Middle School Physical Sciences

Students in middle school develop understanding of key concepts to help lay the groundwork for future studies in the Physical Sciences. These ideas build upon students' science understanding from earlier grades and from the disciplinary core ideas, science and engineering practices, and crosscutting concepts of other experiences with life and earth sciences. There are two main Physical Science topics in middle school: 1) Chemistry and 2) Physics. The performance expectations in middle school blend core ideas with scientific and engineering practices and crosscutting concepts to support students in developing useable knowledge across the science disciplines. While the performance expectations in middle school physical science couple particular practices with specific disciplinary core ideas, instructional decisions should include use of many science and engineering practices integrated in the performance expectations. The concepts and practices in the performance expectations are based on the grade-band endpoints described in A Framework for K-12 Science Education (NRC, 2012).

The Performance Expectations in **Matter and its Interactions** help students formulate an answer to the questions, "What is all matter composed of?" and "How is that matter organized in the Periodic Table?" Middle school students can plan and carry out investigations to develop evidence that all matter is composed of smaller particles called atoms. Students can use understanding of atomic theory to develop physical and conceptual models of atoms and molecules. They can construct explanations for the interactions of different elements and how those interactions are responsible for the formation of other materials in our environment. Also can explain the concepts of conservation of matter and energy. By the end of their studies, students understand and can explain the concepts behind atomic theory, how elements are organized into the Periodic Table, how atoms interact to form molecules, and how chemical reactions take place. Crosscutting concepts of cause and effect, structure and function, scale and proportion, and matter and energy are called out as organizing concepts for these core ideas.

The Performance Expectations in **Motion and Stability: Forces and Interactions** help students formulate an answer to the questions, "How are Newton's Laws of Motion applied to everyday life?" and "How do the interactions of forces effect our everyday lives?" Students understand how forces are calculated and used to calculate measurements such as speed, velocity and acceleration. They also demonstrate understanding of Bernoulli's and Pascal's Principles by applying what they have learned to plan and carry out investigations highlighting the topics. Finally, students will plan and carry out investigations highlighting how forces combine and illustrating their understanding of Newton's Laws. Students can use the practices of analyzing and interpreting data, using models, conducting investigations and communicating information in conjunction with these topics. Crosscutting concepts of structure and function, change and stability, and matter and energy support understanding across the topics in this unit.

SCIENTIFIC SKILLS UNIT (REVIEW)

NJCCCS

5.1.8 A 1. Habits of Mind – evaluate data
5.1.8 A 2. Habits of Mind – communicate with others
5.1.8 A 4. Habits of Mind – curiosity, skepticism,honesty, open-mindedness
5.1.8 B 1. Inquiry & Problem Solving – identify questions & make predictions
5.1.8 B 3. Inquiry & Problem Solving – collect, organize & interpret
5.1.8 C 1. Safety – when & how to use safety equipment
5.1.8 C 2. Safety – practice safety procedures during experiments
5.2.8 A 1. Cultural Contributions – constantly change over time; many people, reflect social & political
5.2.8 A 2. Cultural Contributions – many cultures work together – NOT specific scientists
5.2.8 B 1. Historical Perspectives – science/tech in conjunction with other history events
5.2.8 B 2. Historical Perspectives – development & exponential growth of innovation
5.3.8 A 1. Numerical Operations – appropriate use of decimals, percents, sci. notation
5.3.8 B 1. Geometry and Measurement – compute using labels & units
5.3.8 D 1. Data Analysis / Probability – represent & describe in graphs/tables
5.3.8 D 4. Data Analysis / Probability – use computers for analysis

The above NJCCCS standards will be applied throughout each unit during the course of the school year:

Instructional Actions

Activities/Strategies	Assessment
• Warm-ups • Group and classroom discussion • Hands-on activities • Inquiry-based Learning Activities • Group Demonstrations • Internet Technology (visual aids, videos, and interactive websites) • Class Surveys/Debates	• Tests & quizzes • Current Science Assignments • Classwork on various topics • Homework Assignments • Differentiated Projects • Teacher observations • Discussion/Class participation • Lab Reports

Science Skills

- Classroom expectations/rules
- Lab safety equipment and procedures
- Lab equipment identification and function
- Definitions and samples of observation and inferences.
- Lab expectations/ scientific method: to include: Purpose, Research, Hypothesis, Experiment, Analysis, Conclusion (Throughout the year)
- Current Science expectations & importance
- Skills for thinking critically
- How to use the metric system (Conversions and Conversion Factors)

Next Generation Science Standards	
Students who demonstrate understanding can:	
MS-PS1-1.	**Develop models to describe the atomic composition of simple molecules and extended structures.** [Clarification Statement: Emphasis is on developing models of molecules that vary in complexity. Examples of simple molecules could include ammonia and methanol. Examples of extended structures could include sodium chloride or diamonds. Examples of molecular-level models could include drawings, 3D ball and stick structures, or computer representations showing different molecules with different types of atoms.] [*Assessment Boundary: Assessment does not include valence electrons and bonding energy, discussing the ionic nature of subunits of complex structures, or a complete description of all individual atoms in a complex molecule or extended structure is not required.*]
MS-PS1-2.	**Analyze and interpret data on the properties of substances before and after the substances interact to determine if a chemical reaction has occurred.** [Clarification Statement: Examples of reactions could include burning sugar or steel wool, fat reacting with sodium hydroxide, and mixing zinc with hydrogen chloride.] [*Assessment boundary: Assessment is limited to analysis of the following properties: density, melting point, boiling point, solubility, flammability, and odor.*]
MS-PS1-3.	**Gather and make sense of information to describe that synthetic materials come from natural resources and impact society.** [Clarification Statement: Emphasis is on natural resources that undergo a chemical process to form the synthetic material. Examples of new materials could include new medicine, foods, and alternative fuels.] [*Assessment Boundary: Assessment is limited to qualitative information.*]
MS-PS1-4.	**Develop a model that predicts and describes changes in particle motion, temperature, and state of a pure substance when thermal energy is added or removed.** [Clarification Statement: Emphasis is on qualitative molecular-level models of solids, liquids, and gases to show that adding or removing thermal energy increases or decreases kinetic energy of the particles until a change of state occurs. Examples of models could include drawing and diagrams. Examples of particles could include molecules or inert atoms. Examples of pure substances could include water, carbon dioxide, and helium.]
MS-PS1-5.	**Develop and use a model to describe how the total number of atoms does not change in a chemical reaction and thus mass is conserved.** [Clarification Statement: Emphasis is on law of conservation of matter and on physical models or drawings, including digital forms, that represent atoms.] [*Assessment Boundary: Assessment does not include the use of atomic masses, balancing symbolic equations, or intermolecular forces.*]
MS-PS1-6.	**Undertake a design project to construct, test, and modify a device that either releases or absorbs thermal energy by chemical processes.*** [Clarification Statement: Emphasis is on the design, controlling the transfer of energy to the environment, and modification of a device using factors such as type and concentration of a substance. Examples of designs could involve chemical reactions such as dissolving ammonium chloride or calcium chloride.] [*Assessment Boundary: Assessment is limited to the criteria of amount, time, and temperature of substance in testing the device.*]

NJCCCS
5.1.8 A (1-4) 5.1.8 B (1-3) 5.1.8 C (1-2) 5.2.8 A (1-3) 5.2.8 B (1-2) 5.3.8 A, B, C, D (1-4) 5.4.8 A, B, C

5.6.8 A (1-4)
5.6.8 B (1-4)

Common Core State Standards

Common Core State Standards Connections:

ELA/Literacy -

RST.6-8.1	Cite specific textual evidence to support analysis of science and technical texts, attending to the precise details of explanations or descriptions.*(MS-PS1-2)*,(MS-PS1-3)
RST.6-8.3	Follow precisely a multistep procedure when carrying out experiments, taking measurements, or performing technical tasks. (MS-PS1-6)
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-PS1-1)*,(MS-PS1-2),*(MS-PS1-4),(MS-PS1-5)*
WHST.6-8.7	Conduct short research projects to answer a question (including a self-generated question), drawing on several sources and generating additional related, focused questions that allow for multiple avenues of exploration. (MS-PS1-6)
WHST.6-8.8	Gather relevant information from multiple print and digital sources, using search terms effectively; assess the credibility and accuracy of each source; and quote or paraphrase the data and conclusions of others while avoiding plagiarism and following a standard format for citation. (MS-PS1-3)

Mathematics -

MP.2	Reason abstractly and quantitatively. (MS-PS1-1),(MS-PS1-2),(MS-PS1-5)
MP.4	Model with mathematics. *(MS-PS1-1)*,(MS-PS1-5)
6.RP.A.3	Use ratio and rate reasoning to solve real-world and mathematical problems. *(MS-PS1-1),(MS-PS1-2)*,(MS-PS1-5)
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-PS1-4)
8.EE.A.3	Use numbers expressed in the form of a single digit times an integer power of 10 to estimate very large or very small quantities, and to express how many times as much one is than the other. *(MS-PS1-1)*
6.SP.B.4	Display numerical data in plots on a number line, including dot plots, histograms, and box plots. *(MS-PS1-2)*
6.SP.B.5	Summarize numerical data sets in relation to their context. (MS-PS1-2)

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
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)	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-PS1-2),(MS-PS1-3) • Gases and liquids are made of molecules or inert atoms that are moving about relative to each other. (MS-PS1-4) • In a liquid, the molecules are constantly in contact with others; in a gas, they are widely spaced except when they happen to collide. In a solid, atoms are closely spaced and may vibrate in position but do not change relative locations. (MS-PS1-4) • 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	Patterns • Macroscopic patterns are related to the nature of microscopic and atomic-level structure. (MS-PS1-2) Cause and Effect • Cause and effect relationships may be used to predict phenomena in natural or designed systems. (MS-PS1-4) Scale, Proportion, and Quantity • Time, space, and energy phenomena can be observed at various scales using models to study systems that are too large or too small. (MS-PS1-1) Energy and Matter • Matter is conserved because atoms are conserved in physical and chemical processes. (MS-PS1-5) • The transfer of energy can be tracked as energy flows through a designed or natural system. (MS-PS1-6) Structure and Function • Structures can be designed to serve particular functions by taking into account properties of different materials, and how materials can be shaped and used. (MS-PS1-3) - *Connections to Engineering,Technology, and Applications of Science*

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) - *Connections to Nature of Science* Scientific Knowledge is Based on Empirical Evidence • Science knowledge is based upon logical and conceptual connections between evidence and explanations. (MS-PS1-2) Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena • Laws are regularities or mathematical descriptions of natural phenomena. (MS-PS1-5)	• Substances react chemically in characteristic ways. In a chemical process, the atoms that make up the original substances are regrouped into different molecules, and these new substances have different properties from those of the reactants. (MS-PS1-2),(MS-PS1-3),(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) 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)* 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)*	Interdependence of Science, Engineering, and Technology • Engineering advances have led to important discoveries in virtually every field of science, and scientific discoveries have led to the development of entire industries and engineered systems. (MS-PS1-3) Influence of Science, Engineering and Technology on Society and the Natural World • The uses of technologies and any limitation on their use are driven by individual or societal needs, desires, and values; by the findings of scientific research; and by differences in such factors as climate, natural resources, and economic conditions. Thus technology use varies from region to region and over time. (MS-PS1-3)

Instructional Actions	
Activities/Strategies	Assessment
• Warm-ups/Science Starters • Group and classroom discussion • Hands-on activities • Inquiry-based Learning Activities • Atomic Structure Modeling • Periodic Table Construction Activities • Group Demonstrations • Internet Technology (visual aids, videos, and interactive websites) • Class Surveys/Debates	• Tests & quizzes • Current Science Assignments • Classwork on various topics • Homework Assignments • Differentiated Projects • Teacher observations • Discussion/Class participation • Lab Reports

Motion and Stability: Forces and Interactions (Motion, Newton's Laws and Energy)

Next Generation Science Standards
Students who demonstrate understanding can: MS-PS2-1. **Apply Newton's Third Law to design a solution to a problem involving the motion of two colliding objects.***[Clarification Statement: Examples of practical problems could include the impact of collisions between two cars, between a car and stationary objects, and between a meteor and a space vehicle.] [*Assessment Boundary: Assessment is limited to vertical or horizontal interactions in one dimension.*] MS-PS2-2. **Plan an investigation to provide evidence that the change in an object's motion depends on the sum of the forces on the object and the mass of the object.** [Clarification Statement: Emphasis is on balanced (Newton's First Law) and unbalanced forces in a system, qualitative comparisons of forces, mass and changes in motion (Newton's Second Law), frame of reference, and specification of units.] [*Assessment Boundary: Assessment is limited to forces and changes in motion in one-dimension in an inertial reference frame and to change in one variable at a time. Assessment does not include the use of trigonometry.*] MS-PS2-3. **Ask questions about data to determine the factors that affect the strength of electric and magnetic forces.** [Clarification Statement: Examples of devices that use electric and magnetic forces could include electromagnets, electric motors, or generators. Examples of data could include the effect of the number of turns of wire on the strength of an electromagnet, or the effect of increasing the number or strength of magnets on the speed of an electric motor.] [*Assessment Boundary: Assessment about questions that require quantitative answers is limited to proportional reasoning and algebraic thinking.*] MS-PS2-4. **Construct and present arguments using evidence to support the claim that gravitational interactions are attractive and depend on the masses of interacting objects.** [Clarification Statement: Examples of evidence for arguments could include data generated from simulations or digital tools; and charts displaying mass, strength of interaction, distance from the Sun, and orbital periods of objects within the solar system.] [*Assessment Boundary: Assessment does not include Newton's Law of Gravitation or Kepler's Laws.*] MS-PS2-5. **Conduct an investigation and evaluate the experimental design to provide evidence that fields exist between objects exerting forces on each other even though the objects are not in contact.** [Clarification Statement: Examples of this phenomenon could include the interactions of magnets, electrically-charged strips of tape, and electrically-charged pith balls. Examples of investigations could include first-hand experiences or simulations.] [*Assessment Boundary: Assessment is limited to electric and magnetic fields, and limited to qualitative evidence for the existence of fields.*]
NJCCCS
5.1.8 A (1-4) 5.1.8 B (1-3) 5.1.8 C (1-2) 5.2.8 A (1-3) 5.2.8 B (1-2) 5.3.8 A, B, C, D (1-4) 5.4.8 A, B, C 5.7.8 B (2-3)
Common Core State Standards
Common Core State Standards Connections: *ELA/Literacy -* RST.6-8.1 Cite specific textual evidence to support analysis of science and technical texts, attending to the precise details of explanations or descriptions. *(MS-PS2-1),(MS-PS2-3)* RST.6-8.3 Follow precisely a multistep procedure when carrying out experiments, taking measurements, or performing technical tasks. *(MS-PS2-1),(MS-PS2-2),(MS-PS2-5)*

WHST.6-8.1	Write arguments focused on *discipline-specific content*. (MS-PS2-4)
WHST.6-8.7	Conduct short research projects to answer a question (including a self-generated question), drawing on several sources and generating additional related, focused questions that allow for multiple avenues of exploration. *(MS-PS2-1)*,(MS-PS2-2),*(MS-PS2-5)*
Mathematics -	
MP.2	Reason abstractly and quantitatively. (MS-PS2-1),(MS-PS2-2),(MS-PS2-3)
6.NS.C.5	Understand that positive and negative numbers are used together to describe quantities having opposite directions or values; use positive and negative numbers to represent quantities in real-world contexts, explaining the meaning of 0 in each situation. (MS-PS2-1)
6.EE.A.2	Write, read, and evaluate expressions in which letters stand for numbers. *(MS-PS2-1),(MS-PS2-2)*
7.EE.B.3	Solve multi-step real-life and mathematical problems posed with positive and negative rational numbers in any form, using tools strategically. Apply properties of operations to calculate with numbers in any form; convert between forms as appropriate; and assess the reasonableness of answers using mental computation and estimation strategies. *(MS-PS2-1),(MS-PS2-2)*
7.EE.B.4	Use variables to represent quantities in a real-world or mathematical problem, and construct simple equations and inequalities to solve problems by reasoning about the quantities. *(MS-PS2-1),(MS-PS2-2)*

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
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)	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)	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) - *Connections to Engineering,Technology, and Applications of Science* Influence of Science, Engineering, and Technology on Society and the Natural World • The uses of technologies and any limitations on their use are driven by individual or societal needs, desires, and values; by the findings of scientific research; and by differences in such factors as climate, natural resources, and economic conditions. (MS-PS2-1)

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) - *Connections to Nature of Science* Scientific Knowledge is Based on Empirical Evidence • Science knowledge is based upon logical and conceptual connections between evidence and explanations. (MS-PS2-2),(MS-PS2-4)		

Instructional Actions	
Activities/Strategies	Assessment
• Warm-ups • Group and classroom discussion • Hands-on activities • Inquiry-based Learning Activities • Group Demonstrations • Internet Technology (visual aids, videos, and interactive websites) • Class Surveys/Debates	• Tests & quizzes • Current Science Assignments • Classwork on various topics • Homework Assignments • Differentiated Projects Balloon Cars Buoyant Boats Let's Take Flight • Teacher observations • Discussion/Class participation • Lab Reports