framework for K-12 Science Education:**		
Science and Engineering Practices	**Disciplinary Core Ideas**	**Crosscutting Concepts**

Developing and Using Models · Develop a model to predict and/or describe phenomena. (MS-PS1-1) **Analyzing and Interpreting Data** · Analyze and interpret data to determine similarities and differences in findings. (MS-PS1-2)	**PS1.A: Structure and Properties of Matter** · Substances are made from different types of atoms, which combine with one another in various ways. Atoms form molecules that range in size from two to thousands of atoms. (MS-PS1-1) · Solids may be formed from molecules, or they may be extended structures with repeating subunits (e.g., crystals). (MS-PS1-1) · Each pure substance has characteristic physical and chemical properties (for any bulk quantity under given conditions) that can be used to identify it. (MS-PS1-2) **PS1.B: Chemical Reactions** ● Substances react chemically in characteristic ways. In a chemical process, the atoms that make up the original substances are regrouped into different molecules, and these new substances have different properties from those of the reactants. (MS-PS1-2)	**Scale, Proportion, and Quantity** · Time, space, and energy phenomena can be observed at various scales using models to study systems that are too large or too small. (MS-PS1-1) **Patterns** · Macroscopic patterns are related to the nature of microscopic and atomic-level structure. (MS-PS1-2) - ***Connections to Nature of Science*** **Scientific Knowledge is Based on Empirical Evidence** · Science knowledge is based upon logical and conceptual connections between evidence and explanations. (MS-PS1-2)

Grade 8 Unit 2: Changes in Matter **Approximate Instructional Days: 20**

Unit Summary
Essential Questions: How can one explain the structure, properties, and interactions of matter? Students build understandings of what occurs at the atomic and molecular scale. Students apply their understanding that pure substances have characteristic properties and are made from a single type of atom or molecule. They also provide a molecular level accounts to explain states of matter and changes between states. The crosscutting concepts of *cause and effect*, *scale, proportion and quantity*, *structure and function*, *interdependence of science, engineering, and technology*, and *the influence of science, engineering and technology on society and the natural world* provide a framework for understanding the disciplinary core ideas. Students demonstrate grade appropriate proficiency in *developing and using models*, and *obtaining, evaluating, and communicating information*. Students are also expected to use the scientific and engineering practices to demonstrate an understanding of the core ideas.
Student Learning Objectives
Gather and make sense of information to describe that synthetic materials come from natural resources and impact society. ***[Clarification Statement: Emphasis is on natural resources that undergo a chemical process to form the synthetic material. Examples of new materials could include new medicines, foods, and alternative fuels.] [Assessment Boundary: Assessment is limited to qualitative information.]*** **(MS-PS1-3)**
Develop a model that predicts and describes changes in particle motion, temperature, and state of a pure substance when thermal energy is added or removed. ***[Clarification Statement: Emphasis is on qualitative molecular-level models of solids, liquids, and gasses to show that adding or removing thermal energy increases or decreases kinetic energy of the particles until a change of state occurs. Examples of models could include drawings and diagrams. Examples of particles could include molecules or inert atoms. Examples of pure substances could include water, carbon dioxide, and helium.]*** **(MS-PS1-4)**
Possible Student Misconceptions (based on research):
Students may think everything that exists is matter, including heat, light, and electricity. Alternatively, they may believe that matter does not include liquids and gasses or they are weightless materials. With specially designed instruction, some middle school students can learn the scientific notion of matter. Students are deeply committed to a theory of continuous matter. Although some students may think that substances can be divided up into small particles, they do not recognize the particles as building blocks, but as formed as basically continuous substances under certain conditions. Students at the beginning of middle school may be at different points in their conceptualization of a "theory" of matter. Although some 5th graders may start seeing weight as a fundamental property of all matter, many students in 6th and 7th grade still appear to think of weight simply as "felt weight" -- something whose weight they can't feel is considered to have no weight at all. Accordingly, some students believe that if one keeps dividing a piece of Styrofoam, one would soon obtain a piece that weighed nothing. Students of all ages show a wide range of beliefs about the nature and behavior of particles. They lack an appreciation of the very small size of particles; attribute macroscopic properties to particles; believe there must be something in the space between particles; have difficulty in appreciating the intrinsic motion of particles in solids, liquids and gasses; and have problems in conceptualizing forces between particles. Despite these difficulties, there is some evidence that carefully designed instruction carried out over a long period of time may help middle-school students develop correct ideas about particles (NSDL, 2015).
Unit Sequence

Part A - Essential Question: ***How can you tell what the molecules are doing in a substance?***

Concepts/ Enduring Understanding

- Changes in particle motion, temperature, and state of a pure substance occurs when thermal energy is added or removed.
- Qualitative molecular-level models of solids, liquids, and gasses can be used to show that adding or removing thermal energy increases or decreases the kinetic energy of the particles until a change of state occurs.
- Gasses and liquids are made of molecules or inert atoms that are moving about relative to each other.
- In a liquid, the molecules are constantly in contact with others.
- In a gas, the molecules are widely spaced except when they happen to collide.
- In a solid, atoms are closely spaced and may vibrate in position but do not change relative locations.
- The changes of state that occur with variations in temperature or pressure can be described and predicted using models of matter.
- The term heat as used in everyday language refers both to thermal energy and the transfer of thermal energy from one object to another.
- Thermal energy is the motion of atoms or molecules within a substance.
- In science, heat is used to refer to the energy transferred due to the temperature difference between two objects.
- The temperature of a system is proportional to the average internal kinetic energy and potential energy per atom or molecule (whichever is the appropriate building block for the system's material).
- The details of the relationship between the average internal kinetic energy and the potential energy per atom or molecule depend on the type of atom or molecule and the interactions among the atoms in the material.
- Temperature is not a direct measure of a system's total thermal energy.
- The total thermal energy (sometimes called the total internal energy) of a system depends jointly on the temperature, the total number of atoms in the system, and the state of the material.
- Cause-and-effect relationships may be used to predict and describe changes in particle motion, temperature, and state of a pure substance when thermal energy is added or removed in natural systems.

Formative Assessment

Students who understand the concepts are able to:

- Develop a model that predicts and describes changes in particle motion that could include molecules or inert atoms or pure substances.
- Use cause-and-effect relationships to predict changes in particle motion, temperature, and state of a pure substance when thermal energy is added or removed in natural or designed systems.

Recommended Activities/Assessments

- Activities to develop qualitative molecular models for different states of matter representing the number of the particles and using arrows to show the motion of the particles.
- Activities to construct/ analyze a graph showing the effect of heat on the number and motion of particles including the transition of states of matter at each state
- Activities/ lessons to explore the relationship between motion of particles and the kinetic energy

- District Unit 2 Common Assessment

Resources

- McGraw Hill iScience Textbook- Chapter 6 Lesson 1 (pages 194-201)
- McGraw Hill iScience Textbook- Chapter 8 Lesson 1 & 2 (pages 273-288)
- Discovery Education Techbook- States of Matter (1.3)
- Discovery Education Techbook- Types of energy (2.3)

States of Matter | Solids, Liquids & Gases | Changes of States

Part B - Essential Question: ***How can we trace synthetic materials back to natural ingredients?***

Concepts/ Enduring Understanding

- Each pure substance has characteristic physical and chemical properties that can be used to identify it.
- Substances react chemically in characteristic ways.
- In a chemical process, the atoms that make up the original substances are regrouped into different molecules.
- New substances that result from chemical processes have different properties from those of the reactants.
- Natural resources can undergo a chemical process to form synthetic material.
- Structures can be designed to serve particular functions by taking into account properties of different materials and how materials can be shaped and used.
- Engineering advances have led to discoveries of important synthetic materials, and scientific discoveries have led to the development of entire industries and engineered systems using these materials.
- Technology use varies from region to region and over time.
- The uses of technologies (engineered/synthetic materials) and any limitations on their use are driven by individual or societal needs, desires, and values.
- The uses of technologies (engineered/synthetic materials) and any limitations on their use are driven by the findings of scientific research and by differences in such factors as climate, natural resources, and economic conditions.

Formative Assessment

Students who understand the concepts are able to:

- Obtain, evaluate, and communicate information to show that synthetic materials come from natural resources and affect society.
- Gather, read, and synthesize information about how synthetic materials formed from natural resources affect society.
- Assess the credibility, accuracy, and possible bias of each publication and methods used within the publication.
- Describe how information about how synthetic materials formed from natural resources affect society is supported or not supported by evidence.

Recommended Assignments/Assessments

- NSTA Plastics From Milk Lab
- Plan a research project with a focus on any natural resource undergoing a chemical process to make synthetic material Example of new material could include new medicine, fuel and alternative fuels
- Students will gather, read, and synthesize qualitative information from multiple sources about the use of natural resources to form synthetic materials and how these new materials affect society.
- Lesson to teach students how to assess the credibility, accuracy, and possible bias of each publication and methods used within the publication.

Resources

- McGraw Hill iScience Textbook (pages 156-157)
- McGraw Hill iScience Textbook- chapter 14 Lesson 2 (pages 502-504)
- Discovery Education Techbook - Matter (1.6)

Common Core Standards Alignment

ELA/Literacy	Mathematics	Technology	Career Ready Practice
Gather relevant information from multiple print and digital sources, using search terms effectively; assess the credibility and accuracy of each source; and quote or paraphrase the data and conclusions of others while avoiding plagiarism and following a standard format for citation. (MS-PS1-3) **WHST.6-8.8** Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g. in a flowchart, diagram, model, graph or table). (MS-PS1-4) **RST.6-8.7** Cite specific textual evidence to support analysis of science and technical texts, attending to the precise details of explanations or descriptions. (MS-PS1-3) **RST 6-8.1**	Understand that positive and negative numbers are used together to describe quantities having opposite directions or values (e.g., temperature above/below zero, elevation above/below sea level, credits/debits, positive/negative electric charge); use positive and negative numbers to represent quantities in real-world contexts, explaining the meaning of 0 in each situation. (MS-PS1-4) **6.NS.C.5**	8.1.8.A.1 Demonstrate knowledge of a real world problem using digital tools	CRP8. Utilize critical thinking to make sense of problems and persevere in solving them.

Next Generation Science Standards and Foundations for the Unit
The performance expectations above were developed using the following elements from A Framework for K-12 Science Education:

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Obtaining, Evaluating, and Communicating Information · Gather, read, and synthesize information from multiple appropriate sources and assess the credibility, accuracy, and possible bias of each publication and methods used, and describe how they are supported or not supported by evidence. (MS-PS1-3) **Developing and Using Models** Develop a model to predict and/or describe phenomena. (MS-PS1-4)	**PS1.A: Structure and Properties of Matter** · Each pure substance has characteristic physical and chemical properties (for any bulk quantity under given conditions) that can be used to identify it. (MS-PS1-3) · Gases and liquids are made of molecules or inert atoms that are moving about relative to each other. (MS-PS1-4) · In a liquid, the molecules are constantly in contact with others; in a gas, they are widely spaced except when they happen to collide. In a solid, atoms are closely spaced and may vibrate in position but do not change relative locations. (MS-PS1-4) **PS1.B: Chemical Reactions** · Substances react chemically in characteristic ways. In a chemical process, the atoms that make up the original substances are regrouped into different molecules, and these new substances have different properties from those of the reactants. (MS-PS1-2),(MS-PS1-3) **PS3.A: Definitions of Energy** · The term "heat" as used in everyday language refers both to thermal energy (the motion of atoms or molecules within a substance) and the transfer of that thermal energy from one object to another. In science, heat is used only for this second meaning; it refers to the energy transferred due to the temperature difference between two objects. *(secondary to MS-PS1-4)* The temperature of a system is proportional to the average internal kinetic energy and potential energy per atom or molecule (whichever is the appropriate building block for the system's material). The details of that relationship depend on the type of atom or molecule and the interactions among the atoms in the material. Temperature is not a direct measure of a system's total thermal energy. The total thermal energy (sometimes called the total internal energy) of a system depends jointly on the temperature, the total number of atoms in the system, and the state of the material. *(secondary to MS-PS1-4)*	**Structure and Function** · Structures can be designed to serve particular functions by taking into account properties of different materials, and how materials can be shaped and used. (MS-PS1-3) **Cause and Effect** · Cause and effect relationships may be used to predict phenomena in natural or designed systems. (MS-PS1-4) - ***Connections to Engineering, Technology,*** ***and Applications of Science*** **Interdependence of Science, Engineering, and Technology** · Engineering advances have led to important discoveries in virtually every field of science, and scientific discoveries have led to the development of entire industries and engineered systems. (MS-PS1-3) **Influence of Science, Engineering and Technology on Society and the Natural World** · The uses of technologies and any limitation on their use are driven by individual or societal needs, desires, and values; by the findings of scientific research; and by differences in such factors as climate, natural resources, and economic conditions. Thus technology use varies from region to region and over time. (MS-PS1-3)

Grade 8 Unit 3: Chemical Reactions **Approximate Instructional Days: 20**

Unit Summary
Essential Questions: How do substances combine or change (react) to make a new substance? Students provide molecular-level accounts of states of matter and changes between states, of how chemical reactions involve regrouping of atoms to form new substances, and of how atoms rearrange during chemical reactions. Students also apply their understanding of optimization design and process in engineering to chemical reaction systems. The crosscutting concept of *energy and matter* provides a framework for understanding the disciplinary core ideas. Students are expected to demonstrate proficiency in *developing and using models, analyzing and interpreting data, designing solutions*, and *obtaining, evaluating, and communicating information*. Students are also expected to use these science and engineering practices to demonstrate understanding of the disciplinary core ideas.
Student Learning Objectives
Develop and use a model to describe how the total number of atoms does not change in a chemical reaction and thus mass is conserved. ***[Clarification Statement: Emphasis is on law of conservation of matter and on physical models or drawings, including digital forms, that represent atoms.] [Assessment Boundary: Assessment does not include the use of atomic masses, balancing symbolic equations, or intermolecular forces.]*** **(MS-PS1-5)**
Undertake a design project to construct, test, and modify a device that either releases or absorbs thermal energy by chemical processes. * ***[Clarification Statement: Emphasis is on the design, controlling the transfer of energy to the environment, and modification of a device using factors such as type and concentration of a substance. Examples of designs could involve chemical reactions such as dissolving ammonium chloride or calcium chloride.] [Assessment Boundary: Assessment is limited to the criteria of amount, time, and temperature of substance in testing the device.]*** **(MS-PS1-6)**
Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success. (MS-ETS1-3)
Possible Student Misconceptions (based on research):
Students may think everything that exists is matter, including heat, light, and electricity. Alternatively, they may believe that matter does not include liquids and gasses or they are weightless materials. With specially designed instruction, some middle school students can learn the scientific notion of matter. Students are deeply committed to a theory of continuous matter. Although some students may think that substances can be divided up into small particles, they do not recognize the particles as building blocks, but as formed as basically continuous substances under certain conditions. Students at the beginning of middle school may be at different points in their conceptualization of a "theory" of matter. Although some 5th graders may start seeing weight as a fundamental property of all matter, many students in 6th and 7th grade still appear to think of weight simply as "felt weight" -- something whose weight they can't feel is considered to have no weight at all. Accordingly, some students believe that if one keeps dividing a piece of Styrofoam, one would soon obtain a piece that weighed nothing. Students of all ages show a wide range of beliefs about the nature and behavior of particles. They lack an appreciation of the very small size of particles; attribute macroscopic properties to particles; believe there must be something in the space between particles; have difficulty in appreciating the intrinsic motion of particles in solids, liquids and gasses; and have problems in conceptualizing forces between particles. Despite these difficulties, there is some evidence that carefully designed instruction carried out over a long period of time may help middle-school students develop correct ideas about particles (NSDL, 2015).

Unit Sequence

Part A - Essential Question: ***What happens to the atoms when I bake a cake?***

Concepts/ Enduring Understanding

- Substances react chemically in characteristic ways.
- In a chemical process, the atoms that make up the original substances are regrouped into different molecules.
- New substances created in a chemical process have different properties from those of the reactants.
- The total number of each type of atom in a chemical process is conserved, and thus the mass does not change (the law of conservation of matter).
- Matter is conserved because atoms are conserved in physical and chemical processes.
- The law of conservation of mass is a mathematical description of natural phenomena.

Formative Assessment

Students who understand the concepts are able to:

- Use physical models or drawings, including digital forms, to represent atoms in a chemical process.
- Use mathematical descriptions to show that the number of atoms before and after a chemical process is the same.
- Analyze and interpret data to determine similarities and differences from the results of chemical reactions between substances before and after they undergo a chemical process.
- Analyze and interpret data on the properties of substances before and after they undergo a chemical process.
- Identify and describe possible correlation and causation relationships evidenced in chemical reactions.
- Make logical and conceptual connections between evidence that chemical reactions have occurred and explanations of the properties of substances before and after they undergo a chemical process.

Recommended Activities/Assessments

- Use molecular level models (3D ball and stick structures, drawings) showing different molecules of reactants and products in a chemical reaction
- Activities using mathematical descriptions to show the number of atoms of reactants and products in a chemical reaction. (counting the atoms)
- Analyze the data to identify patterns (arrangement of molecules before & after the chemical reactions)
- Counting the number of atoms before and after the reaction to support student interpretation of data
- Activity identifying the type of Chemical Reactions (Combustion, Decomposition Synthesis, Replacement, Double Replacement)
- District Unit 3 Common Assessment

Resources

- McGraw Hill iScience Textbook- Chapter 12 Lesson 1 (pages 419-426)
- Discovery Education Techbook-Chemical reactions and equations (1.5)

Part B - Essential Question: ***How can a device be designed, constructed, tested, and modified that either releases or absorbs thermal energy by chemical processes?***

Concepts/ Enduring Understanding

- Some chemical reactions release energy, while others store energy.
- The transfer of thermal energy can be tracked as energy flows through a designed or natural system.
- Models of all kinds are important for testing solutions
- There are systematic processes for evaluating solutions with respect to how well they meet the criteria and constraints of a problem.
- The iterative process of testing the most promising solutions and modifying what is proposed on the basis of the test results leads to greater refinement and ultimately to an optimal solution.
- A solution needs to be tested and then modified on the basis of the test results in order to for it to be improved.
- Although one design may not perform the best across all tests, identifying the characteristics of the design that performed the best in each test can provide useful information for the redesign process.
- Some of the characteristics identified as having the best performance may be incorporated into the new design.

Formative Assessment

Students who understand the concepts are able to:

- Undertake a design project, engaging in the design cycle, to construct, test, and modify a device that either releases or absorbs thermal energy by chemical processes.
- Specific criteria are limited to amount, time, and temperature of a substance.
- Analyze and interpret data for the amount, time, and temperature of a substance in testing a device that either releases or absorbs thermal energy by chemical processes to determine similarities and differences in findings.
- Develop a model to generate data for testing a device that either releases or absorbs thermal energy by chemical processes, including those representing inputs and outputs of thermal energy.
- Track the transfer of thermal energy as energy flows through a designed system that either releases or absorbs thermal energy by chemical processes.

Recommended Activities/Assessments

- Engineering processes introduction lesson
- Engineering project: design a device that either absorbs or releases energy
- Lab or activities on how to collect meaningful information using qualitative and quantitative observation, experimental errors etc.
- Labs: Interpretation of data to identify the differences and similarities in data using variables
- Activities : lab using the collected data to make a claim that best meets the design and modify the design that meets the best result

Science Grade 8

Resources
● McGraw Hill iScience Textbook- Chapter 12 Lesson 3 (pages 436 - 443) ● Discovery Education Techbook- Chemical reactions and equations (1.5)
Common Core Standards Alignment

ELA/Literacy	Mathematics	Technology	Career Ready Practice
Cite specific textual evidence to support analysis of science and technical texts. (MS-ETS1-3) **RST.6-8.1** Follow precisely a multi step procedure when carrying out experiments, taking measurements or performing technical tasks. (MS-PS1-6) **RST. 6-8.3** Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g. in a flowchart, diagram, model, graph or table) (MS-PS1-5) **RST 6-8.7** Compare and contrast the information gained from experiments, simulations, video, or multimedia sources with that gained from reading a text on the same topic. (MS-ETS1-3) **RST.6-8.9** Conduct short research projects to answer a question (including a self-generated question), drawing on several sources and generating additional related, focused questions that allow for multiple avenues of exploration. (MS-PS1-6) (MS-ETS1-3) **WHST.6-8.7** Use ratio and rate reasoning to solve real-world and mathematical problems. (MS-PS1-5) **6.RP.A.3**	Solve multi-step real-life and mathematical problems posed with positive and negative rational numbers in any form (whole numbers, fractions, and decimals), using tools strategically. Apply properties of operations to calculate with numbers in any form; convert between forms as appropriate; and assess the reasonableness of answers using mental computation and estimation strategies. (MS-ETS1-3) **7.EE.3** Reason abstractly and quantitatively. (MS-PS1-5) (MS-ETS1-3) **MP.2** Model with mathematics. (MS-PS1-5) **MP.4**	8.1.8.A.1 Demonstrate knowledge of a real world problem using digital tools	CRP8. Utilize critical thinking to make sense of problems and persevere in solving them.

Next Generation Science Standards and Foundations for the Unit The performance expectations above were developed using the following elements from A Framework for K-12 Science Education:		
Science and Engineering Practices	**Disciplinary Core Ideas**	**Crosscutting Concepts**

Developing and Using Models · Develop a model to describe unobservable mechanisms. (MS-PS1-5) **Constructing Explanations and Designing Solutions** · Undertake a design project, engaging in the design cycle, to construct and/or implement a solution that meets specific design criteria and constraints. (MS-PS1-6) **Analyzing and Interpreting Data** Analyze and interpret data to determine similarities and differences in findings. (MS-ETS1-3)	**PS1.B: Chemical Reactions** · Substances react chemically in characteristic ways. In a chemical process, the atoms that make up the original substances are regrouped into different molecules, and these new substances have different properties from those of the reactants. (MS-PS1-5) · The total number of each type of atom is conserved, and thus the mass does not change. (MS-PS1-5) · Some chemical reactions release energy, others store energy. (MS-PS1-6) **ETS1.B: Developing Possible Solutions** · A solution needs to be tested, and then modified on the basis of the test results, in order to improve it. (*secondary to MS-PS1-6*) · There are systematic processes for evaluating solutions with respect to how well they meet the criteria and constraints of a problem. (MS-ETS1-3) · Sometimes parts of different solutions can be combined to create a solution that is better than any of its predecessors. (MS-ETS1-3) **ETS1.C: Optimizing the Design Solution** · Although one design may not perform the best across all tests, identifying the characteristics of the design that performed the best in each test can provide useful information for the redesign process - that is, some of the characteristics may be incorporated into the new design. (*secondary to MS-PS1-6*) · The iterative process of testing the most promising solutions and modifying what is proposed on the basis of the test results leads to greater refinement and ultimately to an optimal solution. (secondary to MS-PS1-6) Although one design may not perform the best across all tests, identifying the characteristics of the design that performed the best in each test can provide useful information for the redesign process—that is, some of those characteristics may be incorporated into the new design. (MS-ETS1-3)	**Energy and Matter** · Matter is conserved because atoms are conserved in physical and chemical processes. (MS-PS1-5) · The transfer of energy can be tracked as energy flows through a designed or natural system. (MS-PS1-6) - **Connections to Nature of Science** **Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena** · Laws are regularities or mathematical descriptions of natural phenomena. (MS-PS1-5)

Grade 8 Unit 4: Force and Motion **Approximate Instructional Days: 20**

Unit Summary
Essential Questions: How can one explain and predict interactions between objects and within systems of objects? Students use *system and system models* and *stability and change* to understanding ideas related to why some objects will keep moving and why objects fall to the ground. Students apply Newton's third law of motion to related forces to explain the motion of objects. Students also apply an engineering practice and concept to solve a problem caused when objects collide. The crosscutting concepts of *system and system models* and *stability and change* provide a framework for understanding the disciplinary core ideas. Students demonstrate proficiency in *asking questions*, *planning and carrying out investigations, designing solutions, engaging in argument from evidence*, *developing and using models,* and *constructing explanations and designing solutions*. Students are also expected to use these practices to demonstrate an understanding of the core ideas.
Student Learning Objectives
Apply Newton's Third Law to design a solution to a problem involving the motion of two colliding objects. * ***[Clarification Statement: Examples of practical problems could include the impact of collisions between two cars, between a car and stationary objects, and between a meteor and a space vehicle.] [Assessment Boundary: Assessment is limited to vertical or horizontal interactions in one dimension.]*** **(MS-PS2-1**
Plan an investigation to provide evidence that the change in an object's motion depends on the sum of the forces on the object and the mass of the object. ***[Clarification Statement: Emphasis is on balanced (Newton's First Law) and unbalanced forces in a system, qualitative comparisons of forces, mass and changes in motion (Newton's Second Law), frame of reference, and specification of units.] [Assessment Boundary: Assessment is limited to forces and changes in motion in one-dimension in an inertial reference frame and to change in one variable at a time. Assessment does not include the use of trigonometry.]*** **(MS-PS2-2**
Possible Student Misconceptions (based on research):
Students tend to think of force as a property of an object ("an object has force," or "force is within an object") rather than as a relation between objects. In addition, students tend to distinguish between active objects and objects that support or block or otherwise act passively. Students tend to call the active actions "force" but do not consider passive actions as "forces". Teaching students to integrate the concept of passive support into the broader concept of force is a challenging task even at the high-school level. Students believe constant speed needs some cause to sustain it. In addition, students believe that the amount of motion is proportional to the amount of force; that if a body is not moving, there is no force acting on it; and that if a body is moving there is a force acting on it in the direction of the motion. Students also believe that objects resist acceleration from the state of rest because of friction -- that is, they confuse inertia with friction. Students tend to hold on to these ideas even after instruction in high-school or college physics. Specially designed instruction does help high-school students change their ideas. Research has shown less success in changing middle-school students' ideas about force and motion. Nevertheless, some research indicates that middle-school students can start understanding the effect of constant forces to speed up, slow down, or change the direction of motion of an object. This research also suggests it is possible to change middle-school students' belief that a force always acts in the direction of motion. Students have difficulty appreciating that all interactions involve equal forces acting in opposite directions on the separate, interacting bodies. Instead they believe that "active" objects (like hands) can exert forces whereas "passive" objects (like tables) cannot. Alternatively, students may believe that the object with more of some obvious property will exert a greater force (NSDL, 2015).
Unit Sequence

Part A - Essential Questions: ***How can one predict an object's continued motion, changes in motion, or stability? How does the mass of an object affect the outcome when an unbalanced force acts on it?***

Concepts/ Enduring Understanding

- For any pair of interacting objects, the force exerted by the first object on the second object is equal in strength to the force that the second object exerts on the first, but in the opposite direction (Newton's third law).
- Models can be used to represent the motion of objects in colliding systems and their interactions, such as inputs, processes, and outputs, as well as energy and matter flows within systems.

Formative Assessment

Students who understand the concepts are able to:

- Apply Newton's third law to design a solution to a problem involving the motion of two colliding objects.

Recommended Activities/Assessments

- Lab-based lesson on analyzing and interpreting data and graphs
- Plan a lab using the material provided (must write procedure ,variable and controls, dependent and independent variables, collecting and interpreting data to support the claim)

Resources

- McGraw Hill iScience Textbook- Chapter 1 Lesson 3 (pages 26-33)
- McGraw Hill iScience Textbook- Chapter 2 Lesson 4 (pages 69-75)
- Discovery Education-Force and Motion Unit 4 (Concepts 4.1, 4.2)
- Force & Motion

Part B - Essential Question: ***How do objects at rest and in motion respond in the presence of an external, unbalanced force?***

Concepts/ Enduring Understanding

- The change in an object's motion depends on balanced (Newton's first law) and unbalanced forces in a system Evidence that the change in an object's motion depends on the sum of the forces on the object and the mass of the object includes qualitative comparisons of forces, mass, and changes in motion (Newton's second law); frame of reference; and specification of units
- The motion of an object is determined by the sum of the forces acting on it; if the total force on the object is not zero, its motion will change.
- The greater the mass of the object, the greater the force needed to achieve the same change in motion.
- For any given object, a larger force causes a larger change in motion.
- Explanations of stability and change in natural or designed systems can be constructed by examining the changes over time and forces at different scales..

Formative Assessment

Students who understand the concepts are able to:

- Plan an investigation individually and collaboratively to provide evidence that the change in an object's motion depends on the sum of the forces on the object and the mass of the object.
- Design an investigation and identify independent and dependent variables and controls, what tools are needed to do the gathering, how measurements will be recorded, and how many data are needed to support a claim.
- Make logical and conceptual connections between evidence and explanations.
- Examine the changes over time and forces at different scales to explain the stability and change in designed systems.

Recommended Activities/Assessments

- Activities could include pushing objects of different masses and comparing the forces needed to accelerate the objects.
- District Unit 4 Common Assessment
- District MP 2 Benchmark Assessment

Resources

- McGraw Hill iScience Textbook- Chapter 2 Lesson 2 (pages 53-60)
- McGraw Hill iScience Textbook- Chapter 2 Lesson 3 (pages 61-68)
- Discovery Ed - Force & Motion (concepts 4.1, 4.2)

Common Core Standards Alignment

ELA/Literacy	Mathematics	Technology	Career Ready Practice
Cite specific textual evidence to support analysis of science and technical texts, attending to the precise details of explanations or descriptions. (MS-PS2-1),(MS-ETS1-1),(MS-ETS1-2) **RST.6-8.1**	Reason abstractly and quantitatively. (MS-PS2-1),(MS-PS2-2),(MS-PS2-3),(MS-ETS1-1),(MS-ETS1-2) **MP.2** Understand that positive and negative numbers are used together to describe quantities having opposite directions or values; use positive and negative	8.1.8.A.1 Demonstrate knowledge of a real world problem using digital tools	CRP8. Utilize critical thinking to make sense of problems and persevere in solving them.

Follow precisely a multistep procedure when carrying out experiments, taking measurements, or performing technical tasks. (MS-PS2-1),(MS-PS2-2) **RST.6-8.3** Compare and contrast the information gained from experiments, simulations, video, or multimedia sources with that gained from reading a text on the same topic. (MS-ETS1-2),(MS-ETS1-3) **RST.6-8.9**	numbers to represent quantities in real-world contexts, explaining the meaning of 0 in each situation. (MS-PS2-1) **6.NS.C.5** Write, read, and evaluate expressions in which letters stand for numbers. (MS-PS2-1),(MS-PS2-2) **6.EE.A.2** Solve multi-step real-life and mathematical problems posed with positive and negative rational numbers in any form, using tools strategically. Apply properties of operations to calculate with numbers in any form; convert between forms as appropriate; and assess the reasonableness of answers using mental computation and estimation strategies. (MS-PS2-1),(MS-PS2-2) **7.EE.B.3** Use variables to represent quantities in a real-world or mathematical problem, and construct simple equations and inequalities to solve problems by reasoning about the quantities. (MS-PS2-1),(MS-PS2-2) **7.EE.B.4**		

Next Generation Science Standards and Foundations for the Unit **The performance expectations above were developed using the following elements from A Framework for K-12 Science Education:**		
Science and Engineering Practices	**Disciplinary Core Ideas**	**Crosscutting Concepts**
Planning and Carrying Out Investigations · Plan an investigation individually and collaboratively, and in the design: identify independent and dependent variables and controls, what tools are needed to do the gathering, how measurements will be recorded, and how many data are needed to support a claim. (MS-PS2-2) **Constructing Explanations and Designing Solutions** · Apply scientific ideas or principles to design an object, tool, process or system. (MS-PS2-1)	**PS2.A: Forces and Motion** · For any pair of interacting objects, the force exerted by the first object on the second object is equal in strength to the force that the second object exerts on the first, but in the opposite direction (Newton's third law). (MS-PS2-1) · The motion of an object is determined by the sum of the forces acting on it; if the total force on the object is not zero, its motion will change. The greater the mass of the object, the greater the force needed to achieve the same change in motion. For any given object, a larger force causes a larger change in motion. (MS-PS2-2) · All positions of objects and the directions of forces and motions must be described in an arbitrarily chosen reference frame and arbitrarily chosen units of size. In order to share information with other people, these choices must also be shared. (MS-PS2-2) ·	**Systems and System Models** · Models can be used to represent systems and their interactions—such as inputs, processes and outputs—and energy and matter flows within systems. (MS-PS2-1) **Stability and Change** · Explanations of stability and change in natural or designed systems can be constructed by examining the changes over time and forces at different scales. (MS-PS2-2) - ***Connections to Engineering, Technology,*** ***and Applications of Science*** **Influence of Science, Engineering, and Technology on Society and the Natural World** · The uses of technologies and any limitations on their use are driven by individual or societal needs, desires, and values; by the findings of scientific research; and by

		differences in such factors as climate, natural resources, and economic conditions. (MS-PS2-1) · All human activity draws on natural resources and has both short and long-term consequences, positive as well as negative, for the health of people and the natural environment. (MS-ETS1-1) · The uses of technologies and limitations on their use are driven by individual or societal needs, desires, and values; by the findings of scientific research; and by differences in such factors as climate, natural resources, and economic conditions. (MS-ETS1-1)

Grade 8 Unit 5: Types of Forces **Approximate Instructional Days: 20**

Unit Summary
Essential Questions: What underlying forces explain the variety of interactions observed? Students use *cause and effect*; *system and system models*; and *stability and change* to understand ideas that explain why some materials are attracted to each other while others are not. Students apply ideas about gravitational, electrical, and magnetic forces to explain a variety of phenomena including beginning ideas about why some materials attract each other while others repel. In particular, students develop understandings that gravitational interactions are always attractive but that electrical and magnetic forces can be both attractive and negative. Students also develop ideas that objects can exert forces on each other even though the objects are not in contact, through fields. Students are expected to consider the influence of science, engineering, and technology on society and the natural world. Students are expected to demonstrate proficiency in *asking questions*, *planning and carrying out investigations*, *designing solutions*, and *engaging in argument*. Students are also expected to use these practices to demonstrate an understanding of the core ideas
Student Learning Objectives
Conduct an investigation and evaluate the experimental design to provide evidence that fields exist between objects exerting forces on each other even though the objects are not in contact. ***[Clarification Statement: Examples of this phenomenon could include the interactions of magnets, electrically-charged strips of tape, and electrically-charged pith balls. Examples of investigations could include first-hand experiences or simulations.] [Assessment Boundary: Assessment is limited to electric and magnetic fields, and is limited to qualitative evidence for the existence of fields.]*** **(MS-PS2-5)**
Ask questions about data to determine the factors that affect the strength of electric and magnetic forces. ***[Clarification Statement: Examples of devices that use electric and magnetic forces could include electromagnets, electric motors, or generators. Examples of data could include the effect of the number of turns of wire on the strength of an electromagnet, or the effect of increasing the number or strength of magnets on the speed of an electric motor.] [Assessment Boundary: Assessment about questions that require quantitative answers is limited to proportional reasoning and algebraic thinking.]*** **(MS-PS2-3)**
Construct and present arguments using evidence to support the claim that gravitational interactions are attractive and depend on the masses of interacting objects. ***[Clarification Statement: Examples of evidence for arguments could include data generated from simulations or digital tools; and charts displaying mass, strength of interaction, distance from the Sun, and orbital periods of objects within the solar system.] [Assessment Boundary: Assessment does not include Newton's Law of Gravitation or Kepler's Laws.]*** **(MS-PS2-4**
Possible Student Misconceptions (based on research):
Students tend to think of force as a property of an object ("an object has force," or "force is within an object") rather than as a relation between objects. In addition, students tend to distinguish between active objects and objects that support or block or otherwise act passively. Students tend to call the active actions "force" but do not consider passive actions as "forces". Teaching students to integrate the concept of passive support into the broader concept of force is a challenging task even at the high-school level. Students believe constant speed needs some cause to sustain it. In addition, students believe that the amount of motion is proportional to the amount of force; that if a body is not moving, there is no force acting on it; and that if a body is moving there is a force acting on it in the direction of the motion. Students also believe that objects resist acceleration from the state of rest because of friction -- that is, they confuse inertia with friction. Students tend to hold on to these ideas even after instruction in high-school or college physics. Specially designed instruction does help students change their ideas.

Research has shown less success in changing middle-school students' ideas about force and motion. Nevertheless, some research indicates that middle-school students can start understanding the effect of constant forces to speed up, slow down, or change the direction of motion of an object. This research also suggests it is possible to change middle-school students' belief that a force always acts in the direction of motion.

Students have difficulty appreciating that all interactions involve equal forces acting in opposite directions on the separate, interacting bodies. Instead they believe that "active" objects (like hands) can exert forces whereas "passive" objects (like tables) cannot. Alternatively, students may believe that the object with more of some obvious property will exert a greater force. Teaching high-school students to seek consistent explanations for the "at rest" condition of an object can lead them to appreciate that both "active" and "passive" objects exert forces. Showing high-school students that apparently rigid or supporting objects actually deform might also lead them to appreciate that both "active" and "passive" objects exert forces (NSDL, 2015).

Unit Sequence

Part A - Essential Question: ***Can you apply a force on something without touching it?***

Concepts/ Enduring Understanding

- Fields exist between objects that exert forces on each other even though the objects are not in contact.
- The interactions of magnets, electrically charged strips of tape, and electrically charged pith balls are examples of fields that exist between objects exerting forces on each other, even though the objects are not in contact.
- Forces that act at a distance (electric, magnetic, and gravitational) can be explained by fields that extend through space and can be mapped by their effect on a test object (a charged object or a ball, respectively).
- Cause-and-effect relationships may be used to predict phenomena in natural or designed systems.

Formative Assessment

Students who understand the concepts are able to:

- Students will conduct an investigation and evaluate an experimental design to produce data that can serve as the basis for evidence that fields exist between objects exerting forces on each other even though the objects are not in contact.
- Students will identify the cause-and-effect relationships between fields that exist between objects and the behavior of the objects.

Recommended Activities/Assessments

- Introduction to scientific Models
- Practice making scientific models
- Lab - Static electricity (cause and effect)
- Conduct an investigation that produces data to provide evidence that objects exert a force on each other even when they are not touching.
- District Unit 5 Common Assessment

Resources

- McGraw Hill iScience Textbook- Chapter 2 Lesson 1 (pages 44-52)
- McGraw Hill iScience Textbook- Chapter 19 Lesson 1 (pages 678-688)
- McGraw Hill iScience Textbook- Chapter 20 Lesson 1 (pages 716-725)
- Discovery Education Techbook- Gravity & Friction (4.3, 4.4)
- Discovery Education Techbook- Electricity & Magnetism (5.1, 5.2)

Part B - Essential Question: ***What factors affect the strength of electric and magnetic forces?***

Concepts/ Enduring Understanding

- Factors affect the strength of electric and magnetic forces.
- Devices that use electric and magnetic forces could include electromagnets, electric motors, and generators.
- Electric and magnetic (electromagnetic) forces can be attractive or repulsive.
- The size of an electric or magnetic (electromagnetic) force depends on the magnitude of the charges, currents, or magnetic strengths involved and on the distances between the interacting objects.
- Cause-and-effect relationships may be used to predict the factors that affect the strength of electrical and magnetic forces in natural or designed systems

Formative Assessment

Students who understand the concepts are able to:

- Students will ask questions about data to determine the effect of the strength of electric and magnetic forces that can be investigated within the scope of the classroom, outdoor environment, and museums and other public facilities with available resources and, when appropriate, frame a hypothesis based on observations and scientific principles.
- Students will perform investigations using devices that use electromagnetic forces.
- Students will collect and analyze data that could include the effect of the number of turns of wire on the strength of an electromagnet or the effect of increasing the number or strength of magnets on the speed of an electric motor.

Recommended Activities/Assessments

- Activities on the forces and magnetic fields
- CER Investigation - Electromagnetic force (collect and analyze data)

Resources

- McGraw Hill iScience Textbook- Chapter 19 Lesson 1 (pages 678-688)
- McGraw Hill iScience Textbook- Chapter 20 Lesson 1 (pages 716-725)

- Discovery Education Techbook- Gravity & Friction (4.3, 4.4)
- Discovery Education Techbook- Electricity & Magnetism (5.1, 5.2)

Part C - Essential Question: *What factors affect the gravitational pull of an object?*

Concepts/ Enduring Understanding

- Gravitational interactions are always attractive and depend on the masses of interacting objects.
- There is a gravitational force between any two masses, but it is very small, except when one or both of the objects have large mass.
- Evidence supporting the claim that gravitational interactions are attractive and depend on the masses of interacting objects could include data generated from simulations or digital tools and charts displaying mass, strength of interaction, distance from the sun, and orbital periods of objects within the solar system.

Formative Assessment

Students who understand the concepts are able to:

- Students construct and present oral and written arguments supported by empirical evidence and scientific reasoning to support the claim that gravitational interactions are attractive and depend on the masses of interacting objects.
- Students use models to represent the gravitational interactions between two masses.

Recommended Activities/Assessments

- Gravity Lab
- Apollo 15 Hammer - Feather Drop
- CER investigations on gravitational interactions which are attractive and depend on the masses of interacting objects.
- Activities allowing students to use models to represent the gravitational interactions between two masses.

Resources

- McGraw Hill iScience Textbook- Chapter 2 Lesson 1 (pages 44-52)
- Discovery Education Techbook- Gravity & Friction (4.3, 4.4)
- Discovery Education Techbook- Electricity & Magnetism (5.1, 5.2)

Common Core Standards Alignment

ELA/Literacy	Mathematics	Technology	Career Ready Practice
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.(HS-PS2-5), (HS-PS2-3) **WHST.11-12.7** Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the strengths and limitations of each source in terms of the specific task, purpose, and audience; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and over reliance on any one source and following a standard format for citation. (HS-PS2-5) **WHST.11-12.8** Draw evidence from informational texts to support analysis, reflection, and research. (HS-PS2-5) **WHST.11-12.9**	Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. (HS-PS2-5),(HS-PS2-4) **HSN.Q.A.1** Define appropriate quantities for the purpose of descriptive modeling. (HS-PS2-5),(HS-PS2-4) **HSN.Q.A.2** Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. (HS-PS2-5),(HS-PS2-4) **HSN.Q.A.3** Reason abstractly and quantitatively. (HS-PS2-4) **MP.2** Model with mathematics. (HS-PS2-4) **MP.4** Interpret expressions that represent a quantity in terms of its context. (HS-PS2-4) **HSA.SSE.A.1** Choose and produce an equivalent form of an expression to reveal and explain properties of the quantity represented by the expression. (HS-PS2-4) **HSA.SSE.B.3**	8.1.8.A.1 Demonstrate knowledge of a real world problem using digital tools	CRP8. Utilize critical thinking to make sense of problems and persevere in solving them.

Next Generation Science Standards and Foundations for the Unit **The performance expectations above were developed using the following elements from A Framework for K-12 Science Education:**		
Science and Engineering Practices	**Disciplinary Core Ideas**	**Crosscutting Concepts**

Using Mathematics and Computational Thinking · Use mathematical representations of phenomena to describe explanations. **(HS-PS2-4)** **Constructing Explanations and Designing Solutions** · Apply scientific ideas to solve a design problem, taking into account possible unanticipated effects. (HS-PS2-3) **Planning and Carrying Out Investigations** · **Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence, and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the data (e.g., number of trials, cost, risk, time), and refine the design accordingly. (HS-PS2-5)**	**PS2.B: Types of Interactions** · Newton's law of universal gravitation and Coulomb's law provide the mathematical models to describe and predict the effects of gravitational and electrostatic forces between distant objects. (HS-PS2-4) · Forces at a distance are explained by fields (gravitational, electric, and magnetic) permeating space that can transfer energy through space. Magnets or electric currents cause magnetic fields; electric charges or changing magnetic fields cause electric fields. (HS-PS2-4) **PS2.A: Forces and Motion** · If a system interacts with objects outside itself, the total momentum of the system can change; however, any such change is balanced by changes in the momentum of objects outside the system. (HS-PS2-3) **ETS1.A: Defining and Delimiting an Engineering Problem** · Criteria and constraints also include satisfying any requirements set by society, such as taking issues of risk mitigation into account, and they should be quantified to the extent possible and stated in such a way that one can tell if a given design meets them. (secondary) (HS-PS2-3) **ETS1.C: Optimizing the Design Solution** · Criteria may need to be broken down into simpler ones that can be approached systematically, and decisions about the priority of certain criteria over others (trade-offs) may be needed. *(secondary HS-PS2-3)* **PS2.B: Types of Interactions** · Newton's law of universal gravitation and Coulomb's law provide the mathematical models to describe and predict the effects of gravitational and electrostatic forces between distant objects. (HS-PS2-5) · Forces at a distance are explained by fields (gravitational, electric, and magnetic) permeating space that can transfer energy through space. Magnets or electric currents cause magnetic fields; electric charges or changing magnetic fields cause electric fields. (HS-PS2-5) **PS3.A: Definitions of Energy**	**Patterns** · Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena. (HS-PS2-4) **Cause and Effect** · Systems can be designed to cause a desired effect. (HS-PS2-3) · Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. (HS-PS2-5) ---------------------------------- - ***Connections to Nature of Science*** **Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena** · Theories and laws provide explanations in science. (HS-PS2-4) · Laws are statements or descriptions of the relationships among observable phenomena. (HS-PS2-4)

	“Electrical energy” may mean energy stored in a battery or energy transmitted by electric currents. *(secondary HS-PS2-5)*·	

Grade 8 Unit 6: Forms of Energy **Approximate Instructional Days: 20**

Unit Summary
Essential Questions: How is energy transferred and conserved? In this unit, students use the practices of *analyzing and interpreting data*, *developing and using models*, and *engaging in argument from evidence* to make sense of the relationship between energy and forces. Students develop their understanding of important qualitative ideas about the conservation of energy. Students understand that objects that are moving have kinetic energy and that objects may also contain stored (potential) energy, depending on their relative positions. Students also understand the difference between energy and temperature, and the relationship between forces and energy. The crosscutting concepts of *scale, proportion, and quantity*, *systems and system models*, and *energy and matter* are called out as organizing concepts for these disciplinary core ideas. Students use the practices of *analyzing and interpreting data*, *developing and using models*, and *engaging in argument from evidence*. Students are also expected to use these practices to demonstrate an understanding of the core ideas.
Student Learning Objectives
Construct and interpret graphical displays of data to describe the relationships of kinetic energy to the mass of an object and the speed of an object. ***[Clarification Statement: Emphasis is on descriptive relationships between kinetic energy and mass separately from kinetic energy and speed. Examples could include riding a bicycle at different speeds, rolling different sizes of rocks downhill, and getting hit by a wiffle ball versus a tennis ball.]*** **(MS-PS3-1)**
Develop a model to describe that when the arrangement of objects interacting at a distance changes, different amounts of potential energy are stored in the system. ***[Clarification Statement: Emphasis is on relative amounts of potential energy, not on calculations of potential energy. Examples of objects within systems interacting at varying distances could include: the Earth and either a roller coaster cart at varying positions on a hill or objects at varying heights on shelves, changing the direction/orientation of a magnet, and a balloon with static electrical charge being brought closer to a classmate's hair. Examples of models could include representations, diagrams, pictures, and written descriptions of systems.] [Assessment Boundary: Assessment is limited to two objects and electric, magnetic, and gravitational interactions.]*** **(MS-PS3-2)**
Construct, use, and present arguments to support the claim that when the kinetic energy of an object changes, energy is transferred to or from the object. ***[Clarification Statement: Examples of empirical evidence used in arguments could include an inventory or other representation of the energy before and after the transfer in the form of temperature changes or motion of object.] [Assessment Boundary: Assessment does not include calculations of energy.]*** **(MS-PS3-5)**
Possible Student Misconceptions (based on research):
Students tend to think that energy transformations involve only one form of energy at a time. Although they develop some skill in identifying different forms of energy, in most cases their descriptions of energy-change focus only on forms which have perceivable effects. Finally, it may not be clear to students that some forms of energy, such as light, sound, and chemical energy, can be used to make things happen. The idea of energy conservation seems counterintuitive to middle- school students who hold on to the everyday use of the term energy. Even after instruction, however, students do not seem to appreciate that energy conservation is a useful way to explain phenomena. A key difficulty students have in understanding conservation appears to derive from not considering the appropriate system and environment. In addition, middle school students tend to use their conceptualizations of energy to interpret energy conservation ideas. For example, some students interpret the idea that "energy is not created or destroyed" to mean that energy is stored up in the system and can even be released again in its original form. Or, students may believe that no energy remains at the end of a process, but may say that "energy is not lost" because an effect was caused during the process (for example, a weight was lifted) (NSDL, 2015)

Unit Sequence
Part A - Essential Question: ***What is the relationship between the kinetic energy of an object and its velocity and mass?***
Concepts/ Enduring Understanding
• Kinetic energy is related to the mass of an object and the speed of an object. • Kinetic energy has a relationship to mass separate from its relationship to speed. • Motion energy is properly called kinetic energy; it is proportional to the mass of the moving object and grows with the square of the object's speed. • Proportional relationships among different types of quantities provide information about the magnitude of properties and processes.
Formative Assessment
Students who understand the concepts are able to: • Construct and interpret graphical displays of data to identify linear and nonlinear relationships of kinetic energy to the mass of an object and the speed of an object.
Recommended Activities/Assessments
• Activities: Interpret graphs showing the relationship between kinetic energy and mass and kinetic energy and speed (increase either of the factor mass or speed) • Construct a line graph showing the relationship between kinetic energy and the mass of an object.
Resources
• McGraw Hill iScience Textbook- Chapter 5 Lesson 1 (pages 160-167) • Discovery Education Techbook- Types of energy (2.1)
Part B - Essential Question: ***How is kinetic energy transformed into potential energy?***
Concepts/ Enduring Understanding

- When the arrangement of objects interacting at a distance changes, different amounts of potential energy are stored in the system.
- A system of objects may contain stored (potential) energy, depending on the objects' relative positions.
- When two objects interact, each one exerts a force on the other that can cause energy to be transferred to or from the objects.
- Models that could include representations, diagrams, pictures, and written descriptions of systems can be used to represent systems and their interactions, such as inputs, processes, outputs, and energy and matter flows within systems.

Formative Assessment

Students who understand the concepts are able to:

- Develop a model to describe what happens to the amount of potential energy stored in the system when the arrangement of objects interacting at a distance changes
- Use models to represent systems and their interactions, such as inputs, processes, and outputs, and energy and matter flows within systems. Models could include representations, diagrams, pictures, and written descriptions

Recommended Activities/Assessments

- Activities to allow students to develop models for the effect of mass and height on the potential energy of an object.

Resources

- McGraw Hill iScience Textbook- Chapter 5 Lesson 2 (pages 168-175)
- Discovery Education Techbook- Types of energy (2.1, 2.2)

Part C - Essential Question: ***Who can design the best roller coaster?***

Concepts/ Enduring Understanding

- When the kinetic energy of an object changes, energy is transferred to or from the object.
- When the motion energy of an object changes, there is inevitably some other change in energy at the same time.
- Kinetic energy may take different forms (e.g. energy in fields, thermal energy, and energy of motion).

Formative Assessment

Students who understand the concepts can:

- Construct, use, and present oral and written arguments supported by empirical evidence and scientific reasoning to support the claim that when the kinetic energy of an object changes, energy is transferred to or from the object.
- Conduct an inventory or other representation of the energy before and after the transfer in the form of temperature changes or motion of an object. Do not include calculations of energy.

Recommended Activities/Assessments

- Better Lesson: Designing a Roller Coaster
- Roller Coaster Web Research
- CER Investigation - Relationship between energy transfer and change in kinetic energy
- District Unit 6 Common Assessment (includes Part A, B & C)
- District MP 3 Benchmark Assessment

Resources

- McGraw Hill iScience Textbook- Chapter 5 Lesson 1 (pages 160-167)
- McGraw Hill iScience Textbook- Chapter 5 Lesson 2 (pages 168-175)
- Discovery Education Techbook-Types of energy (2.1, 2.2)

Common Core Standards Alignment

ELA/Literacy	Mathematics	Technology	Career Ready Practice
Cite specific textual evidence to support analysis of science and technical texts, attending to the precise details of explanations or descriptions. *(MS-PS3-1),(MS-PS3-5)* **RST.6-8.1** Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table). (MS-PS3-1) **RST.6-8.7** Write arguments focused on discipline content. *(MS-PS3-5)* **WHST.6-8.1** Conduct short research projects to answer a question (including a self-generated question), drawing on several sources and generating additional related, focused questions that allow for multiple avenues of exploration. (MS-PS3-3) **WHST.6-8.7**	Reason abstractly and quantitatively. (MS-PS3-1),(MS-PS3-5) **MP.2** Understand the concept of ratio and use ratio language to describe a ratio relationship between two quantities. (MS-PS3-1),(MS-PS3-5) **6.RP.A.1** Understand the concept of a unit rate a/b associated with a ratio a:b with b ≠ 0, and use rate language in the context of a ratio relationship. (MS-PS3-1) **6.RP.A.2** Recognize and represent proportional relationships between quantities. (MS-PS3-1),(MS-PS3-5) **7.RP.A.2** Know and apply the properties of integer exponents to generate equivalent numerical expressions. (MS-PS3-1) **8.EE.A.1** Use square root and cube root symbols to represent solutions to equations of the form $x^2 = p$ and $x^3 = p$, where p is a positive	8.1.8.A.1 Demonstrate knowledge of a real world problem using digital tools	CRP8. Utilize critical thinking to make sense of problems and persevere in solving them.

Integrate multimedia and visual displays into presentations to clarify information, strengthen claims and evidence, and add interest. *(MS-PS3-2)* **SL.8.5**	rational number. Evaluate square roots of small perfect squares and cube roots of small perfect cubes. Know that √2 is irrational. (MS-PS3-1) **8.EE.A.2** Interpret the equation y = mx + b as defining a linear function, whose graph is a straight line; give examples of functions that are not linear. (MS-PS3-1),(MS-PS3-5) **8.F.A.3**		

Next Generation Science Standards and Foundations for the Unit
The performance expectations above were developed using the following elements from A Framework for K-12 Science Education:

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Developing and Using Models • **Develop a model to describe unobservable mechanisms. (MS-PS3-2)** **Analyzing and Interpreting Data** • **Construct and interpret graphical displays of data to identify linear and nonlinear relationships. (MS-PS3-1)** **Engaging in Argument from Evidence** · **Construct, use, and present oral and written arguments supported by empirical evidence and scientific reasoning to support or refute an explanation or a model for a phenomenon. (MS-PS3-5)** ***Connections to Nature of Science*** **Scientific Knowledge is Based on Empirical Evidence** Science knowledge is based upon logical and conceptual connections between evidence and explanations (MS-PS3-5)	**PS3.A: Definitions of Energy** · Motion energy is properly called kinetic energy; it is proportional to the mass of the moving object and grows with the square of its speed. (MS-PS3-1) · A system of objects may also contain stored (potential) energy, depending on their relative positions. (MS-PS3-2) **PS3.B: Conservation of Energy and Energy Transfer** · When the motion energy of an object changes, there is inevitably some other change in energy at the same time. (MS-PS3-5) **PS3.C: Relationship Between Energy and Forces** · When two objects interact, each one exerts a force on the other that can cause energy to be transferred to or from the object. (MS-PS3-2)	**Scale, Proportion, and Quantity** · Proportional relationships (e.g. speed as the ratio of distance traveled to time taken) among different types of quantities provide information about the magnitude of properties and processes. (MS-PS3-1) **Systems and System Models** · Models can be used to represent systems and their interactions – such as inputs, processes, and outputs – and energy and matter flows within systems. (MS-PS3-2) **Energy and Matter** Energy may take different forms (e.g. energy in fields, thermal energy, energy of motion). (MS-PS3-5)

Grade 8 Unit 7: Thermal Energy **Approximate Instructional Days: 20**

Unit Summary
Essential Questions: What is the relationship between thermal energy, temperature, and the motion of molecules in a substance? In this unit, students *ask questions*, *plan and carry out investigations*, *engage in argument from evidence*, *analyze and interpret data, construct explanations*, *define problems and design solutions* as they make sense of the difference between energy and temperature. They use the practices to make sense of how the total change of energy in any system is always equal to the total energy transferred into or out of the system. The crosscutting concepts of *energy and matter, scale, proportion, and quantity*, and *influence of science, engineering, and technology on society and the natural world* are the organizing concepts for these disciplinary core ideas. Students ask *questions*, *plan and carry out investigations*, *engage in argument from evidence*, *analyze and interpret data*, *construct explanations*, *define problems and design solutions.* Students are also expected to use these practices to demonstrate an understanding of the core ideas
Student Learning Objectives
Apply scientific principles to design, construct, and test a device that either minimizes or maximizes thermal energy transfer. ***[Clarification Statement: Examples of devices could include an insulated box, a solar cooker, and a Styrofoam cup.] [Assessment Boundary: Assessment does not include calculating the total amount of thermal energy transferred.]*** **(MS-PS3-3)**
Plan an investigation to determine the relationships among the energy transferred, the type of matter, the mass, and the change in the average kinetic energy of the particles as measured by the temperature of the sample. ***[Clarification Statement: Examples of experiments could include comparing final water temperatures after different masses of ice melted in the same volume of water with the same initial temperature, the temperature change of samples of different materials with the same mass as they cool or heat in the environment, or the same material with different masses when a specific amount of energy is added.] [Assessment Boundary: Assessment does not include calculating the total amount of thermal energy transferred.]*** **(MS-PS3-4**
Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem. (MS-ETS1-2)
Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success. (MS-ETS1-3)
Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved. (MS-ETS1-4)
Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions. (MS-ETS1-1)
Possible Student Misconceptions (based on research):
Students tend to think that energy transformations involve only one form of energy at a time. Although they develop some skill in identifying different forms of energy, in most cases their descriptions of energy-change focus only on forms which have perceivable effects. Finally, it may not be clear to students that some forms of energy, such as light, sound, and chemical energy, can be used to make things happen.

The idea of energy conservation seems counterintuitive to middle- school students who hold on to the everyday use of the term energy. Even after instruction, however, students do not seem to appreciate that energy conservation is a useful way to explain phenomena. A key difficulty students have in understanding conservation appears to derive from not considering the appropriate system and environment. In addition, middle school students tend to use their conceptualizations of energy to interpret energy conservation ideas. For example, some students interpret the idea that "energy is not created or destroyed" to mean that energy is stored up in the system and can even be released again in its original form. Or, students may believe that no energy remains at the end of a process, but may say that "energy is not lost" because an effect was caused during the process (for example, a weight was lifted) (NSDL, 2015)

Unit Sequence

Part A - Essential Question: ***How can a standard thermometer be used to tell you how particles are behaving?***

Concepts/ Enduring Understanding

- There are relationships among the energy transferred, the type of matter, the mass, and the change in the average kinetic energy of particles as measured by the temperature of the sample.
- Temperature is a measure of the average kinetic energy of particles of matter.
- The amount of energy transfer needed to change the temperature of a matter sample by a given amount depends on the nature of the matter, the size of the sample, and the environment.
- Proportional relationships among the amount of energy transferred, the mass, and the change in the average kinetic energy of particles as measured by temperature of the sample provide information about the magnitude of properties and processes.

Formative Assessment

Students who understand the concepts are able to:

- Individually and collaboratively plan an investigation to determine the relationships among the energy transferred, the type of matter, the mass, and the change in the average kinetic energy of particles as measured by the temperature of the sample.
- As part of a planned investigation, identify independent and dependent variables and controls, what tools are needed to do the gathering, how measurements will be recorded, and how many data are needed to support a claim.
- Make logical and conceptual connections between evidence and explanations.

Recommended Activities/Assessments

- Lab Investigation - Students will plan and carry out an investigation to determine the relationships among the energy transferred, the type of matter, the mass, and the change in the average kinetic energy of particles as measured by the temperature of the sample.
- Activities to brainstorm(sketch, graphic organizer, written response) what might happen if student changes the temperature in the sample of a matter, guide students to identify which variables should be tested

Resources
● McGraw Hill iScience Textbook- Chapter 6 Lesson 1 (199-201) ● Discovery Education Techbook Types of energy (2.3)
Part B - Essential Question: ***How do different materials respond to thermal energy and how it is transferred?***
Concepts/ Enduring Understanding
● The relationship between the temperature and the total energy of a system depends on the types, states, and amounts of matter present. ● Energy is spontaneously transferred out of hotter regions or objects and into colder ones. ● The transfer of energy can be tracked as energy flows through a designed or natural system. ● The more precisely a design task's criteria and constraints can be defined, the more likely it is that the designed solution will be successful. ● Specification of constraints includes consideration of scientific principles and other relevant knowledge that is likely to limit possible solutions. ● A solution needs to be tested and then modified on the basis of the test results in order to improve it ● There are systematic processes for evaluating solutions with respect to how well they meet the criteria and constraints of a problem.
Formative Assessment
Students who understand the concepts are able to: ● Apply scientific ideas or principles to design, construct, and test a design of a device that either minimizes or maximizes thermal energy transfer. ● Determine design criteria and constraints for a device that either minimizes or maximizes thermal energy transfer. ● Test design solutions and modify them on the basis of the test results in order to improve them. ● Use a systematic process for evaluating solutions with respect to how well they meet criteria and constraints.
Recommended Activities/Assessments
● Design, construct and test a design of a device that either minimizes or maximizes thermal energy transfer given the design constraints. Examples of devices could include an insulated box, a solar cooker, and a Styrofoam cup. ● Determine design criteria and constraints ● Test and improve the design on the basis of the results ● District Unit 7 Common Assessment
Resources

- McGraw Hill iScience Textbook- Chapter 6 Lessons 2 & 3 (205-221)
- Discovery Education Techbook: Types of energy (2.3)

Common Core Standards Alignment

ELA/Literacy	Mathematics	Technology	Career Ready Practice
Cite specific textual evidence to support analysis of science and technical texts. (MS-PS3-5),MS-ETS1-1),(MS-ETS1-2),(MS-ETS1-3) **RST.6-8.1** Follow precisely a multistep procedure when carrying out experiments, taking measurements, or performing technical tasks. (MS-PS3-3),(MS-PS3-4) **RST.6-8.3** Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table). (MS-PS3-3),(MS-PS3-4),(MS-ETS1-3) **RST.6-8.7** Compare and contrast the information gained from experiments, simulations, videos, or multimedia sources with that gained from reading a text on the same topic. (MS-ETS1-2),(MS-ETS1-3) **RST.6-8.9** Conduct short research projects to answer a question (including a self-generated question), drawing on several sources and generating additional related, focused questions that allow for multiple avenues of exploration. (MS-ETS1-2) **WHST.6-8.7** Gather relevant information from multiple print and digital sources, using search terms effectively; assess the credibility and accuracy of each source; and quote or paraphrase the data and conclusions of others while avoiding plagiarism and following a standard format for citation. (MS-ETS1-1) **WHST.6-8.8** Draw evidence from informational texts to support analysis, reflection, and research. (MS-ETS1-2) **WHST.6-8.9** Integrate multimedia and visual displays into presentations to clarify information,strengthen claims and evidence, and add interest. (MS-ETS1-4) **SL.8.5**	Reason abstractly and quantitatively. (MS-PS3-4),(MS-ETS1-1),(MS-ETS1-2),(MS-ETS1-3),(MS-ETS1-4) **MP.2** Summarize numerical data sets in relation to their context. (MS-PS3-4) **6.SP.B.5** Solve multi-step real-life and mathematical problems posed with positive and negative rational numbers in any form (whole numbers, fractions, and decimals), using tools strategically. Apply properties of operations to calculate with numbers in any form; convert between forms as appropriate; and assess the reasonableness of answers using mental computation and estimation strategies. (MS-ETS1-1),(MS-ETS1-2),(MS-ETS1-3) **7.EE.3** Develop a probability model and use it to find probabilities of events. Compare probabilities from a model to observed frequencies; if the agreement is not good, explain possible sources of the discrepancy. (MS-ETS1-4) **7.SP**	8.1.8.A.1 Demonstrate knowledge of a real world problem using digital tools.	CRP8. Utilize critical thinking to make sense of problems and persevere in solving them.

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Science and Engineering Practices	**Disciplinary Core Ideas**	**Crosscutting Concepts**
Developing and Using Models • **Develop a model to describe unobservable mechanisms. (MS-PS3-2)** **Analyzing and Interpreting Data** • **Construct and interpret graphical displays of data to identify linear and nonlinear relationships. (MS-PS3-1)** **Engaging in Argument from Evidence** · **Construct, use, and present oral and written arguments supported by empirical evidence and scientific reasoning to support or refute an explanation or a model for a phenomenon. (MS-PS3-5)** ------------------------------------ ***Connections to Nature of Science*** **Scientific Knowledge is Based on Empirical Evidence** Science knowledge is based upon logical and conceptual connections between evidence and explanations (MS-PS3-5)	**PS3.A: Definitions of Energy** · Motion energy is properly called kinetic energy; it is proportional to the mass of the moving object and grows with the square of its speed. (MS-PS3-1) · A system of objects may also contain stored (potential) energy, depending on their relative positions. (MS-PS3-2) **PS3.B: Conservation of Energy and Energy Transfer** · When the motion energy of an object changes, there is inevitably some other change in energy at the same time. (MS-PS3-5) **PS3.C: Relationship Between Energy and Forces** · When two objects interact, each one exerts a force on the other that can cause energy to be transferred to or from the object. (MS-PS3-2)	**Scale, Proportion, and Quantity** · Proportional relationships (e.g. speed as the ratio of distance traveled to time taken) among different types of quantities provide information about the magnitude of properties and processes. (MS-PS3-1) **Systems and System Models** · Models can be used to represent systems and their interactions – such as inputs, processes, and outputs – and energy and matter flows within systems. (MS-PS3-2) **Energy and Matter** Energy may take different forms (e.g. energy in fields, thermal energy, energy of motion). (MS-PS3-5)

Grade 8 Unit 8: Energy and Waves **Approximate Instructional Days: 20**

Unit Summary
Essential Questions: ***How are waves used to transfer energy and information?*** In this unit of study, students *develop and use models, use mathematical thinking,* and *obtain, evaluate, and communicate information* in order to describe and predict characteristic properties and behaviors of waves. Students also apply their understanding of waves as a means of sending digital information. The crosscutting concepts of *patterns* and *structure and function* are used as organizing concepts for these disciplinary core ideas. Students *develop and use models, use mathematical thinking,* and *obtain, evaluate, and communicate information.* Students are also expected to use these practices to demonstrate an understanding of the core ideas
Student Learning Objectives
Use mathematical representations to describe a simple model for waves that includes how the amplitude of a wave is related to the energy in a wave. ***[Clarification Statement: Emphasis is on describing waves with both qualitative and quantitative thinking.] [Assessment Boundary: Assessment does not include electromagnetic waves and is limited to standard repeating waves.]*** **(MS-PS4-1)**
Develop and use a model to describe that waves are reflected, absorbed, or transmitted through various materials. ***[Clarification Statement: Emphasis is on both light and mechanical waves. Examples of models could include drawings, simulations, and written descriptions.] [Assessment Boundary: Assessment is limited to qualitative applications pertaining to light and mechanical waves.]*** **(MS-PS4-2)**
Integrate qualitative scientific and technical information to support the claim that digitized signals are a more reliable way to encode and transmit information than analog signals. ***[Clarification Statement: Emphasis is on a basic understanding that waves can be used for communication purposes. Examples could include using fiber optic cable to transmit light pulses, radio wave pulses in wifi devices, and conversion of stored binary patterns to make sound or text on a computer screen.] [Assessment Boundary: Assessment does not include binary counting. Assessment does not include the specific mechanism of any given device.]*** **(MS-PS4-3)**
Part A - Essential Question: ***What are the characteristics and properties of waves?***
Concepts/ Enduring Understanding
• A simple wave has a repeating pattern with a specific wavelength, frequency, and amplitude. • Describe a simple model for waves that includes how the amplitude of a wave is related to the energy in a wave. • Graphs and charts can be used to identify patterns in data. • Waves can be described with both qualitative and quantitative thinking.
Formative Assessment

Students who understand the concepts are able to:

- Use mathematical representations to describe and/or support scientific conclusions about how the amplitude of a wave is related to the energy in a wave.
- Use mathematical representations to describe a simple model.

Recommended Activities/Assessments

- Activities using a slinky to make a small wave, and then increase the energy input and observe that an increase in energy results in an increase in the amplitude of the wave.
- Use teacher provided graphs and charts to identify patterns in the data
- Representations that students can use as evidence to provide scientific conclusions about amplitude and energy of the wave.
- Waves on a string (Students will learn about frequency, amplitude, how to calculate the speed of sound, and sound waves)

Resources

- McGraw Hill iScience Textbook- Chapter 15 Lesson 1 (pages 528-537)
- McGraw Hill iScience Textbook- Chapter 15 Lesson 2 (pages 538-545)
- Discovery Education Techbook- Energy and Waves(3.5)

Part B - Essential Question: ***How do sound waves and light waves carry energy differently?***

Concepts/ Enduring Understanding

- When light shines on an object, it is reflected, absorbed, or transmitted through the object, depending on the object's material and the frequency (color) of the light.
- The path that light travels can be traced as straight lines, except at surfaces between different transparent materials (e.g., air and water, air and glass) where the light path bends.
- A wave model of light is useful for explaining brightness, color, and the frequency-dependent bending of light at a surface between media.
- Waves are reflected, absorbed, or transmitted through various materials.
- A sound wave needs a medium through which it is transmitted.
- Because light can travel through space, it cannot be a matter (mechanical) wave, like sound or water waves.
- The structure of a wave can be modified to serve particular functions by taking into account properties of different materials and how materials can be shaped and used.

Formative Assessment

Students who understand the concepts are able to:

- Develop and use models to describe the movement of waves in various materials.

Recommended Activities/Assessment
• Activity: Have students develop and use models to describe the movement of waves in various mediums. Students can observe the behavior of ways by using a penlight and tracing the path that light travels between different transparent materials (e.g., air and water, air and glass. Students could also shine a light through a prism onto a screen or piece of paper; observe a pencil in a glass of water. • Plan activities to demonstrate the importance of medium for sound waves to travel for example For example Alarm Clock Demonstration Sound Waves: Students will learn about frequency, amplitude, how to calculate the speed of sound, and sound waves. Electromagnetic Math is designed to supplement teaching about electromagnetism.
Resources
• McGraw Hill iScience Textbook- Chapter 15 Lesson 3 (pages 546-553) • McGraw Hill iScience Textbook- Chapter 18 Lesson 2 (pages 642-647) • McGraw Hill iScience Textbook- Chapter 18 Lesson 3 (pages 649-658) • Discovery Education Techbook-Unit 3 Energy and Waves (3.1, 3.2, 3.3, 3.6)
Part C* - Essential Question: *How are instruments that transmit and detect waves used to expand human senses?
Concepts/ Enduring Understanding
• Structures can be designed to use properties of waves to serve particular functions. • Waves can be used for communication purposes. • Digitized signals (sent as wave pulses) are a more reliable way to encode and transmit information than are analog signals. • Wave-related technologies extend the measurement, exploration, modeling, and computational capacity of scientific investigations.
Formative Assessment
Students who understand the concepts can: • *Integrate qualitative scientific and technical information in written text with that contained in media and visual displays to clarify claims that digitized signals are a more reliable way to encode and transmit information than analog signals are.*
Recommended Activities/Assessment
• Construct models of the Electromagnetic Spectrum • Opportunities where students obtain, evaluate, and communicate information that allows them to argue the merits and limitations of analog and digital devices such as clocks, recording devices, and measurement tools.

Resources
• McGraw Hill iScience Textbook- Chapter 15 Lesson 2 (pages 538-545) • McGraw Hill iScience Textbook- Chapter 17 Lesson 2 (pages 608-612) • McGraw Hill iScience Textbook- Chapter 17 Lesson 3 (pages 614-623) • Discovery Education Techbook-Unit 3 Energy and Waves (3.4, 3.7)
Common Core Standards Alignment

ELA/Literacy	Mathematics	Technology	Career Ready Practice
Cite specific textual evidence to support analysis of science and technical texts. (MS-PS4-3) **RST.6-8.1** Determine the central ideas or conclusions of a text; provide an accurate summary of the text distinct from prior knowledge or opinions. (MS-PS4-3) **RST.6-8.2** Compare and contrast the information gained from experiments, simulations, videos, or multimedia sources with that gained from reading a text on the same topic. (MS-PS4-3) **RST.6-8.9** Draw evidence from informational texts to support analysis, reflection, and research. (MS-PS4-3) **WHST.6-8.9** Integrate multimedia and visual displays into presentations to clarify information, strengthen claims and evidence, and add interest. (MS-PS4-1),(MS-PS4-2) **SL.8.5**	Reason abstractly and quantitatively. (MS-PS4-1) **MP.2** Model with mathematics. (MS-PS4-1) **MP.4** Understand the concept of a ratio and use ratio language to describe a ratio relationship between two quantities. (MS-PS4-1) **6.RP.A.1** Use ratio and rate reasoning to solve real-world and mathematical problems. (MS-PS4-1) **6.RP.A.3** Recognize and represent proportional relationships between quantities. (MS-PS4-1) **7.RP.A.2** Interpret the equation y = mx + b as defining a linear function, whose graph is a straight line; give examples of functions that are not linear. (MS-PS4-1) **8.F.A.3**	**8.1.8.A.1** Demonstrate knowledge of a real world problem using digital tools	**CRP8.** Utilize critical thinking to make sense of problems and persevere in solving them.

Next Generation Science Standards and Foundations for the Unit
The performance expectations above were developed using the following elements from A Framework for K-12 Science Education:

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts

Using Mathematics and Computational Thinking

- Use mathematical representations to describe and/or support scientific conclusions and design solutions. (MS-PS4-1)

Developing and Using Models

- Develop and use a model to describe phenomena. (MS-PS4-2)

Obtaining, Evaluating, and Communicating Information

- Integrate qualitative scientific and technical information in written text with that contained in media and visual displays to clarify claims and findings. (MS-PS4-3)

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Connections to Nature of Science

Scientific Knowledge is Based on Empirical Evidence

- Science knowledge is based upon logical and conceptual connections between evidence and explanations. (MS-PS4-1)

PS4.A: Wave Properties

- A simple wave has a repeating pattern with a specific wavelength, frequency, and amplitude. (MS-PS4-1)
- A sound wave needs a medium through which it is transmitted. (MS-PS4-2)

PS4.B: Electromagnetic Radiation

- When light shines on an object, it is reflected, absorbed, or transmitted through the object, depending on the object's material and the frequency (color) of the light. (MS-PS4-2)
- The path that light travels can be traced as straight lines, except at surfaces between different transparent materials (e.g., air and water, air and glass) where the light path bends. (MS-PS4-2)
- A wave model of light is useful for explaining brightness, color, and the frequency-dependent bending of light at a surface between media. (MS-PS4-2)
- However, because light can travel through space, it cannot be a matter wave, like sound or water waves. (MS-PS4-2)

PS4.C: Information Technologies and Instrumentation

Digitized signals (sent as wave pulses) are a more reliable way to encode and transmit information. (MS-PS4-3)

Patterns

- Graphs and charts can be used to identify patterns in data. (MS-PS4-1)

Structure and Function

- Structures can be designed to serve particular functions by taking into account properties of different materials, and how materials can be shaped and used. (MS-PS4-2)
- Structures can be designed to serve particular functions. (MS-PS4-3)

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Connections to Engineering, Technology, and Applications of Science

Influence of Science, Engineering, and Technology on Society and the Natural World

- Technologies extend the measurement, exploration, modeling, and computational capacity of scientific investigations. (MS-PS4-3)

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Connections to Nature of Science

Science is a Human Endeavor

Advances in technology influence the progress of science and science has influenced advances in technology. (MS-PS4-3)