PHYSICAL SCIENCE
GRADE 8

EWING PUBLIC SCHOOLS
2099 Pennington Road
Ewing, NJ 08618

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In accordance with The Ewing Public Schools' Policy 2230, Course Guides, this curriculum has been reviewed and found to be in compliance with all policies and all affirmative action criteria.

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Course Description and Rationale

Students in this course will learn to explain phenomena central to the physical sciences, but also to the life sciences and earth and space science from previous middle school grades. The Next Generation Science Standards (NGSS) performance expectations rely on three dimensions of learning to develop student understanding of scientific concepts. Core conceptual ideas are learned by engaging in scientific and engineering practices and considering crosscutting concepts. These three dimensions support students in developing useable knowledge to explain real world phenomena in the physical, biological and earth and space sciences.

In the physical sciences, performance expectations at the middle school level use three dimensional learning to foster student understanding of physical science concepts.

Students will use the following eight NGSS Science and Engineering Practices to demonstrate understanding of the disciplinary core ideas and develop critical thinking skills:

- Asking questions (science) and defining problems (engineering)
- Developing and using models
- Planning and carrying out investigations
- Analyzing and interpreting data
- Using math and computational thinking
- Constructing explanations (science) and designing solutions (engineering)
- Engaging in argument from evidence
- Obtaining, evaluating and communicating information

The following crosscutting concepts support the development of a deeper understanding of the disciplinary core ideas:

- Patterns
- Cause and effect: mechanism and explanation
- Scale, proportion and quantity
- Systems and system models
- Energy and matter: flows, cycles and conservation
- Structure and function

Course Description and Rationale

The eighth grade physical science course develops student understanding of key concepts to help them make sense of life science. Conceptual understanding is built upon students' science understanding from earlier grades. Learning aligned to the Next Generation Science Standards (NGSS) is three dimensional. Students develop understanding of the disciplinary core ideas through the use of science and engineering practices and by connecting crosscutting concepts of other experiences with life and earth sciences. NGSS performance expectations (standards) in middle school physical science couple particular practices with specific disciplinary core ideas. However, instruction includes the use of many overlapping science and engineering practices integrated into each unit and each unit requires students to engage in problem-based and inquiry learning.

Students use the eight NGSS Science and Engineering Practices to demonstrate understanding of the disciplinary core ideas:

- Asking questions (science) and defining problems (engineering)
- Developing and using models
- Planning and carrying out investigations
- Analyzing and interpreting data
- Using math and computational thinking
- Constructing explanations (science) and designing solutions (engineering)
- Engaging in argument from evidence
- Obtaining, evaluating and communicating information

The following seven crosscutting concepts support the development of a deeper understanding of the disciplinary core ideas in life science and between the other science disciplines:

- Patterns
- Cause and effect: mechanism and explanation
- Scale, proportion and quantity
- Systems and system models
- Energy and matter: flows, cycles and conservation
- Structure and function
- Stability and change

There are four life science disciplinary core ideas addressed in the middle school:

PS1: Matter and its Interactions
PS2: Motion and Stability: Forces and Interactions
PS3: Energy
PS4: Waves and Their Applications in Technologies for Information Transfer

The course follows a block semester schedule, with students meeting daily for 82 minutes. The course content is arranged into six units of study:

- Properties of Matter
- Chemical Reactions
- Forces and Motion
- Types of Interactions
- Energy Transfer and Relationship to Forces
- Wave Properties, Electromagnetic Radiation, Information Technology and Instrumentation

Career Readiness, Life Literacies, and Key Skills

During this course, students will work on developing, to an age appropriate level, the following Career Readiness, Life Literacies, and Key Skills:

Disciplinary Concepts:

- Career Awareness and Planning
  - An individual's strengths, lifestyle goals, choices, and interests affect employment and income.
  - Developing and implementing an action plan is an essential step for achieving one's personal and professional goals.
  - Communication skills and responsible behavior in addition to education, experience, certifications, and skills are all factors that affect employment and income.
- Creativity and Innovation
  - Gathering and evaluating knowledge and information from a variety of sources, including global perspectives, fosters creativity and innovative thinking.
- Critical Thinking and Problem-solving
  - Multiple solutions exist to solve a problem.
  - An essential aspect of problem solving is being able to self-reflect on why possible solutions for solving problems were or were not successful.
- Digital Citizenship
  - Detailed examples exist to illustrate crediting others when incorporating their digital artifacts in one's own work.
  - Digital communities are used by Individuals to share information, organize, and engage around issues and topics of interest.
  - Digital technology and data can be leveraged by communities to address effects of climate change.
- Global and Cultural Awareness
  - Awareness of and appreciation for cultural differences is critical to avoid barriers to productive and positive interaction.
- Information and Media Literacy
  - Increases in the quantity of information available through electronic means have heightened the need to check sources for possible distortion, exaggeration, or misrepresentation.
  - Digital tools make it possible to analyze and interpret data, including text, images, and sound. These tools allow for broad concepts and data to be more effectively communicated.

    - Sources of information are evaluated for accuracy and relevance when considering the use of information.
    - There are ethical and unethical uses of information and media.

- Technology Literacy
    - Some digital tools are appropriate for gathering, organizing, analyzing, and presenting information, while other types of digital tools are appropriate for creating text, visualizations, models, and communicating with others.
- Digital tools allow for remote collaboration and rapid sharing of ideas unrestricted by geographic location or time.

Technology Integration

Computer Science and Design Thinking

During this course, students will work on developing, to an age appropriate level, the following Computer Science and Design Thinking Skills:

Disciplinary Concepts and Core Ideas:

- Data & Analysis
    - People use digital devices and tools to automate the collection, use, and transformation of data.
    - The manner in which data is collected and transformed is influenced by the type of digital device(s) available and the intended use of the data.
    - Data is represented in many formats. Software tools translate the low-level representation of bits into a form understandable by individuals. Data is organized and accessible based on the application used to store it.
    - The purpose of cleaning data is to remove errors and make it easier for computers to process.
    - Computer models can be used to simulate events, examine theories and inferences, or make predictions.
- Engineering Design
    - Engineering design is a systematic, creative and iterative process used to address local and global problems.
    - The process includes generating ideas, choosing the best solution, and making, testing, and redesigning models or prototypes.
    - Engineering design requirements and specifications involve making trade-offs between competing requirements and desired design features.

- Interaction of Technology and Humans

  - Economic, political, social, and cultural aspects of society drive development of new technological products, processes, and systems.
  - Technology interacts with society, sometimes bringing about changes in a society's economy, politics, and culture, and often leading to the creation of new needs and wants.
  - New needs and wants may create strains on local economies and workforces.
  - Improvements in technology are intended to make the completion of tasks easier, safer, and/or more efficient.

- Nature of Technology

  - Technology advances through the processes of innovation and invention which relies upon the imaginative and inventive nature of people.
  - Sometimes a technology developed for one purpose is adapted to serve other purposes.
  - Engineers use a systematic process of creating or modifying technologies that is fueled and constrained by physical laws, cultural norms, and economic resources. Scientists use systematic investigation to understand the natural world.

- Effects of Technology on the Natural World

  - Resources need to be utilized wisely to have positive effects on the environment and society.
  - Some technological decisions involve trade-offs between environmental and economic needs, while others have positive effects for both the economy and environment.

ELA Integration:

NJSLS.RST.6-8.1 Cite specific textual evidence to support analysis of science and technical texts. (MS-ESS2-5) (MS-ESS3-5)
NJSLS.RST.6-8.7 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-ESS1-3) (MS-ESS2-3)
NJSLS.RST.6-8.9 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-ESS2-5)
NJSLS.WHST.6-8.2 Write informative/explanatory texts to examine a topic and convey ideas, concepts and information through the selection, organization and analysis of relevant content. (MS-ESS1-4), (MS-ESS2-2)
NJSLS.WHST.6-8.8 Gather relevant information from multiple print and digital sources; assess the credibility of each source; and quote or paraphrase the data and conclusions of others while avoiding plagiarism and providing basic bibliographic information for sources. (MS-ESS2-5)
NJSLS.WHST.6-8.9 Draw evidence from informational texts to support analysis, reflection and research. (MS-ESS3-1)
NJSLS.SL.8.5 Include multimedia components and visual displays in presentations to clarify claims and findings and emphasize salient points. (MS-ESS2-2) (MS-ESS2-6)

Math Integration:

NJSLS.MP.2 Reason abstractly and quantitatively. (MS-ESS2-5), (MS-ESS3-5)
NJSLS.MP.4 Model with mathematics. (MS-ESS1-1) (MS-ESS1-2)
NJSLS.6.EE.B.6 Use variables to represent numbers and write expressions when solving a real-world or mathematical problem; understand that a variable can represent an unknown number, or, depending on the purpose at hand, any number in a specified set. (MS-ESS1-2) (MS-ESS3-5)
NJSLS.6.NS.C.5 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-ESS2-5)
NJSLS.6.RP.A.1 Understand the concept of a ratio and use ratio language to describe a ratio relationship between two quantities. (MS-ESS1-1) (MS-ESS1-2) (MS-ESS1-3)

Unit 1: Properties of Matter (Pacing: 14 Days)

Why Is This Unit Important?

Chemistry is the scientific study of matter, its properties and its interactions with other matter and with energy. Chemists examine the properties and composition of matter and the interactions between substances.

When students come to better understand how the composition of materials differ by physical and chemical properties and how these properties define and limit the use of certain materials, their understanding and interests of the world around them increases. Students learn the importance of making systematic and detailed quantitative and qualitative observations by increased practice and familiarity of the 'methods' and processes by which scientists and engineers address 'problems' and 'needs' of the society within identified limits and constraints.

Students are able to apply skills learned through these systematic procedures and iterative processes in many other subject areas (the study and application of mathematics, English language arts, the visual arts) with increased confidence, creativity and 21st Century Skills (including collaboration, communication and use of and application of technology).

Disciplinary Core Ideas:

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:

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 now supported by evidence. (MS-PS1-3)

Cross Cutting Concepts:

<u>Cause and Effect</u>

- Cause and effect relationships may be used to predict phenomena in natural or designed systems. (MS-PS1-4)

<u>Scale, Proportion, and Quantity</u>

- 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)

<u>Structure and Function</u>

- 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)

Enduring Understandings:

- Atomic structure of materials determine their physical and chemical properties.
- Elements and compounds react in different ways to form new substances.
- Matter will seek the most stable arrangement (lowest energy state) unless arranged differently by living organisms.
- Matter is described by characteristic physical properties [melting point, boiling point, density, solubility, polarity].
- Amount of energy determines the state of matter [heat energy affects varying properties of matter].
- Heat energy transfers from high to low ‘seeking’ an equal balance between the two.
- Elements are organized on the Periodic Table according to atomic structure.

Essential Question(s):

- How do properties of materials determine their use?
- What is the Periodic Table of Elements?
- How do we use the Periodic Table of Elements?

Acquired Knowledge:

- Learn that matter is made up of atoms and combinations of atoms.
- Learn that atoms have a unique structure which determines how they will combine.
- Learn that the Periodic Table is arranged according to similarities in atomic structure and systematic differences.
- Learn that the average kinetic energy (temperature) changes when thermal energy is added or removed.
- Learn that changes of state of matter occur with variations in temperature or pressure.
- Learn that in a liquid, the molecules are constantly in contact with each other, in a gas, they are widely spaced except when they happen to collide. In a solid, atoms are closely spaced and vibrate in position but do not change relative locations.
- Learn that pure substances are made from a single type of atom or molecule.
- Learn that each pure substance has characteristic physical and chemical properties that can be used to identify it.

Acquired Skills:

- Learn that use data to show that the Periodic Table is arranged according to similarities in atomic structure and systematic differences.
- Learn that design an experiment to show the average kinetic energy (temperature) changes when thermal energy is added or removed.
- Learn that determine properties (e.g., density) through measurement and calculation.
- Learn that model phase changes.
- Learn that identify atoms by the number and arrangement of the subatomic particles.

Assessments:

Formative Assessments:

- Develop models of atomic composition of structures that vary in complexity (Modeling- Formative Learning Assessment)
- Model the relationship of the components of states of matter: molecular motion and kinetic energy of particles; average kinetic energy and thermal energy of a system; change in kinetic energy and change in state of matter - solid, liquid, gas, plasma; pressure and thermal energy (Test - Formative Diagnostic Assessment)
- Describe the relationship of the components of states of matter: molecular motion and kinetic energy of particles; average kinetic energy and thermal energy of a system; change in kinetic energy and change in state of matter - solid, liquid, gas, plasma (Lab Reflections - Formative Diagnostic Assessment)

- Group discussions/presentations:
  - Propose higher order questions
  - Present information to students and ask a question
  - Have students discuss their answers with their peers at their table and discuss together as a group

Summative Assessments:

- Properties of Matter Unit Test

Benchmarks:

- Students will be assessed on their ability to develop models to describe the atomic composition of simple molecules and extended structures.
- Students will be assessed on their ability to gather and make sense of information to describe that synthetic materials come from natural resources and impact society.
- Students will be assessed on their ability to 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.

Alternative Assessments:

- Modified project requirements and rubrics

Suggested Learning Experiences and Instructional Activities:

<u>Anticipatory Sets</u>:

- Matter Tree
- Alien Periodic Table
- Periodic Table of Atom Drawings

<u>In-Class Activities and Laboratory Experiences</u>:

- Heating curve of a liquid
- PHet thermal energy simulation
- Separating a Mixture
- Ooblek/Oobleck
- Properties Lab
- Model States of Matter
- Creating Models of an Atom

Closure and Reflection Activities:

- Claim, Evidence, Reasoning [C.E.R.] - What state of matter is a ‘specific’ substance?
- Poster Session (peer review rubric)

Instructional Materials:

- Textbook
- Student engineering journals
- Argumentation (claim evidence reasoning) rubric
- Lab materials
- Scientific calculators

Technology Connections:

- Phet simulations
- Pasco Probeware SparkLabs (temperature probe)
- Hot Plates (states of matter)

List of Applicable Performance Expectations (PE) Covered in This Unit:

- **MS-PS1-1**
- **MS-PS1-3**
- **MS-PS1-4**

Unit 2: Chemical Reactions (Pacing: 12 Days)

Why Is This Unit Important?

Chemistry is the scientific study of matter, its properties and its interactions with other matter and with energy. Chemists examine the properties and composition of matter and the interactions between substances.

When students come to better answer the question, "How do atomic and molecular interactions explain the properties of matter that we see and feel?" They will be able to provide evidence of molecular level accounts to explain not only states of matter changing and changes between states of matter (Properties of Matter) but the chemical reactions involved in the regrouping of atoms to form new substances and the rearrangement of atoms during chemical reactions.

Students learn the importance of making systematic and detailed quantitative and qualitative observations by increased practice and familiarity of the 'methods' and processes by which scientists and engineers address 'problems' and 'needs' of the society within identified limits and constraints.

Disciplinary Core Ideas:

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) *(Note: This Disciplinary Core Idea is also addressed by MS-PS1-3.)*

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-PS1-2), (MS-PS1-5) *(Note: This Disciplinary Core Idea is also addressed by MS-PS1-3.)*
- 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. *(secondary to MS-PS1-6)*

Science and Engineering Practices:

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)
- 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)

Cross Cutting Concepts:

Patterns

- Macroscopic patterns are related to the nature of microscopic and atomic-level structure. (MS-PS1-2)

<u>Energy and Matter</u>

- 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)

Enduring Understandings:

- The total amount of mass remains constant before and after any change (physical and chemical) within a closed system.
- Matter is electrical in nature and made up of particles in constant motion.
- Energy can be transformed.
- Chemical reactions among substances cause changes producing new products that have different properties from the original substance.
- Chemical reactions involve the flow of energy.
- $E = mc^2$; the total mass plus energy involved in any reaction or change is conserved.

Essential Question(s):

- What determines the type of and extent of a chemical reaction?
- Can a chemical system have both energy and matter?

Acquired Knowledge:

- Learn that substances are made of different atoms which combine in various ways
- Learn that atoms can combine to form molecules that varying sizes
- Learn that the substances have their own unique chemical and physical properties
- Learn that when chemical changes occur the atoms that make up the original substances are regrouped to make a new substance with different properties
- Learn that some chemical reactions release energy, others absorb/ store energy

Acquired Skills:

- Learn that identify when physical and chemical changes occur.
- Learn that Identify reactants and products of chemical reactions.
- Learn that count atoms in a chemical formula.
- Learn that demonstrate with models how atoms in molecules rearrange during a reaction, but are not created or destroyed.
- Learn that use the engineering design process.
- Learn that determine which reactions will release or absorb energy in order to optimize a device with a specific purpose.

Assessments:

Formative Assessments:

- Organize data on characteristic physical/ chemical properties before/ after chemical reactions; identify relationships in changes of properties; determine if a chemical reaction has occurred, with evidence (Bag O' Chemicals Lab II - Formative Diagnostic Assessment)
- Identify the number of components that make up reactants and products; describe the properties of (i.e., mass) and relationship between components when new molecules are formed; (Test - Formative Diagnostic Assessment)
- Group discussions/presentations:
  - Propose higher order questions
  - Present information to students and ask a question
  - Have students discuss their answers with their peers at their table and discuss together as a group

Summative Assessments:

- Generate design solutions for heating and/or cooling (tracking thermal energy transfer) through chemical reactions via a device; describe criteria and constraints; evaluate potential solutions through systematic and iterative testing (Product - Summative Assessment)

Benchmarks:

- Students will be assessed on their ability to analyze and interpret data on the properties of substances before and after the substances interact to determine if a chemical reaction has occurred.
- Students will be assessed on their ability to 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.
- Students will be assessed on their ability to undertake a design project to construct, test and modify a device that either releases or absorbs thermal energy by chemical processes.

Alternative Assessments:

- Modified project requirements and rubrics

Suggested Learning Experiences and Instructional Activities:

Anticipatory Sets:

- Bag O'Chemicals I (performance-based lab)
- What's a Chemical Indicator? [Phenol Red; Bromothymol Blue]
- Lit Candle (physical vs. chemical change)
- Sodium Bicarbonate and Vinegar (chemical change)
- Videos (include but not limited to):
  - Elements [App]
  - In Action [App]
  - MentalFloss.com (11 Chemical Reactions Explained)
  - Amazing Chemical Reactions (YouTube)
  - BeautifulChemistry.net

In-Class Activities and Laboratory Experiences:

- Chemical reaction demonstrations
- Chemical bonding puzzle
- Bag O'Chemicals II (performance-based)
- Career Exploration: Chemist

Closure and Reflection Activities:

- Indicators: How do we benefit from indicators (chemical or physical)?
- CER - real world use of product of chemical reaction.

Instructional Materials:

- Chemicals [including but not limited to: calcium chloride, sodium bicarbonate, acetic acid, phenol red solution, bromothymol blue, iodine, cabbage juice]
- Candles

Technology Connections:

- PHet labs/simulations
- Pasco Probeware SparkLabs (temperature probe; Kelvin probe, graphing data in real-time)

List of Applicable Performance Expectations (PE) Covered in This Unit:

- **MS-PS1-2**
- **MS-PS1-5**
- **MS-PS1-6**

Unit 3: Forces and Motion (Pacing: 20 Days)

Why Is This Unit Important?

The basics: Push or Pull. Students will experience and describe a variety of pushes and pulls and apply this to explain how objects have a change in motion. Students will be able to answer the question, "How can one describe physical interactions between objects and within systems of objects?" Students will get to know what Sir Isaac Newton was talking about when he formulated his three 'Laws of Motion' and make application to forces and the behavior of objects in regards to their motion.

Students become increasingly familiar and comfortable with identifying problems in need of solutions, identifying criteria and constraints and evaluating possible solutions based on best results.

Disciplinary Core Ideas:

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)

Science and Engineering Practices:

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)

Cross Cutting Concepts:

Cause and Effect

- Cause and effect relationships may be used to predict phenomena in natural or designed systems. (MS-PS2-3),(MS-PS2-5)

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),(MS-PS2-4)

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)

Enduring Understandings:

- The same basic rules govern the motion of all bodies.
- Newton's three basic Laws of Motion govern the relationship between forces and motion.
- An object's position can be described by locating the object relative to other objects or a background.
- The description of an object's motion be different between two observers.
- An object is in motion when its position is changing.
- Students should relate imbalance of force to change of motion.
- The speed of an object is defined by how far it travels over the amount of time it took to travel.

Essential Question(s):

- How can something appear to be standing still when it is actually moving forward?
- What variables can you manipulate to affect the movement of objects?
- How would objects move if one or more laws of motion did not exist?

Acquired Knowledge:

- Learn that the motion of an object is determined by the sum of the forces acting on it
- Learn that the motion of an object is directly related to its mass and the size of the force acting on it
- Learn that in order to describe the motion of an object you must first determine a frame of reference and unit
- Learn that for any pair of interacting objects, the force exerted by the first object on the second object is equal in size, but in the opposite direction to the force that the second object exerts back (Newton's third law).

Acquired Skills:

- 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.
- Learn that develop a method to control the impact forces when two objects collide.

Assessments:

Formative Assessments:

- Identify the effects of balanced and unbalanced forces; Analyze variables (independent, dependent and controlled) that affect the motion of any given object based on reference frames, utilizing appropriate units (Test - Formative Diagnostic Assessment)

- Group discussions/presentations:
  - Propose higher order questions
  - Present information to students and ask a question
  - Have students discuss their answers with their peers at their table and discuss together as a group

Summative Assessments:

- Identify phenomenon of change in motion; identify the purpose of investigating change in motion due to balanced, unbalanced forces and mass; develop a plan to collect data for the investigation; collecting and analyzing (Water Bottle Rocket Reflection - Benchmark Assessment)

Benchmarks:

- Students will be assessed on their ability to apply Newton’s Third Law to design a solution to a problem involving the motion of two colliding objects.
- Students will be assessed on their ability to 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.

Alternative Assessments:

- Modified project requirements and rubrics

Suggested Learning Experiences and Instructional Activities:

Anticipatory Sets:

- Paper Airplane videos and Teacher throw
- ‘Car’ crash demonstration
- Bottle Rocket video

In-Class Activities and Laboratory Experiences:

- Paper Airplane Challenge
- Bottle Rocket Transport System
- Inertia Demos
- Speed Lab
- Acceleration Lab

Closure and Reflection Activities:

- Lab discussion and reflection

Instructional Materials:

- Textbook
- Student engineering journals
- Argumentation (claim evidence reasoning) rubric
- Lab materials
- Scientific calculators

Technology Connections:

- PASCO Probeware SparkLabs (motion sensors, temperature probe)
- High Altitude Altimeters

List of Applicable Performance Expectations (PE) Covered in This Unit:

- MS-PS2-1
- MS-PS2-2

Unit 4: Types of Interactions (Pacing: 10 Days)

Why Is This Unit Important?

Students apply the idea that gravitational, electrical and magnetic forces explain the motion of objects: some objects attract others while some repel. They will develop the understanding that gravitational forces are always attractive and work at a distance, the strength of which depends on mass and the distance between two objects.

During this unit students strengthen their skills in developing cross cutting concepts of cause and effect, systems and their models, stability and change and engineering design practices while asking questions, planning and carrying out investigations.

Disciplinary Core Ideas:

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, a magnet, or a ball, respectively). (MS-PS2-5)

Science and Engineering Practices:

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)

Cross Cutting Concepts:

Cause and Effect

- Cause and effect relationships may be used to predict phenomena in natural or designed systems. (MS-PS2-3),(MS-PS2-5)

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),(MS-PS2-4)

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)

Enduring Understandings:

- Different forces are responsible for the transfer of different forms of energy.
- Magnetic, electrical and gravitational forces act at a distance.
- Energy is transferred to matter through the action of forces.

Essential Question(s):

- What is the relationship between distance and magnitude of a force (magnetic, electrical and gravitational)?

Acquired Knowledge:

- Learn that electric force builds as charge differences increase.
- Learn that magnetic fields develop when magnetic domains align.
- Learn that how electric fields and magnetic fields are related.
- Learn that the gravitational forces between two objects vary depending upon the mass of the objects, but are always attractive.
- Learn that forces that act at a distance (electric, magnetic and gravitational) can be explained by fields that extend through space

Acquired Skills:

- Learn that interpret data to demonstrate that electric force builds as charge differences increase.
- Learn that develop questions that could be used to determine the factors that affect the strengths of these fields.
- Learn that to create arguments by citing evidence and using scientific reasoning.
- Learn that design experimental procedures to examine the forces exerted by magnets or Static Electric Fields.
- Learn that evaluate the experimental procedures to determine reliability of results.

Assessments:

Formative Assessments:

- Formulate questions from examining data of interacting forces (electric and magnetic) and make predictions of magnitude (electric current and magnetic strength) based on cause-and-effect relationships driving a specific system; frame a hypothesis (Poster Presentation/ PowerPoint Presentation/ Web Design Presentation - Formative Diagnostic Assessment)
- Formulate questions from examining data of interacting forces (electric and magnetic) and make predictions of magnitude (electric current and magnetic strength) based on cause-and-effect relationships driving a specific system; frame a hypothesis (Test - Formative Diagnostic Assessment)
- Group discussions/presentations:
  - Propose higher order questions
  - Present information to students and ask a question
  - Have students discuss their answers with their peers at their table and discuss together as a group

Summative Assessments:

- Populations and Communities Test
- Ecosystems and Biomes Test
- Living Resources Test
- Food web project
- Engineering design - Pelican nests

Benchmarks:

- Students will be assessed on their ability to ask questions about data to determine the factors that affect the strength of electric and magnetic forces.
- Students will be assessed on their ability to construct and present arguments using evidence to support the claim that gravitational interactions are attractive and depend on the masses of interacting objects
- Students will be assessed on their ability to 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.

Alternative Assessments:

- Modified project requirements and rubrics

Suggested Learning Experiences and Instructional Activities:

Anticipatory Sets:

- Magnet demonstrations
- Video: MagLev Train
- 'Floating' Globe
- Newton's Cradle/ LARGE Newton's Cradle
- Large gravity demonstrator
- Van de Graaff Generator demo

In-Class Activities and Laboratory Experiences:

- MagLevian Vehicles (magnetic levitation vehicles)
- Forces (Station)
- Force Cars (mass/ height/ distance/ velocity)
- Static Electricity Lab

Closure and Reflection Activities:

- **Q:** How does the Balloon stick to the Wall?

Instructional Materials:

- Textbook
- Student engineering journals
- Argumentation (claim evidence reasoning) rubric
- Lab materials
- Scientific calculators

Technology Connections:

- Pasco Probeware SparkLabs (force sensors, motion sensors, voltage sensor)

List of Applicable Performance Expectations (PE) Covered in This Unit:

- **MS-PS2-3**
- **MS-PS2-4**
- **MS-PS2-5**

Unit 5: Energy: Transfer and Its Relationship to Forces (Pacing: 16 Days)

Why Is This Unit Important?

The Sun is the main source of energy for all of the systems on Earth. Knowing this, students will be able to answer the question, "How can energy be transferred from one object or system to another?"

Through planning investigations, making claims, collecting data, using evidence to support their claim, students will better communicate this reasoning in explaining how the interactions between objects can be explained and predicted using the concept of transfer of energy from one system 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, whether moving (kinetic energy) or energy based on their position (potential energy).

During this unit students strengthen their skills in developing the design process of energy transfer. They will continue to enhance their knowledge and practice of applying cross cutting concepts of scale, proportion and quantity; and systems and system models; analyzing data, designing solutions and engaging in argument from evidence.

Disciplinary Core Ideas:

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)

Science and Engineering Practices:

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.
- 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)

Cross Cutting Concepts:

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),(MS-PS3-4)

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, and energy of motion). (MS-PS3-5)
- The transfer of energy can be tracked as energy flows through a designed or natural system. (MS-PS3-3)

Enduring Understandings:

- Energy cannot be created or destroyed; only changed from one form to another.
- Energy takes many forms (nuclear, electromagnetic, thermal, mechanical, chemical)
- Forms of energy can be grouped into types of energy that are associated with the motion of mass (kinetic energy) and types of energy associated with the position of mass and with energy fields (potential energy).
- Energy can be transformed.
- Changes take place because of the transfer of energy.
- Thermal energy can be transferred (conduction-evaporation, convection and radiation) and used in heating and cooling systems.
- Energy can be transferred from one system to another; the amount of energy before transfer equals the amount of energy after the transfer.
- Many devices transfer one form of energy into another form (examples: batteries convert chemical potential energy into electrical energy; light bulbs convert electrical energy into light and thermal energy).
- Energy is transferred to matter through forces.
- Different forces are responsible for the transfer of different forms of energy.
- Magnetic, electrical and gravitational forces can act at a distance.

Essential Questions:

- How do we know things have energy?
- In what ways do we witness the effects of something having energy?
- Where does energy in the world come from?
- Where does the energy in our world come from?
- Why can our perception of temperature be subjective?
- How is the energy from the Sun used here on Earth?
- How can energy be transferred within a system (example: roller coaster or pendulum)?
- What happens to a material when energy is transferred to it?
- How is energy transformed into forms used by humans?

Acquired Knowledge:

- Learn that a system of objects may contain stored (potential) energy depending on their relative positions.
- Learn that Potential Energy can be changed into Kinetic Energy.
- Learn that kinetic energy is motion energy and is proportional to the mass of the moving object.
- Learn that when a change occurs in an object's Kinetic Energy some other change occurs in energy at the same time.
- Learn that the amount of energy needed to change the temperature of a matter sample is related to the size, environment and nature of the matter.
- Learn that the various ways that thermal energy can be transferred including convection, conduction, radiation.
- Learn that materials differ in their abilities to conduct thermal energy.
- Learn that temperature is a measure of the average kinetic energy of particles of matter.
- Learn that the relationship between temperature and energy in a system.
- Learn that the Kinetic Energy of an object changes as its motion changes.
- Learn that energy is conserved.
- Learn that different materials heat up faster than others.
- Learn that energy spontaneously transfers from hotter objects or regions to colder.
- Learn that when two objects interact each one exerts a force on the other that can cause energy to be transferred to or from the object.
- Learn that a force is necessary to increase or decrease the energy.
- Learn that forces acting at a distance increase as the distance decreases.
- Learn that how total potential energy of a system changes as the forces act on the objects in the system.

Acquired Skills:

- Learn that model how Potential Energy can be changed into Kinetic Energy.
- Learn that interpret data showing that kinetic energy is motion energy and is proportional to the mass of the moving object.
- Learn that compare total energy in a system which may include both movement and stored energies.
- Learn that to collect data and construct graphs based on experiments that vary the mass and speed of objects.
- Learn that compare energies in a system of objects which contain stored (potential) energy relative to their positions.
- Learn that conduct experiments to determine how potential energy changes as distance changes.
- Learn that design an experiment that explores how materials differ in their abilities to conduct thermal energy.
- Learn that create a structure that controls the flow of thermal energy.
- Learn that use experimental data to show that mechanical energy is transferred to or from some other form as the motion of an object changes.
- Learn that measure mass and temperature.
- Learn that show that different materials heat up faster than others.
- Learn that show that energy spontaneously transfers from hotter objects or regions to colder.
- Learn that inhibit or increase convection, conduction, radiation depending upon problem being proposed.
- Learn that show that a force is necessary to increase or decrease the energy.
- Learn that design an experiment demonstrates that forces acting at a distance increase as the distance decreases.
- Learn that compare how total potential energy of a system changes as the forces act on the objects in the system.

Assessments:

Formative Assessments:

- Plan, carry out and support investigation with evidence: objects can interact at a distance; fields can exist between objects and can exert forces on each other even when not in contact; distinguish between electric and magnetic forces (Visual Presentation/ C.E.R.- Formative Diagnostic Assessment)
- Group discussions/presentations:
  - Propose higher order questions
  - Present information to students and ask a question
  - Have students discuss their answers with their peers at their table and discuss together as a group

Summative Assessments:

- Evaluation of a graphical display of the relationship of: mass, speed, kinetic energy (Presentation - Summative Assessment)
- Design and build a solution to a problem: identify thermal energy being transferred from 'hotter' items to 'colder' items; describe different types of materials that maximize or minimize thermal energy transfer [ex. thickness, heat conductivity, reflectivity]; describe and test constraints in design and construction (PBL - Summative Assessment)

Benchmarks:

- Students will be assessed on their ability 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.
- Students will be assessed on their ability to 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.
- Students will be assessed on their ability to apply scientific principles to design, construct and test a device that either minimizes or maximizes thermal energy transfer.
- Students will be assessed on their ability to 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.
- Students will be assessed on their ability to 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.

Alternative Assessments:

- Modified project requirements and rubrics

Suggested Learning Experiences and Instructional Activities:

<u>Anticipatory Sets</u>:

- Q: Where is the light coming from? [Flashlight, fire, moon]
- Q: How do the planets maintain an orbit around the Sun?
- Q: If I drop my phone, why does it break depending on the height dropped? (Yikes)

In-Class Activities and Laboratory Experiences:

- Phet energy simulations (skate park, pendulum, etc.)
- Roller coaster investigation
- Thermal energy transfer activity
- M.I.R.F. --- Mars Informational Research Facility

Closure and Reflection Activities:

- Lab reflection
- Q: Why is it important to purchase and put a protective case on your smartphone or MP3/4 player?

Instructional Materials:

- Textbook
- Student engineering journals
- Argumentation (claim evidence reasoning) rubric
- Lab materials
- Scientific calculators

Technology Connections:

- Pasco SparkLab (temperature Probeware)
- Pasco SparkLab (graphical analysis)

List of Applicable Performance Expectations (PE) Covered in This Unit:

- **MS-PS3-1**
- **MS-PS3-2**
- **MS-PS3-3**
- **MS-PS3-4**
- **MS-PS3-5**

Unit 6: Wave Properties, Electromagnetic Radiation, Information Technology and Instrumentation (Pacing: 12 Days)

Why Is This Unit Important?

What is the deal with LIGHT? Can you see it? What is it? This 8th grade unit helps students to formulate an answer to the question, "What are the characteristic properties of waves and how can they be used?" Students will be able to describe and predict characteristic properties and behaviors of waves.

With the increased change in societal methods of communication, students can apply an understanding of waves as a means to send digital information - increasing the security of personal information.

Students will focus on demonstrating proficiency in developing and using models, using mathematical thinking and obtaining and evaluating and communicating information.

Disciplinary Core Ideas:

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:

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)

Cross Cutting Concepts:
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)

Enduring Understandings:

- Energy travels in waves.
- There are different types of waves (transverse, longitudinal, electromagnetic and mechanical) that transfer energy.
- Mechanical and electromagnetic waves can explain natural phenomena and be used for technological applications by use of their properties (i.e., thunder before lightning, antennas for cell phone transmission and reception, noise cancellation, musical instruments, decibel-hearing loss, Doppler-radar, echo location / sonography and ultrasound.)
- Mechanical and electromagnetic waves can explain natural phenomena and be used for technological applications by use of their properties (i.e., thunder before lightning, antennas for cell phone transmission and reception, noise cancellation, musical instruments, decibel-hearing loss, Doppler-radar, echo location / sonography and ultrasound.)
- White light consists of a continuous spectrum of colors that can be reflected, transmitted or absorbed by different materials.

Essential Questions:

- How is energy transferred?
- How do waves travel?
- How do transverse and longitudinal waves behave?
- What is the electromagnetic spectrum?
- How are different parts of the electromagnetic spectrum identified?
- How do electromagnetic waves interact with matter (example: light, microwaves)?
- How do the properties of EM waves determine their uses?
- What is spectroscopy and how is it useful and what determines the colors you see in nature?
- How does light interact with matter (example: transparent materials, optical tools, other light technologies)?
- What are digital signals and how do they work (ex. Wi-Fi, fiber optics)?
- Why are optical fibers preferred over electrical cables to send information?
- How are instruments that transmit and detect waves use to extend human senses?
- What limits the amount of data storage on an optical disk and why are lasers used to read them?
- Why has the world gone digital (compared to analog)?

Acquired Knowledge:

- Learn that waves have a simple repeating pattern that consists of specific wavelengths, frequency and amplitudes.
- Learn that mechanical waves carry energy through a medium.
- Learn that the amplitude of a mechanical wave is related to the amount of energy a wave possesses.
- Learn that certain waves can be reflected, absorbed or transmitted through different materials.
- Learn that the behaviors of waves vary as they encounter different mediums.
- Learn that EM waves can be reflected, absorbed, or transmitted depending on the material encountered.

Acquired Skills:

- Learn that model waves to demonstrate wave structure and behavior.
- Learn that explain why and how waves change as they move from one medium to another.
- Learn that create a model of the behavior of light when it strikes a new medium.
- Learn that how waves are used to transmit signals through pulses.
- Learn that compare analog signals to digital signals.
- Learn that obtain and integrate scientific information from technical sources.

Assessments:

Formative Assessments:

- Identify characteristics of a simple longitudinal and transverse wave; types of waves based on wave characteristics; relationship of characteristics and behavior [i.e., light and material interaction: reflected, absorbed, transmitted - refracted, filtered; frequency and amplitude]; compare energy waves versus material waves (Test - Formative Diagnostic Assessment)
- Group discussions/presentations:
  - Propose higher order questions
  - Present information to students and ask a question
  - Have students discuss their answers with their peers at their table and discuss together as a group

Summative Assessments:

- Wave Properties Quiz
- Electromagnetic Radiation Quiz
- Unit Test on Waves

Benchmark Assessments:

- Students will be assessed on their ability 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.
- Students will be assessed on their ability to develop and use a model to describe that waves are reflected, absorbed, or transmitted through various materials.
- Students will be assessed on their ability to 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.

Alternative Assessments:

- Modified project requirements and rubrics

Suggested Learning Experiences and Instructional Activities:

Anticipatory Sets:

- Wave demonstrator
- Video
- Q: Why do quacks from ducks not echo? (Hmmmmm - true or false?)
- Q: Can you yell in space?
- Demo: Doppler Effect
- Bell in Vacuum Chamber

In-Class Activities and Laboratory Experiences:

- Spectroscopes
- Diagramming/constructing waves
- Spring wave demonstrator
- Flashlights with lens, filters and mirrors
- Spectra-tubes
- Career Exploration: Physicist
- Physical Scientists Report Project

Closure and Reflection Activities:

- **Q:** What is color? What do we see when we are 'perceiving' color?
- **Q:** When you yell in space, why can it not be heard?

Instructional Materials:

- Textbook
- Student engineering journals
- Argumentation (claim evidence reasoning) rubric
- Lab materials
- Scientific calculators

Technology Connections:

- Pasco GLX (sound meter)
- Pasco SparkLab light probe
- PHet simulation
- Spectroscopes

List of Applicable Performance Expectations (PE) Covered in This Unit:

- MS-PS4-1
- S-PS4-2
- MS-PS4-3

Sample Standards Integration

<u>Career Readiness, Life Literacies, and Key Skills</u> **9.4.8.CI.3:** For example, in Unit 1, students explore the resistance to accepting the atomic structure of matter. **9.4.8.CT.2:** For example, in Unit 2, students undertake a design project to construct, test and modify a device that either releases or absorbs thermal energy by chemical processes. **9.4.8.IML.7:** For example in Unit 6, students 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.
<u>8.1 Computer Science and Design Thinking</u> **All students will use digital tools to access, manage, evaluate, and synthesize information in order to solve problems individually and collaborate and create and communicate knowledge.** For example in Unit 5, students will access, manage, evaluate, and synthesize information to apply scientific principles to design, construct and test a device that either minimizes or maximizes thermal energy transfer.
LGBT and Disabilities Law: In Unit 4 the Physical Scientists Report Project has students explore the contributions of Physical Scientists from varying minorities including those who are LGBTQ and have disabilities
Career Exploration: There are two Career Exploration projects: • Unit 2 – Chemist • Unit 6 - Physicist
<u>Interdisciplinary Connections</u> **NJSLS.RST.9-10.8. Assess the extent to which the reasoning and evidence in a text support the author's claim or a recommendation for solving a scientific or technical problem.**

NJSLS.RST.11-12.1 Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account.

NJSLS.RST.11-12.7 Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem.

NJSLS.RST.11-12.8 Evaluate the hypotheses, data, analysis and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information.

NJSLS.SL.11-12.4 Present claims and findings, emphasizing salient points in a focused, coherent manner with relevant evidence, sound valid reasoning and well-chosen details; use appropriate eye contact, adequate volume and clear pronunciation.

NJSLS.SL.11-12.5 Make strategic use of digital media (e.g., textual, graphical, audio, visual and interactive elements) in presentations to enhance understanding of findings, reasoning and evidence and to add interest.

NJSLS.WHST.9-12.2 Write informative/explanatory texts, including the narration of historical events, scientific procedures/experiments, or technical processes.

NJSLS.WHST.9-12.7 Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.

NJSLS.WHST.9-12.9 Draw evidence from informational texts to support analysis, reflection and research.

NJSLS.WHST.11-12.8 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 overreliance on any one source and following a standard format for citation.

These standards are met through the completion of the benchmark performances in all 5 units. For example in:

- Unit 1: Students will 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.
- Unit 2: Students will 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.
- Unit 3: Students will 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.
- Unit 4: Students will construct and present arguments using evidence to support the claim that gravitational interactions are attractive and depend on the masses of interacting objects.
- Unit 5: Students will 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 6: Students will 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.MP.2 Reason abstractly and quantitatively.

NJSLS.MP.4 Model with mathematics.

NJSLS.HSN-Q.A.1 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.

NJSLS.HSN-Q.A.2 Define appropriate quantities for the purpose of descriptive modeling.

NJSLS.HSN-Q.A.3 Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.

NJSLS.HSS-IC.A.1Understand statistics as a process for making inferences about population parameters based on a random sample from that population.

NJSLS.HSS-ID.A.1Represent data with plots on the real number line.

These standards are met through the completion of the benchmark performances in all 5 units. For example in:

- Unit 1: Students will gather and make sense of information to describe that synthetic materials come from natural resources and impact society.
- Unit 2: Students will analyze and interpret data on the properties of substances before and after the substances interact to determine if a chemical reaction has occurred.
- Unit 3: Students will apply Newton's Third Law to design a solution to a problem involving the motion of two colliding objects.
- Unit 4: Students will 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 5: Students will 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.
- Unit 6: Students will 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.