

Fairfield Public Schools Science Curriculum

Draft Units

Grade 8



FAIRFIELD
PUBLIC SCHOOLS

Grade 8 Science: Description

Full course description

Students in middle school continue to develop understanding of four core ideas in the physical sciences. The middle school performance expectations in the Physical Sciences build on the ideas and capabilities that allow learners to explain phenomena. The performance expectations blend the core ideas with scientific and engineering practices and crosscutting concepts to support students in developing useable knowledge to explain real world phenomena. Performance expectations at the middle school level focus on students developing understanding of several scientific practices that demonstrate the core ideas. Some of these practices include developing and using models, planning and conducting investigations, analyzing and interpreting data, and constructing explanations for scientific phenomenon. Students are also expected to demonstrate understanding of several of engineering practices including design and evaluation.

Standards for this course are taken from the *Next Generation Science Standards* and are of three types:

Disciplinary Core Ideas: Shown as content objectives, these standards define what students should know about the most essential ideas in the major science disciplines. The focus is on a limited number of core ideas in science and engineering both within and across the disciplines to avoid the shallow coverage of a large number of topics and to allow more time for teachers and students to explore each idea in greater depth. Reduction of the sheer sum of details to be mastered is intended to give time for students to engage in scientific investigations and argumentation and to achieve depth of understanding of the core ideas presented.

Science and Engineering Practices: These standards enable students to apply the content in the DCI's and the skills of practicing scientists and engineers to explain phenomena and solve real world problems. Engaging in the practices of science helps students understand how scientific knowledge develops; such direct involvement gives them an appreciation of the wide range of approaches that are used to investigate, model, and explain the world. Engaging in the practices of engineering likewise helps students understand the work of engineers, as well as the links between engineering and science.

Cross-cutting Concepts: These standards provide students with connections and intellectual tools that are related across the differing areas of disciplinary content and can enrich their application of practices and their understanding of core ideas. These broad concepts tie together the influence of engineering, technology, and science on society and the natural world.

<http://www.nextgenscience.org/next-generation-science-standards>

CROSS CUTTING CONCEPTS

Patterns: Observed patterns of forms and events guide organization and classification, and they prompt questions about relationships and the factors that influence them.

Cause and effect: Mechanism and explanation. Events have causes, sometimes simple, sometimes multifaceted. A major activity of science is investigating and explaining causal relationships and the mechanisms by which they are mediated. Such mechanisms can then be tested across given contexts and used to predict and explain events in new contexts.

Scale, proportion, and quantity. In considering phenomena, it is critical to recognize what is relevant at different measures of size, time, and energy and to recognize how changes in scale, proportion, or quantity affect a system's structure or performance.

Systems and system models. Defining the system under study—specifying its boundaries and making explicit a model of that system—provides tools for understanding and testing ideas that are applicable throughout science and engineering.

Energy and matter: Flows, cycles, and conservation. Tracking fluxes of energy and matter into, out of, and within systems helps one understand the systems' possibilities and limitations.

Structure and function. The way in which an object or living thing is shaped and its substructure determine many of its properties and functions.

Stability and change. For natural and built systems alike, conditions of stability and determinants of rates of change or evolution of a system are critical elements of study.

Grade 8 Science: Overview

Course Essential Questions

- How can one describe physical interactions between objects and within systems of objects?
- How can energy be transferred from one object or system to another?
- What are the characteristic properties of waves and how can they be used?
- How do atomic and molecular interactions explain the properties of matter?

Monitoring Student Progress

Students' progress in relation to the content and skill standards will be measured with teacher-generated, as well as district-wide, formative and summative assessments in the following areas:

1. Determine the central ideas or information of scientific content and process; provide an accurate synthesis that makes clear the relationships among the key details and ideas

**Course:
Year-at-a
Glance**

Unit	Title	Unit Essential Questions
1	Forces and Interactions	<ul style="list-style-type: none"> ● Why do we know that forces exist if we cannot see them? ● How can we predict the effect of forces on the motion of objects? ● What evidence can we collect to show that forces exist between objects that are not in contact? ● What factors affect the strength of electric, magnetic, and gravitational forces?
2	Energy	<ul style="list-style-type: none"> ● What is the relationship of an object's kinetic energy to its mass and speed? ● How can technology be used to construct a device that minimizes or maximizes thermal energy transfer? ● How do changes to the arrangement of objects affect the potential energy stored in the system? ● How is temperature affected by thermal energy transfer, type of matter and mass of sample?
3	Waves and Electromagnetic Radiation	<ul style="list-style-type: none"> ● How can a wave be qualitatively and quantitatively be described? ● How are waves reflected, absorbed or transmitted through various materials? ● How are waves used for communication purposes?

4	Matter and its Interactions	<ul style="list-style-type: none">● How can models be used to describe the atomic composition of simple molecules and extended structures● How can data on the property of substances before and after the substances react be used to determine if a chemical reaction has occurred?● How do we use natural resources to make synthetic materials and how does doing so impact society?● What is the effect on particle motion, temperature, and state of a pure substance when thermal energy is added or removed?● How can models be used to describe that the total number of atoms does not change in a chemical reaction and thus mass is conserved?● How can a device be constructed that either releases or absorbs thermal energy by chemical or physical processes?
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Motion and Stability: Forces and Interactions

Overview

The performance expectations in **Motion and Stability: Forces and Interactions** focuses on helping students understand ideas related to why some objects will keep moving, why objects fall to the ground and why some materials are attracted to each other while others are not. Students answer the question, “How can one describe physical interactions between objects and within systems of objects?” At the middle school level, the PS2 Disciplinary Core Idea from the NRC Framework is broken down into two sub-ideas: Forces and Motion and Types of interactions. By the end of middle school, students will be able to apply Newton’s Third Law of Motion to relate forces to explain the motion of objects. Students also 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 will develop understanding 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 through fields even though they are not in contact, through fields. Students are also able to apply an engineering practice and concept to solve a problem caused when objects collide. The crosscutting concepts of cause and effect; system and system models; stability and change; and the influence of science, engineering, and technology on society and the natural world serve as organizing concepts for these disciplinary core ideas. In the performance expectations, students are expected to demonstrate proficiency in asking questions, planning and carrying out investigations, and designing solutions, and engaging in argument; and to use these practices to demonstrate understanding of the core ideas.

Unit Content Objectives

At the conclusion of this unit, students will be able to:

- **Apply Newton’s Third Law to design a solution to a problem involving the motion of two colliding objects.* (Engineering)**
- 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.
- Ask questions about data to determine the factors that affect the strength of electric and magnetic forces
- Construct and present arguments using evidence to support the claim that gravitational interactions are attractive and depend on the masses of interacting objects.
- 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.

Unit Essential Questions

- Why do we know that forces exist if we cannot see them?
- How can we predict the effect of forces on the motion of objects?
- What evidence can we collect to show that forces exist between objects that are not in contact?
- What factors affect the strength of electric, magnetic, and gravitational forces?

Crosscutting Concepts

- Cause and Effect
- Systems and System Models
- Stability and Change

NGSS Unit Standards

DISCIPLINARY CORE IDEAS (DCI):

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)

PS2.B: Types of Interactions

- ♣ Electric and magnetic (electromagnetic) forces can be attractive or repulsive, and their sizes depend on the magnitudes of the charges, currents, or magnetic strengths involved and on the distances between the interacting objects. (MS-PS2-3)
- ♣ Gravitational forces are always attractive. 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—e.g., Earth and the sun. (MS-PS2-4)
- ♣ 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). (MS-PS2-5)

SCIENCE AND ENGINEERING PRACTICES (SEP):**Asking Questions and Defining Problems**

Asking questions and defining problems in grades 6–8 builds from grades K–5 experiences and progresses to specifying relationships between variables, and clarifying arguments and models.

♣ Ask questions 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. (MS-PS2-3)

Planning and Carrying Out Investigations

Planning and carrying out investigations to answer questions or test solutions to problems in 6–8 builds on K–5 experiences and progresses to include investigations that use multiple variables and provide evidence to support explanations or design solutions.

♣ 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)

♣ Conduct an investigation and evaluate the experimental design to produce data to serve as the basis for evidence that can meet the goals of the investigation. (MS-PS2-5)

Constructing Explanations and Designing Solutions

Constructing explanations and designing solutions in 6–8 builds on K–5 experiences and progresses to include constructing explanations and designing solutions supported by multiple sources of evidence consistent with scientific ideas, principles, and theories.

♣ Apply scientific ideas or principles to design an object, tool, process or system. (MS-PS2-1)

Engaging in Argument from Evidence

Engaging in argument from evidence in 6–8 builds from K–5 experiences and progresses to constructing a convincing argument that supports or refutes claims for either explanations or solutions about the natural and designed world.

♣ Construct 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 or a solution to a problem. (MS-PS2-4)

Corresponding CT Core Standards:

ELA/Literacy – RST.6-8.1, RST 6.8.3, WHST 6-8.1, WHST 6-8.7

Mathematics –MP.2, 6.NS.C.5, 6.EE.A.2, 7.EE.B.3, 7.EE.B.4

Energy

Overview

The performance expectations in Energy help students formulate an answer to the question, “How can energy be transferred from one object or system to another?” At the middle school level, the Disciplinary Core Idea from the NRC Framework is broken down into four sub-core ideas: Definitions of Energy, Conservation of Energy and Energy Transfer, the Relationship between Energy and Forces, and Energy in Chemical Process and Everyday Life. Students develop their understanding of important qualitative ideas about energy including that the interactions of objects can be explained and predicted using the concept of transfer of energy from one object or system of objects to another, and the total change of energy in any system is always equal to the total energy transferred into or out of the system. 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 will also come to know the difference between energy and temperature, and begin to develop an understanding of the relationship between force and energy. Students are also able to apply an understanding of design to the process of energy transfer. The crosscutting concepts of scale, proportion, and quantity; systems and system models; and energy are called out as organizing concepts for these disciplinary core ideas. The performance expectations expect students to demonstrate proficiency in developing and using models, planning investigations, analyzing and interpreting data, and designing solutions, and engaging in argument from evidence; and to use these practices to demonstrate understanding of the core ideas.

Unit Content Objectives

At the conclusion of this unit, students will be able to:

- 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.
- 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.
- **Apply scientific principles to design, construct, and test a device that either minimizes or maximizes thermal energy transfer.* (Engineering)**
- 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.
- 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.

Unit Essential Questions

- What is the relationship of an object's kinetic energy to its mass and speed?
- How can technology be used to construct a device that minimizes or maximizes thermal energy transfer?
- How do changes to the arrangement of objects affect the potential energy stored in the system?
- How is temperature affected by thermal energy transfer, type of matter and mass of sample?

Crosscutting Concepts

- Scale, Proportion and Quantity
- Systems and System Models
- Energy and Matter

NGSS Unit Standards

DISCIPLINARY CORE IDEAS (DCI):

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)
- ♣ Temperature is a measure of the average kinetic energy of particles of matter. The relationship between the temperature and the total energy of a system depends on the types, states, and amounts of matter present. (MS-PS3-3),(MS-PS3-4)

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)
- ♣ 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. (MS-PS3-4)
- ♣ Energy is spontaneously transferred out of hotter regions or objects and into colder ones. (MS-PS3-3)

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)

ETS1.A: Defining and Delimiting an Engineering Problem

- ♣ 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. (secondary to MS-PS3-3)

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. There are systematic processes for evaluating solutions with respect to how well they meet criteria and constraints of a problem. (secondary to MS-PS3-3)

SCIENCE AND ENGINEERING PRACTICES (SEP):

Developing and Using Models

Modeling in 6–8 builds on K–5 and progresses to developing, using and revising models to describe, test, and predict more abstract phenomena and design systems.

♣ Develop a model to describe unobservable mechanisms. (MS-PS3-2)

Planning and Carrying Out Investigations

Planning and carrying out investigations to answer questions or test solutions to problems in 6–8 builds on K–5 experiences and progresses to include investigations that use multiple variables and provide evidence to support explanations or design solutions.

♣ 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-PS3-4)

Analyzing and Interpreting Data

Analyzing data in 6–8 builds on K–5 and progresses to extending quantitative analysis to investigations, distinguishing between correlation and causation, and basic statistical techniques of data and error analysis.

♣ Construct and interpret graphical displays of data to identify linear and nonlinear relationships. (MS-PS3-1)

Constructing Explanations and Designing Solutions

Constructing explanations and designing solutions in 6–8 builds on K–5 experiences and progresses to include constructing explanations and designing solutions supported by multiple sources of evidence consistent with scientific ideas, principles, and theories.

♣ Apply scientific ideas or principles to design, construct, and test a design of an object, tool, process or system. (MS-PS3-3)

Engaging in Argument from Evidence

Engaging in argument from evidence in 6–8 builds on K–5 experiences and progresses to constructing a convincing argument that supports or refutes claims for either explanations or solutions about the natural and designed worlds.

3 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)

Corresponding CT Core Standards:

ELA/Literacy – RST.6-8.1, RST 6-8.2, RST 6.8.7, WHST 6-8.1, WHST 6-8.7, SL 8.5

Mathematics –MP.2, 6.RP.A.1, 6.RP.A.2, 7.RP.A.2, 8.EE.A.1, 8.EE.A.2, 8.F.A.3, 6.SP B.5

Waves and Electromagnetic Radiation

Overview

The performance expectations in Waves and Their Applications in Technologies for Information Transfer help students formulate an answer to the question, “What are the characteristic properties of waves and how can they be used?” At the middle school level, the Disciplinary Core Idea from the NRC Framework is broken down into Wave Properties, Electromagnetic Radiation, and Information Technologies and Instrumentation. Students are able to describe and predict characteristic properties and behaviors of waves when the waves interact with matter. Students can apply an understanding of waves as a means to send digital information. The crosscutting concepts of patterns and structure and function are used as organizing concepts for these disciplinary core ideas. The performance expectations focus on students demonstrating proficiency in developing and using models, using mathematical thinking, and obtaining, evaluating and communicating information; and to use these practices to demonstrate understanding of the core ideas.

Unit Content Objectives

At the conclusion of this unit, students will be able to:

- 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.
- Develop and use a model to describe that waves are reflected, absorbed, or transmitted through various materials.
- 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.

Unit Essential Questions

- How can a wave be qualitatively and quantitatively be described?
- How are waves reflected, absorbed or transmitted through various materials?
- How are waves used for communication purposes?

Crosscutting Concepts

- Patterns
- Structure and Function

NGSS Unit Standards

DISCIPLINARY CORE IDEAS (DCI):

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)

SCIENCE AND ENGINEERING PRACTICES (SEP):

Developing and Using Models

Modeling in 6–8 builds on K–5 and progresses to developing, using, and revising models to describe, test, and predict more abstract phenomena and design systems.

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

Using Mathematics and Computational Thinking

Mathematical and computational thinking at the 6–8 level builds on K–5 and progresses to identifying patterns in large data sets and using mathematical concepts to support explanations and arguments.

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

Obtaining, Evaluating, and Communicating Information

Obtaining, evaluating, and communicating information in 6-8 builds on K-5 and progresses to evaluating the merit and validity of ideas and methods. ♣ 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)

Corresponding CT Core Standards:

ELA/Literacy – RST.6-8.1, RST 6.8.2, RST 6-8.9, WHST 6-8.9, SL 8.5

Mathematics – MP.2, MP.4, 6.RP.A.1, 6.RP.A.2, 6.RP.A.3, 8.F.A.3

Matter and its Interactions

Overview

The performance expectations in Matter and its Interactions help students to formulate an answer to the question, “How do atomic and molecular interactions explain the properties of matter that we see and feel?” by building understanding of what occurs at the atomic and molecular scale. In middle school, the Disciplinary Core Idea from the NRC Framework is broken down into two sub-ideas: the structure and properties of matter, and chemical reactions. By the end of middle school, students will be able to apply understanding that pure substances have characteristic physical and chemical properties and are made from a single type of atom or molecule. They will be able to provide molecular level accounts to explain states of matters and changes between states, which chemical reactions involve regrouping of atoms to form new substances, and that atoms rearrange during chemical reactions. Students are also able to apply an understanding of the design and the process of optimization in engineering to chemical reaction systems. The crosscutting concepts of patterns; cause and effect; scale, proportion and quantity; energy and matter; structure and function; interdependence of science, engineering, and technology; and influence of science, engineering and technology on society and the natural world are called out as organizing concepts for these disciplinary core ideas. In the performance expectations, students are expected to demonstrate proficiency in developing and using models, analyzing and interpreting data, designing solutions, and obtaining, evaluating, and communicating information. Students use these scientific and engineering practices to demonstrate understanding of the disciplinary core ideas.

Unit Content Objectives

At the conclusion of this unit, students will be able to:

- Develop models to describe the atomic composition of simple molecules and extended structures.
- Analyze and interpret data on the properties of substances before and after the substances interact to determine if a chemical reaction has occurred.
- Gather and make sense of information to describe that synthetic materials come from natural resources and impact society.
- 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.
- 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.

- **Undertake a design project to construct, test, and modify a device that either releases or absorbs thermal energy by chemical processes.* (Engineering)**

Unit Essential Questions

- How can models be used to describe the atomic composition of simple molecules and extended structures
- How can data on the property of substances before and after the substances react be used to determine if a chemical reaction has occurred?
- How do we use natural resources to make synthetic materials and how does doing so impact society?
- What is the effect on particle motion, temperature, and state of a pure substance when thermal energy is added or removed?
- How can models be used to describe that the total number of atoms does not change in a chemical reaction and thus mass is conserved?
- How can a device be constructed that either releases or absorbs thermal energy by chemical **or physical** processes?

Crosscutting Concepts

- Cause and Effect
- Scale, Proportion and Quantity
- Structure and Function
- Patterns
- Energy And Matter

NGSS Unit Standards-Matter and its Interactions

DISCIPLINARY CORE IDEAS (DCI):

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)
- ♣ 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) (Note: This Disciplinary Core Idea is also addressed by MS-PS1-2.)
- ♣ 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)
- ♣ Solids may be formed from molecules, or they may be extended structures with repeating subunits (e.g., crystals). (MS-PS1-1)
- ♣ The changes of state that occur with variations in temperature or pressure can be described and predicted using these models of matter. (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-PS1-3) (Note: This Disciplinary Core Idea is also addressed by MS-PS1-2 and MS-PS1-5.)

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)

SCIENCE AND ENGINEERING PRACTICES (SEP):

Developing and Using Models

Modeling in 6–8 builds on K–5 and progresses to developing, using and revising models to describe, test, and predict more abstract phenomena and design systems.

- ♣ Develop a model to predict and/or describe phenomena. (MS-PS1-1),(MS-PS1-4)

Obtaining, Evaluating, and Communicating Information

Obtaining, evaluating, and communicating information in 6–8 builds on K–5 and progresses to evaluating the merit and validity of ideas and methods. ♣ 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)

Corresponding CT Core Standards:

ELA/Literacy – RST.6-8.1, RST 6-8.7, WHST 6-8.8, **Mathematics** –6.EE.C.9

Mathematics – MP.2, MP.4, 6.RP.A.3, 6.NS.C.5, 8.EE.A.3

NGSS Unit Standards- Matter and its Interactions

DISCIPLINARY CORE IDEAS (DCI):

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-PS1-2)

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),(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)

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.

SCIENCE AND ENGINEERING PRACTICES (SEP):**Developing and Using Models**

Modeling in 6–8 builds on K–5 and progresses to developing, using and revising models to describe, test, and predict more abstract phenomena and design systems.

♣ Develop a model to describe unobservable mechanisms. (MS-PS1-5)

Analyzing and Interpreting Data

Analyzing data in 6–8 builds on K–5 and progresses to extending quantitative analysis to investigations, distinguishing between correlation and causation, and basic statistical techniques of data and error analysis.

♣ Analyze and interpret data to determine similarities and differences in findings. (MS-PS1-2)

Constructing Explanations and Designing Solutions

Constructing explanations and designing solutions in 6–8 builds on K–5 experiences and progresses to include constructing explanations and designing solutions supported by multiple sources of evidence consistent with scientific knowledge, principles, and theories.

♣ 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)

Corresponding CT Core Standards:

ELA/Literacy – RST.6-8.1, RST 6-8.3, RST 6-8.7, WHST.6-8.7

Mathematics – Mp.2, MP.4, 6.RP.A.3, 6.SP.B.4, 6.SP.B.5

Engineering Design

Overview

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 are likely to limit possible solutions. 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. 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.

Unit Content Objectives

At the conclusion of this unit, students will be able to:

- 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.
- Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.
- 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.
- 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.

Unit Essential Questions

- How do engineers 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?
- How do engineers evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem?
- How do engineers 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?
- How do engineers 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. The performance expectations above were developed using the following?

Crosscutting Concepts

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

NGSS Unit Standards

DISCIPLINARY CORE IDEAS (DCI):

ETS1.A: Defining and Delimiting Engineering Problems

♣ 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 are likely to limit possible solutions. (MS-ETS1-1)

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. (MS-ETS1-4)

♣ There are systematic processes for evaluating solutions with respect to how well they meet the criteria and constraints of a problem. (MS-ETS1-2), (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)

♣ Models of all kinds are important for testing solutions. (MSETS1-4)

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 those characteristics may be incorporated into the new design. (MS-ETS1-3)

♣ 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. (MS-ETS1-4)

SCIENCE AND ENGINEERING PRACTICES (SEP):

Asking Questions and Defining Problems

Asking questions and defining problems in grades 6–8 builds on grades K–5 experiences and progresses to specifying relationships between variables, and clarifying arguments and models.

♣ Define a design problem that can be solved through the development of an object, tool, process or system and includes multiple criteria and constraints, including scientific knowledge that may limit possible solutions. (MS-ETS1-1)

Developing and Using Models

Modeling in 6–8 builds on K–5 experiences and progresses to developing, using, and revising models to describe, test, and predict more abstract phenomena and design systems.

♣ Develop a model to generate data to test ideas about designed systems, including those representing inputs and outputs. (MSETS1-4)

Analyzing and Interpreting Data

Analyzing data in 6–8 builds on K–5 experiences and progresses to extending quantitative analysis to investigations, distinguishing between correlation and causation, and basic statistical techniques of data and error analysis.

♣ Analyze and interpret data to determine similarities and differences in findings. (MS-ETS1-3)

Engaging in Argument from Evidence

Engaging in argument from evidence in 6–8 builds on K–5 experiences and progresses to constructing a convincing argument that supports or refutes claims for either explanations or solutions about the natural and designed world.

♣ Evaluate competing design solutions based on jointly developed and agreed-upon design criteria. (MS-ETS1-2)

Corresponding CT Core Standards:

ELA/Literacy – RST.6-8.1, RST 6.8.7, RST 6-8.9, WHST 6-8.7, WHST 6-8.8, WHST 6-8.9, SL 8.5

Mathematics –MP.2, 7.EE.3

