Physical Science 9

Curriculum

Francis Howell School District

LEARNING TOGETHER

Board Approved:

Francis Howell School District

Mission Statement

The mission of the Francis Howell School District is to prepare students today for success tomorrow.

Vision Statement

Every student will graduate with college and career readiness skills.

Values

Francis Howell School District is committed to:

- Providing a consistent and comprehensive education that fosters high levels of academic achievement
- Operating safe and well-maintained facilities
- Providing a safe learning environment for all students
- Promoting parent, community, student, and business involvement in support of the school district
- Ensuring fiscal responsibility
- Developing responsible citizens
- Operating as a professional learning community
- Making appropriate use of technology

Francis Howell School District Graduate Goals

Upon completion of their academic study in the Francis Howell School District, students will be able to:

1. Gather, analyze and apply information and ideas.
2. Communicate effectively within and beyond the classroom.
3. Recognize and solve problems.
4. Make decisions and act as responsible members of society.

Science Graduate Goals

The students in the Francis Howell School District will graduate with the knowledge, skills, and attitudes essential to leading a productive, meaningful life. Graduates will:

- Understand and apply principles of scientific investigation.
- Utilize the key concepts and principles of life, earth, and physical science to solve problems.
- Recognize that science is an ongoing human endeavor that helps us understand our world.
- Realize that science, mathematics, and technology are interdependent, each with strengths and limitations that impact the environment and society.
- Use scientific knowledge and scientific ways of thinking for individual and social purposes.

Physical Science 9 Course Rationale

Science education develops science literacy. Scientific literacy is the knowledge and understanding of scientific concepts and processes required for personal decision making, participation in civic and cultural affairs, and economic productivity. A sound grounding in science strengthens many of the skills that people use every day, like solving problems creatively, thinking critically, working cooperatively in teams, using technology effectively, and valuing life-long learning.   Scientific literacy has become a necessity for everyone.

To accomplish this literacy, science courses will reflect the following:

- Develop scientific reasoning and critical thinking skills.
- Extend problem-solving skills using scientific methods.
- Include lab-based experiences.
- Strengthen positive attitudes about science.
- Incorporate the use of new technologies
- Provide relevant connections to personal and societal issues and events.

Physical Science 9 Course Description

In this course the student will use science and engineering practices to investigate energy, forces and motion, the structures and properties of matter, and chemical reactions. First semester concepts include transfer from potential to kinetic to electrical energy, distance and velocity, graphing, Newton's second law, and collisions. Second semester concepts include atomic structure on the micro and macro scale, periodic trends, writing and balancing simple equations, and investigating what drives chemical reactions to completion.

Physical Science 9 Curriculum Team

Curriculum Committee

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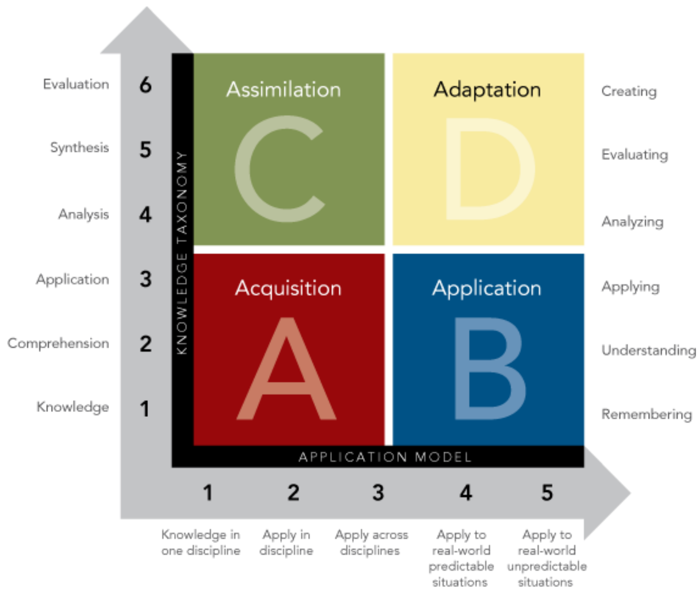
Curriculum Notes

All FHSD performance tasks and sample learning activities are aligned not only to understandings and standards, but also the Rigor and Relevance Framework and 21st Century Skills. Information on these two things is provided below or by clicking on the hyperlinks.

Rigor and Relevance Framework

The Rigor/Relevance Framework is a tool developed by the International Center to examine curriculum, instruction, and assessment along the two dimensions of higher standards and student achievement.



The Rigor/Relevance Framework has four quadrants.
Quadrant A represents simple recall and basic understanding of knowledge for its own sake. Examples of Quadrant A knowledge are knowing that the world is round and that Shakespeare wrote Hamlet.

Quadrant C represents more complex thinking but still knowledge for its own sake. Quadrant C embraces higher levels of knowledge, such as knowing how the U.S. political system works and analyzing the benefits and challenges of the cultural diversity of this nation versus other nations.

Quadrants B and D represent action or high degrees of application. Quadrant B would include knowing how to use math skills to make purchases and count change. The ability to access information in wide-area network systems and the ability to gather knowledge from a variety of sources to solve a complex problem in the workplace are types of Quadrant D knowledge.

A	B	C	D
Students gather and store bits of knowledge and information. Students are primarily expected to remember or understand this knowledge.	Students use acquired knowledge to solve problems, design solutions, and complete work. The highest level of application is to apply knowledge to new and unpredictable situations.	Students extend and refine their acquired knowledge to be able to use that knowledge automatically and routinely to analyze and solve problems and create solutions.	Students have the competence to think in complex ways.

21st Century Skills

These skills have been pared down from 18 skills to what are now called the 4Cs.   The components include critical thinking, communication, collaboration, and creativity. Critical thinking is focused, careful analysis of something to better understand and includes skills such as arguing, classifying, comparing, and problem solving. Communication is the process of transferring a thought from one mind to others and receiving thoughts back and includes skills such as choosing a medium (and/or technology tool), speaking, listening, reading, writing, evaluating messages. Collaboration is working together with others to achieve a common goal and includes skills such as delegating, goal setting, resolving conflicts, team building, decision-making, and managing time. Creativity is expansive, open-ended invention and discovery of possibilities and includes skills such as brainstorming, creating, designing, imagining, improvising, and problem-solving.

Standards

Standards aligned to this course can be found:

Science Standards

Missouri Science Standards 6-12

National Educational Technology Standards

http://www.iste.org/STANDARDS

Units & Standards Overview

Semester 1 **Semester 2**

Unit 1: Energy	Unit 2: Forces and Motion
Anchoring Phenomena: Black Mystery Energy Transfer Box	**Anchoring Phenomena:** Meteor!
Standards Addressed HSPS3-1 HSPS3-2 **HSPS3-3** HSPS3-4	**Standards Addressed** HSPS2-1 HSPS2-2 **HSPS2-3** HSPS2-4 HSPS3-5 (Limited to the relationship between gravitational fields and energy only.)
PE Assessment:1st Quarter Engineering Challenge 1st Quarter Performance Task Assessment.	**PE Assessment:** *2nd Quarter Engineering Challenge* *2nd Quarter Performance Task Assessment*
Unit 3: Structure and Properties of Matter	**Unit 4: Chemical Reactions**
Anchoring Phenomena: Carbon as graphite and diamond	**Anchoring Phenomena:** Teacher's Choice of Totally Awesome Reaction Demonstration (i.e. Elephant's Toothpaste)
Standards Addressed HSPS1-1 **HSPS1-3** HSPS2-6	**Standards Addressed** HSPS1-2 HSPS1-4 **HSPS1-5** HSPS1-7
PE Assessment: 3rd quarter Science Inquiry Practices 3rd Quarter Performance Task Assessment	PE Assessment:4th Quarter Inquiry Performance Task 4th Quarter Performance Task Assessment

Course Map

	Unit Description	PE Summary	PE Standards
Unit 1: Energy **8 weeks**	Students will be able to quantitatively and qualitatively describe the different forms of energy and how they can be transferred. This can include conservation of energy between the macroscopic and microscopic level. This energy conservation includes thermodynamics and uniform energy distribution. Energy of universal gravity can be referenced here, but not assessed until unit 2.	Students will design, build, and refine a device that works within given constraints to convert one form of energy into another form of energy.	HS-PS3-1 HS-PS3-2 **HS-PS3-3**
Unit 2: Forces and Motion **10 weeks**	Students will understand newton's second law, momentum conservation, and impulse. This includes both concepts and calculations, such as forces on objects and collisions. When calculating forces, students will understand gravity can be demonstrated with a field that mitigates based on the distance from the source and the size of the object.	Students will apply scientific and engineering ideas to design, evaluate, and refine a device that minimizes the force on a macroscopic object during a collision.	HSPS2-1 HSPS2-2 **HSPS2-3**
Unit 3: Structure and Properties of Matter **8 weeks**	Students will understand the properties of elements based on their valence electrons and location on the periodic table. Students will use their understanding of the periodic table to later interpret and predict ion formation, chemical bonds, and basic network structures. Students will use knowledge to predict molecular properties such as boiling point, melting point, electrical conductivity, and reaction rates.	Students will plan and conduct an investigation to gather evidence to compare the structure of substances at the bulk scale to infer the strength of electrical forces between particles..	HSPS1-1 **HSPS1-3** HSPS2-6
Unit 4: Chemical Reactions	Student will be able to predict ion formation, chemical bond formation, and the energy input and outputs associated with these chemical reactions. Additionally, students will be able to understand and	Students will apply scientific principles and evidence to provide an explanation about the effects of changing the temperature or concentration of the reacting particles on the	HS-PS1-2 HS-PS1-4 **HS-PS1-5** HS-PS1-7

10 weeks	determine the change in reaction rates due to change in energy, concentrations, etc. Students should demonstrate, quantitatively and qualitatively, that these reactions conserve mass.	rate at which a reaction occurs.	
Sem 1 Final Exam			
Sem 2 Final Exam			

Unit 1: **Energy**

Content Area: Science	Course: Physical Science 9	UNIT: Energy

Unit Description:	Unit Timeline:
Students will be able to quantitatively and qualitatively describe the different forms of energy and how they can be transferred. This can include conservation of energy between the macroscopic and microscopic level. This energy conservation includes thermodynamics and uniform energy distribution. Energy of universal gravity can be referenced here, but not assessed until unit 2.	8 weeks

DESIRED Results

Transfer Goal (Science and Engineering Practices) - ***Students will be able to independently use their learning to……***

1. Ask questions and define problems.
2. Develop and use models.
3. Plan and carry out investigations
4. Analyze and interpret data.
5. Use mathematical and computational thinking.
6. Construct explanations and design solutions
7. Engage in an argument from evidence.
8. Obtain, evaluate, and communicate information.

Understandings (Cross Cutting Concepts) – ***Students will understand… (Big Ideas)***

1. Patterns: Repeating cycles, shapes, or spatial features (What do I notice in this phenomenon or system after careful observation? What patterns do I observe? What questions do I have about these patterns? What additional observations could I make? How do these patterns compare to other patterns? How can I model these patterns? What might cause these patterns? What further investigations would help clarify these patterns and their cause?)
2. Cause and Effect: Events have causes, sometimes simple, sometimes multifaceted. Correlation doesn't imply causation. (What relationships between events or patterns do I observe in this phenomenon or system? What can I explain about these relationships? Are any of these relationships cause and effect? What evidence supports a cause and effect relationship? Can my model provide a mechanism for this cause and effect relationship? What further investigations would help

determine if these relationships are cause and effect?)

3. Scale, Proportion, & Quantity: It is critical to recognize what is relevant at different size, time, and energy scales, and to recognize proportional relationships between different quantities as scales change. (How can we investigate nature at this scale? What aspects of this system do we need to measure to describe it more precisely? On what scale must we make these measurements? What do we need to control as we make these measurements? What relationships between quantities do we observe?)
4. Systems & System Models: A system is an organized group of related objects or components; models can be used for understanding and predicting the behavior of systems. (What system or systems do we need to model to explain this phenomenon? What are the inputs and outputs of the system? What scale(s) within the system do we need these models to describe and represent? How can we delineate the boundary of the system? What are the components or sub-systems of this system? What are the relationships between the components in this system? What predictions can be make from our model? What are the limits of the system model?)
5. Energy and Matter: Tracking energy and matter flows, into, out of, and within systems. (What matter flows into, out of, and within the system? What physical and chemical changes occur in this system? What energy transfer occurs into, out of, or within this system? What transformations of energy are important in this system? What are the needed inputs in this system? What are the desired outputs in this system? How are energy and matter related in this system?)
6. Structure and Function: The way an object is shaped or structured determines many of its properties and functions. (What shapes or structures are observed in this system at this scale? What roles do these structures play in the functioning of the system? How do the structures support the functions? How do different conditions relate to patterns of differences in structures or appearance?)
7. Stability and Change: Conditions that affect stability and factors that control rates of change are critical elements to consider and understand in natural systems. (Under what range of conditions does this system operate effectively? What changes in conditions causes changes in its stable operation? What characteristics of the system change? What changes in conditions could cause it to become unstable or to fail? What feedback loops in the operation of this system enhance its range of stable operations? What feedback loops in the operation of the system tend to destabilize it?)

<u>Essential Questions</u>: *Students will keep considering…*

- How does the Hoover Dam provide electricity to 1.3 million people?
- Where does the electricity to charge your cell phone come from?
- How do roller coasters work?
- How does refrigeration work?

Anchoring Phenomena: Each teacher will be provided with a “mystery box” that has several different energy transformations. Students will be lead through inquiry and modeling to predict what is happening. This box will NEVER be opened and displayed to students.

Standards Addressed
Students who demonstrate understanding can: ● HS-PS3-1 Create a computational model to calculate the change in the energy of one component in a system when the change in energy of the other component(s) and energy flows in and out of the system are known. [Clarification Statement: Emphasis is on explaining the meaning of mathematical expressions used in the model.] [Assessment Boundary: Assessment is limited to basic algebraic expressions or computations; to systems of two or three components; and to thermal energy, kinetic energy, and/or the energies in gravitational, magnetic, or electric fields.] (linked to MLS 9-12-PS3-A-1) ● HS-PS3-2 Develop and use models to illustrate that energy at the macroscopic scale can be accounted for as a combination of energy associated with the motions of particles (objects) and energy associated with the relative positions of particles (objects). [Clarification Statement: Examples of phenomena at the macroscopic scale could include the conversion of kinetic energy to thermal energy, the energy stored due to position of an object above the earth, and the energy stored between two electrically-charged plates. Examples of models could include diagrams, drawings, descriptions, and computer simulations.] (linked to MLS 9-12-PS3-A-2) ● **HS-PS3-3 Design, build, and refine a device that works within given constraints to convert one form of energy into another form of energy.[Clarification Statement: Emphasis is on both qualitative and quantitative evaluations of devices. Examples of devices could include Rube Goldberg devices, wind turbines, solar cells, solar ovens, and generators. Examples of constraints could include use of renewable energy forms and efficiency.] [Assessment Boundary: Assessment for quantitative evaluations is limited to total output for a given input. Assessment is limited to devices constructed with materials provided to students.]** (linked to MLS 9-12-PS3-A-3) ● HS-PS3-4 Plan and conduct an investigation to provide evidence that the transfer of thermal energy when two components of different temperature are combined within a closed system results in a more uniform energy distribution among the components in the system (second law of thermodynamics). [Clarification Statement: Emphasis is on analyzing data from student investigations and using mathematical thinking to describe the energy changes both quantitatively and conceptually. Examples of investigations could include mixing liquids at different initial temperatures or adding objects at different temperatures to water.] [Assessment Boundary: Assessment is limited to investigations based on materials and tools provided to students.] (linked to MLS 9-12-PS3-B-4)

Disciplinary Core Ideas **Students will know...**	**Cross Cutting Concepts** **Students will understand....**	**Science and Engineering Practice** **Students will be able to...**
PS3.A: Definitions of Energy (HS-PS3-1) Energy is a quantitative property of a system that depends on the motion and interactions of matter and radiation within that system. That there is a single quantity called energy is due to the fact that a system's total energy is conserved, even as, within the system, energy	Systems and System Models There are boundaries and reference levels for a system's computations involving energy level. (potential, kinetic, spring, fields, etc. all expressed in Joules) There are limitations to these computational	Mathematical and computational thinking Create a computational model or simulation of a phenomenon, designed device, process, or system. Students identify and describe the components to be computationally modeled, including:

is continually transferred from one object to another and between its various possible forms. **PS3.B: Conservation of Energy and Energy Transfer(HS-PS3-1)** Conservation of energy means that the total change of energy in any system is always equal to the total energy transferred into or out of the system. Energy cannot be created or destroyed, but it can be transported from one place to another and transferred between systems. Mathematical expressions, which quantify how the stored energy in a system depends on its configuration (e.g., relative positions of charged particles, compression of a spring) and how kinetic energy depends on mass and speed, allow the concept of conservation of energy to be used to predict and describe system behavior. The availability of energy limits what can occur in any system	models within the parameters of a defined system. When the energy of one component of the system changes, due to flow of energy, there will be a change in the energy of other components of the system as well. Within a closed system energy is conserved on both the macroscopic and molecular/atomic scales, so that the total energy within a system remains constant. Energy on the macroscopic level can be accounted for as a combination of energy on the microscopic level and relative position of objects. The engineering design process can be used to design or increase the efficiency of energy conversion for set devices. Data can be analyzed to refine devices/experiments and address experimental questions. The energy between objects involved in field forces (universal gravity) can be changed based on relative mass and position of objects.	1. The boundaries of the system and that the reference level for potential energy = 0 (the potential energy of the initial or final state does not have to be zero) 2. The initial energies of the system's components (e.g., energy in fields, thermal energy, kinetic energy, energy stored in springs — all expressed as a total amount of Joules in each component), including a quantification in an algebraic description to calculate the total initial energy of the system 3. The energy flows in or out of the system, including a quantification in an algebraic description with flow into the system defined as positive; and 4. The final energies of the system components, including a quantification in an algebraic description to calculate the total final energy of the system Students use the algebraic descriptions of the initial and final energy state of the system, along with the energy flows to create a computational model (e.g., simple computer program, spreadsheet, simulation software package application) that is based on the principle of the conservation of energy. Students use the computational model to calculate changes in the energy of one component of the system when changes in the energy of the other components and the energy flows are known. Students use the computational model to predict the maximum possible change in the energy of one component of the system for a given set of energy flows. Students identify and describe the limitations of the computational model, based on the assumptions that were made in creating the algebraic descriptions of energy changes and flows in the system.
PS3.A: Definitions of Energy Energy is a quantitative property of a system that depends on the motion and interactions of matter and radiation within that system. That	Energy and Matter Students understand that energy cannot be created or destroyed; it only moves between one place and another place,	Develop and Use Models Students develop models in which they identify and describe the relevant components, including: 1. All the components of the system and the

there is a single quantity called energy is due to the fact that a system's total energy is conserved, even as, within the system, energy is continually transferred from one object to another and between its various possible forms.(HS-PS3-2) At the macroscopic scale, energy manifests itself in multiple ways, such as in motion, sound, light, and thermal energy.(HS-PS3-2) These relationships are better understood at the microscopic scale, at which all of the different manifestations of energy can be modeled as a combination of energy associated with the motion of particles and energy associated with the configuration (relative position of the particles). In some cases the relative position energy can be thought of as stored in fields (which mediate interactions between particles). This last concept includes radiation, a phenomenon in which energy stored in fields moves across space. (HS-PS3-2)	between objects and/or fields, or between systems. Students understand that in closed systems the energy is conserved on both the macroscopic and molecular/atomic scales so that as one form of energy changes, the total system energy remains constant, as evidenced by the other forms of energy changing by the same amount or changes only by the amount of energy that is transferred into or out of the system. Students understand that energy at the macroscopic scale can be accounted for as a combination of energy associated with the motions of particles/objects and energy associated with the relative positions of particles/objects on both the macroscopic and microscopic scales.	surroundings, as well as energy flows between the system and the surroundings; 2. Clearly depicting both a macroscopic and a molecular/atomic-level representation of the system; 3. Depicting the forms in which energy is manifested at two different scales: a. Macroscopic , such as motion, sound, light, thermal energy, potential energy or energy in fields b. Molecular/atomic, such as motions (kinetic energy) of particles (e.g., nuclei and electrons), the relative positions of particles in fields (potential energy), and energy in fields. Students describe the relationships between components in their models, including: 1. Changes in the relative position of objects in gravitational, magnetic or electrostatic fields can affect the energy of the fields (e.g., charged objects moving away from each other change the field energy). 2. Thermal energy includes both the kinetic and potential energy of particle vibrations in solids or molecules and the kinetic energy of freely moving particles (e.g., inert gas atoms, molecules) in liquids and gases. 3. The total energy of the system and surroundings is conserved at a macroscopic and molecular/atomic level. 4. Chemical energy can be considered in terms of systems of nuclei and electrons in electrostatic fields (bonds). 5. As one form of energy increases, others must decrease by the same amount as energy is transferred among and between objects and fields. Students use their models to show that in closed systems the energy is conserved on both the macroscopic and molecular/atomic scales so that as one form of energy changes, the total system energy remains constant, as evidenced by the other forms of energy changing by the same amount or changes only by the amount of energy that is

		transferred into or out of the system. Students use their models to illustrate that energy at the macroscopic scale can be accounted for as a combination of energy associated with the motions of particles/objects and energy associated with the relative positions of particles/objects on both the macroscopic and microscopic scales.
PS3.A: Definitions of Energy **At the macroscopic scale, energy manifests itself in multiple ways, such as in motion, sound, light, and thermal energy. (HS-PS3-3)** **PS3.D: Energy in Chemical Processes** **Although energy cannot be destroyed, it can be converted to less useful forms — for example, to thermal energy in the surrounding environment.(HS-PS3-3)** **ETS1.A: Defining and Delimiting an Engineering Problem** **Criteria and constraints also include satisfying any requirements set by society, such as taking issues of risk mitigation into account, and they should be quantified to the extent possible and stated in such a way that one can tell if a given design meets them. (secondary)(HS-PS3-3)**	**Energy and Matter** **Students understand that changes of energy and matter in a system can be described in terms of energy and matter flows into, out of, and within that system.**	**Constructing explanations and designing solutions** **Students design a device that converts one form of energy into another form of energy.** **Students develop a plan for the device in which they:** **1. Identify what scientific principles provide the basis** **2. Identify the forms of energy that will be converted from one form to another in the designed system;** **3. Identify losses of energy by the design system to the surrounding environment;** **4. Describe the scientific rationale for choices of materials and structure of the device, including how student-generated evidence influenced the design; and** **5. Describe that this device is an example of how the application of scientific knowledge and engineering design can increase benefits for modern civilization while decreasing costs and risk.** **Students describe and quantify (when appropriate) prioritized criteria and constraints for the design of the device, along with the tradeoffs implicit in these design solutions. Examples of constraints to be considered are cost and efficiency of energy conversion.** **Students build and test the device according to the plan.** **Students systematically and quantitatively evaluate the performance of the device against the criteria and constraints.**

		Students use the results of the tests to improve the device performance by increasing the efficiency of energy conversion, keeping in mind the criteria and constraints, and noting any modifications in tradeoffs.
PS3.B: Conservation of Energy and Energy Transfer Energy cannot be created or destroyed, but it can be transported from one place to another and transferred between systems. (HS-PS3-4) Uncontrolled systems always evolve toward more stable states—that is, toward more uniform energy distribution (e.g., water flows downhill, objects hotter than their surrounding environment cool down).(HS-PS3-4) **PS3.D: Energy in Chemical Processes** Although energy cannot be destroyed, it can be converted to less useful forms — for example, to thermal energy in the surrounding environment.(HS-PS3-4)	Systems and System Models Students understand that potential causes of the apparent loss of energy from a closed system (which should be zero in an ideal system) and adjust the design of the experiment accordingly.	Planning and carrying out investigations Students describe the purpose of the investigation, which includes the following idea, that the transfer of thermal energy when two components of different temperature are combined within a closed system results in a more uniform energy distribution among the components in the system (second law of thermodynamics). Students develop an investigation plan and describe the data that will be collected and the evidence to be derived from the data, including: 1. The measurement of the reduction of temperature of the hot object and the increase in temperature of the cold object to show that the thermal energy lost by the hot object is equal to the thermal energy gained by the cold object and that the distribution of thermal energy is more uniform after the interaction of the hot and cold components 2. The heat capacity of the components in the system (obtained from scientific literature). In the investigation plan, students describe: 1. How a nearly closed system will be constructed, including the boundaries and initial conditions of the system 2. The data that will be collected, including masses of components and initial and final temperatures 3. The experimental procedure, including how the data will be collected, the number of trials, the experimental set up, and equipment required. Students collect and record data that can be used to calculate the change in thermal energy of each of the two components of

		the system. Students evaluate their investigation, including: 1. The accuracy and precision of the data collected, as well as the limitations of the investigation 2. The ability of the data to provide the evidence required. If necessary, students refine the plan to produce more accurate, precise, and useful data that address the experimental question. Students identify potential causes of the apparent loss of energy from a closed system (which should be zero in an ideal system) and adjust the design of the experiment accordingly.

EVIDENCE of LEARNING			
Understanding(s) *Matter & Energy* *Structure & Function* *Systems & System Models*	*Standards* ***HSPS3-3*** *HSPS3-1* *HSPS3-2*	***Unit Performance Assessment****:* ***Description of Performance Task:*** *In the 1st Quarter Engineering Challenge students will design, build, and refine a device that works within given constraints to convert one form of energy into another form of energy (students may work in groups for this portion). After completing the Engineering Challenge the students will individually complete the 1st Quarter Performance Task Assessment. Teacher notes provide information about materials available (or that need to be purchased by the department) for the student builds.* ***Teacher will assess:*** ● *Student device will obtain the minimum energy required by the instructor* ● *Students will appropriately model the energy flow in their device by:* ○ *Identifying the forms of energy present in the system.* ○ *Explaining how the motion and position of objects/particles accounts for the energy in the system.* ○ *Demonstrating flow on energy in the device.* ○ *Demonstrating conservation of energy.* ● *Students will correctly complete calculations addressing energy* *CCC: Matter & Energy; Structure & Function; Systems & System Models* *SEP: Developing & Using Models; Computational Thinking; Planning & Carrying Out Investigations* ***Performance:*** ***Mastery:*** *Students can build a device that meets the design challenge, model the energy in their device, and use mathematics to calculate energy.* ***Scoring Guide:*** *Rubric and scoring guide are provided in the 1st quarter Engineering Challenge and 1st Quarter Performance Task Assessment documents.*	**R/R Quadrant** D **21 Century** Critical Thinking Collaboration Communication Creativity

SAMPLE LEARNING PLAN				
Understanding	**Standards**	**Major Learning Activities:**	**Instructional Strategy Category:**	**R/R Quadrant: 21C:**
Energy & Matter *Systems & System Models*	*HSPS3-2* *Developing & Using Models*	**1. Lesson**: Forms of Energy **Objective**: Students will be able to develop and use models to illustrate that energy at the macroscopic scale can be accounted for as a combination of energy associated with the motions of particles (objects) and energy associated with the relative positions of particles (objects). **Learning activity:** Students move about the room in groups to each station (stations are not limited to the ones listed, instructor may set up any station that demonstrates energy, energy transformations, energy transfer). At each station students will model the energy present and any energy transfers and/or transformations. **Check for understanding:** Each group will be asked to place their model for one of the stations (so that each stations is represented) on a large whiteboard or large piece of poster paper. Students will then complete a gallery walk of the models of the stations and use the feedback from their peers and instructor to refine their models. Class discussions about the models will lead to shared models among the class.	*Setting Objectives and providing feedback* *cooperative learning* *Non-linguistic representations*	*Rigor/ Relevance: A* *21C skills: Collaboration Communication, Critical Thinking*
Energy & Matter *Systems & System Models*	*HSPS3-1* *HSPS3-2* *Analyzing & Interpreting Data* *Mathematics & Computatio*	**2. Lesson**: Energy Skate Park **Objective**: Students will be able to develop and use models to illustrate that energy at the macroscopic scale can be accounted for as a combination of energy associated with the motions of particles (objects) and energy associated with the relative positions of particles (objects).Create a computational model to calculate the change in the energy of one component in a system when the change in energy of the other component(s) and energy flows in and out of the system are known. **Learning activity:** Students will use the PhET simulation to see how energy	*Setting Objectives and providing feedback* *Non-linguistic representations* *Assigning Homework and Providing*	*Rigor / Relevance framework? B* *21C skills: Critical Thinking*

	nal Thinking	gets transferred or transformed through a real world application. In this simulation students will manipulate the skater, will change the track, add or take away friction, gravity, and other factors to see the effect of these on a skater who behaves according to the laws of physics. Students will also use computational models to determine the energy, height, and velocity of the skater on different portions of the track. **Check for understanding:** Computational models in part "D" can be checked by the instructor for understanding. The energy pie charts and bar graphs can also be checked by the instructor for understanding.	*Practice* *Generating and Testing Hypotheses*	
Energy & Matter *Systems & System Models*	*HSPS3-4* *Analyzing & Interpreting Data*	**3. Lesson**: Temperature and Thermal Energy **Objective**: Plan and conduct an investigation to provide evidence that the transfer of thermal energy when two components of different temperature are combined within a closed system results in a more uniform energy distribution among the components in the system (2nd law of thermodynamics). **Learning activity:** Students will use data collected in a lab to to differentiate between temperature and thermal energy. Students will explain thermal energy transfer. **Check for understanding:** The post lab questions can be evaluated for understanding of thermal energy and thermal energy transfer.	*Setting Objectives and providing feedback* *Identifying Similarities and Differences*	*Rigor/ Relevance: A* *21C skills: Collaboration, Critical Thinking*
Energy & Matter *Systems & System Models*	*HSPS3-4* *Planning & Carrying Out Investigations, Asking Questions, Developing & Using Models,*	**4. Lesson**: Thermal Energy Transfer **Objective**: Plan and conduct an investigation to provide evidence that the transfer of thermal energy when two components of different temperature are combined within a closed system results in a more uniform energy distribution among the components in the system (2nd law of thermodynamics). **Learning activity:** Students will plan and conduct an investigation to explore thermal energy in order to solve a problem with given material and given constraints provided by the instructor (example constraints: You cannot add more than 50 mL of water to the beaker; example materials: ring stand, Bunsen burners, wire gauze, thermometers, tongs, scales, beakers, water, graduated	*Setting Objectives and providing feedback* *Non-linguistic representations* *Generating and Testing Hypotheses*	*Rigor/ Relevance: C* *21C skills: Collaboration, Critical Thinking*

	Analyzing & Interpreting Data, Constructing Explanations	cylinder). In solving the problem students will provide evidence that the transfer of thermal energy when two components of different temperature are combined within a closed system results in a more uniform energy distribution among the components in the system. They will use this evidence to construct a model of their understanding. **Check for understanding:** Model can be evaluated for understanding of concept of the 2nd Law of Thermodynamics. Whether or not the target temperature was achieved will also be evaluated.		

Unit 1: Resources

UNIT RESOURCES
Teacher Resources: ● *Physical Science Textbook and Teacher Resources* ● *PhET (Founded in 2002 by Nobel Laureate Carl Wieman, the PhET Interactive Simulations project at the University of Colorado Boulder creates free interactive math and science simulations. PhET sims are based on extensive education research and engage students through an intuitive, game-like environment where students learn through exploration and discovery.)* ● *The Physics Classroom (The Physics Classroom is an online, free to use physics website developed primarily for beginning physics students and their teachers. The website features a variety of sections intended to support both teachers and students in the tasks of learning and teaching physics.)* ● *Explore Learning (Gizmos are interactive math and science simulations for grades 3-12. Over 400 Gizmos aligned to the latest standards help educators bring powerful new learning experiences to the classroom.)* ● *NSTA NGSS Resource Hub (Includes NSTA vetted lessons for NGSS Standards)* ● *Next Generation Molecular Workbench (Molecular Workbench (MW) is powerful, award-winning software that provides visual, interactive computational experiments for teaching and learning science.)*

Student Resources:

- *Physical Science Textbook and Teacher Resources*
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Vocabulary:

Law of conservation of energy – energy cannot be created or destroyed but it can be transformed or transferred from one form to another
Work - the product of the distance and the force in the direction an object moves
Gravitational Potential Energy - potential energy that depends upon an object's height above a reference point
Mechanical Energy - the energy associated with the motion and position of everyday objects
Chemical Energy - the energy stored in chemical bonds
Nuclear Energy - the energy stored in atomic nuclei
Mechanical Energy - the energy associated with the motion and position of everyday objects
Electromagnetic Energy - a form of energy consisting of changing electric and magnetic fields
Sound Energy- form of energy associated with the vibration of matter
Thermal energy – the total potential and kinetic energy related to the motion of all particles in an object

Unit 2: Forces and Motion

Content Area: Science	Course: Physical Science	UNIT: Forces and Motion

Unit Description:	**Unit Timeline:**
Students will understand Newton's second law, momentum conservation, and impulse. This includes both concepts and calculations, such as forces on objects and collisions. When calculating forces, students will understand gravity can be demonstrated with a field that mitigates based on the distance from the source and the size of the object.	10 weeks

DESIRED Results
Transfer Goal - ***Students will be able to independently use their learning to……*** 1. Ask questions and define problems. 2. Develop and use models. 3. Plan and carry out investigations 4. Analyze and interpret data. 5. Use mathematical and computational thinking. 6. Construct explanations and design solutions 7. Engage in an argument from evidence. 8. Obtain, evaluate, and communicate information.

Understandings (Cross Cutting Concepts) – *Students will understand… (Big Ideas)*

1. Patterns: Repeating cycles, shapes, or spatial features (What do I notice in this phenomenon or system after careful observation? What patterns do I observe? What questions do I have about these patterns? What additional observations could I make? How do these patterns compare to other patterns? How can I model these patterns? What might cause these patterns? What further investigations would help clarify these patterns and their cause?)
2. Cause and Effect: Events have causes, sometimes simple, sometimes multifaceted. Correlation doesn't imply causation. (What relationships between events or patterns do I observe in this phenomenon or system? What can I explain about these relationships? Are any of these relationships cause and effect? What evidence supports a cause and effect

relationship? Can my model provide a mechanism for this cause and effect relationship? What further investigations would help determine if these relationships are cause and effect?)

3. Scale, Proportion, & Quantity: It is critical to recognize what is relevant at different size, time, and energy scales, and to recognize proportional relationships between different quantities as scales change. (How can we investigate nature at this scale? What aspects of this system do we need to measure to describe it more precisely? On what scale must we make these measurements? What do we need to control as we make these measurements? What relationships between quantities do we observe?)
4. Systems & System Models: A system is an organized group of related objects or components; models can be used for understanding and predicting the behavior of systems. (What system or systems do we need to model to explain this phenomenon? What are the inputs and outputs of the system? What scale(s) within the system do we need these models to describe and represent? How can we delineate the boundary of the system? What are the components or sub-systems of this system? What are the relationships between the components in this system? What predictions can be make from our model? What are the limits of the system model?)
5. Energy and Matter: Tracking energy and matter flows, into, out of, and within systems. (What matter flows into, out of, and within the system? What physical and chemical changes occur in this system? What energy transfer occurs into, out of, or within this system? What transformations of energy are important in this system? What are the needed inputs in this system? What are the desired outputs in this system? How are energy and matter related in this system?)
6. Structure and Function: The way an object is shaped or structured determines many of its properties and functions. (What shapes or structures are observed in this system at this scale? What roles do these structures play in the functioning of the system? How do the structures support the functions? How do different conditions relate to patterns of differences in structures or appearance?)
7. Stability and Change: Conditions that affect stability and factors that control rates of change are critical elements to consider and understand in natural systems. (Under what range of conditions does this system operate effectively? What changes in conditions causes changes in its stable operation? What characteristics of the system change? What changes in conditions could cause it to become unstable or to fail? What feedback loops in the operation of this system enhance its range of stable operations? What feedback loops in the operation of the system tend to destabilize it?)

Essential Questions: ***Students will keep considering…***

- What features does your car have to keep you safe in a crash?
- How does the space travel of space probes like Voyager of Casini work?
- How can concussions be prevented?
- How do meteor impacts work?

Anchoring Phenomena: Students will be shown a video clip of a meteor falling to earth and burning up in the atmosphere.
https://www.cbsnews.com/news/possible-meteor-fireball-michigan-today-2018-01-16/
https://www.youtube.com/watch?v=dpmXyJrs7iU

Standards Addressed
Students who demonstrate understanding can: ● HS-PS2-1 Analyze data to support the claim that Newton's second law of motion describes the mathematical relationship among the net force on a macroscopic object, its mass, and its acceleration. [Clarification Statement: Examples of data could include tables or graphs of position or velocity as a function of time for objects subject to a net unbalanced force, such as a falling object, an object rolling down a ramp, or a moving object being pulled by a constant force.] [Assessment Boundary: Assessment is limited to one-dimensional motion and to macroscopic objects moving at non-relativistic speeds.] (linked to MLS 9-12-PS2-A-1) ● HS-PS2-2 Use mathematical representations to support the claim that the total momentum of a system of objects is conserved when there is no net force on the system. [Clarification Statement: Emphasis is on the quantitative conservation of momentum in interactions and the qualitative meaning of this principle.] [Assessment Boundary: Assessment is limited to systems of two macroscopic bodies moving in one dimension.] (linked to MLS 9-12-PS2-A-2) ● **HS-PS2-3 Apply scientific and engineering ideas to design, evaluate, and refine a device that minimizes the force on a macroscopic object during a collision.* [Clarification Statement: Examples of evaluation and refinement could include determining the success of the device at protecting an object from damage and modifying the design to improve it. Examples of a device could include a football helmet or a parachute.] [Assessment Boundary: Assessment is limited to qualitative evaluations and/or algebraic manipulations.]** (linked to MLS 9-12-PS2-A-3) ● HS-PS2-4 Use mathematical representations of Newton's Law of Gravitation and Coulomb's Law to describe and predict the gravitational and electrostatic forces between objects. [Clarification Statement: Emphasis is on both quantitative and conceptual descriptions of gravitational and electric fields.] [Assessment Boundary: Assessment is limited to systems with two objects.] (linked to MLS 9-12-PS2-B-4) ● HS-PS3-5 Develop and use a model of two objects interacting through electric or magnetic fields to illustrate the forces between objects and the changes in energy of the objects due to the interaction. [Clarification Statement: Examples of models could include drawings, diagrams, and texts, such as drawings of what happens when two charges of opposite polarity are near each other.] [Assessment Boundary: Assessment is limited to systems containing two objects.] *This standard is limited to the relationship between gravitational fields and energy only and will not include electric or magnetic fields in any magnitude. This will be covered in Physics.* (linked to MLS 9-12-PS3-B-5)

Disciplinary Core Ideas **Students will know...**	**Cross Cutting Concepts** **Students will understand....**	**Science and Engineering Practice** **Students will be able to...**
PS2.A: Forces and Motion Newton's second law accurately predicts changes in the motion of macroscopic objects.(HS-PS2-1)	Cause and Effect ● Net force is a function of mass multiplied by acceleration. ● Newton's laws refer to objects with mass.	Analyzing data Students organize data that represent the net force on a macroscopic object, its mass (which is held constant), and its acceleration (e.g., via tables, graphs, charts, vector

	Momentum is a function of mass multiplied by velocity. ● Momentum is conserved in a closed system. This can be proven with mathematical expressions. ● Impulse is Force over a given time with a direct relation to change in momentum. ● By increasing the time of a collision or the mass of objects involved in a collision, the force acting upon objects involved in the collision is reduced. ● The field force of gravity between two objects has a direct relationship with reference to mass and an inverse squared relationship with reference to distance between objects. ● A negative force is attractive. ● Energy stored in fields increases or decreases when objects interact.	drawings). Students use tools, technologies, and/or models to analyze the data and identify relationships within the datasets, including: 1. A more massive object experiencing the same net force as a less massive object has a smaller acceleration, and a larger net force on a given object produces a correspondingly larger acceleration 2. The result of gravitation is a constant acceleration on macroscopic objects as evidenced by the fact that the ratio of net force to mass remains constant. Students use the analyzed data as evidence to describe that the relationship between the observed quantities is accurately modeled across the range of data by the formula a = Fnet/m (e.g., double force yields double acceleration, etc.). Students use the data as empirical evidence to distinguish between causal and correlational relationships linking force, mass, and acceleration. Students express the relationship Fnet=ma in terms of causality, namely that a net force on an object causes the object to accelerate.
PS2.A: Forces and Motion Momentum is defined for a particular frame of reference; it is the mass times the velocity of the object. (HS-PS2-2) If a system interacts with objects outside	Systems and System Models Students understand that the momentum of the system is the same before and after the interaction between the objects in the system, so that momentum of the system is constant.	Mathematical and computational thinking Students clearly define the system of the two interacting objects that is represented mathematically, including boundaries and initial conditions. Students identify and describe the momentum of each

itself, the total momentum of the system can change; however, any such change is balanced by changes in the momentum of objects outside the system. (HS-PS2-2)	Students understand that any change in momentum of one object is balanced by a change in the momentum of the other object, so that the total momentum is constant.	object in the system as the product of its mass and its velocity, p = mv (p and v are restricted to one-dimensional vectors), using the mathematical representations. Students identify the claim, indicating that the total momentum of a system of two interacting objects is constant if there is no net force on the system. Students use the mathematical representations to model and describe the physical interaction of the two objects in terms of the change in the momentum of each object as a result of the interaction. Students use the mathematical representations to model and describe the total momentum of the system by calculating the vector sum of momenta of the two objects in the system. Students use the analysis of the motion of the objects before the interaction to identify a system with essentially no net force on it. Based on the analysis of the total momentum of the system, students support the claim that the momentum of the system is the same before and after the interaction between the objects in the system, so that momentum of the system is constant. Students identify that the analysis of the momentum of each object in the system indicates that any change in momentum of one object is balanced by a change in the momentum of the other object, so that the total momentum is constant.
PS2.A: Forces and Motion If a system interacts with objects outside itself, the total momentum of the system can change; however, any such change is balanced by changes in the momentum of	Cause and Effect Systems can be designed to cause a desired effect. Students describe and quantify (when	Constructing explanations and designing solutions Students design a device that minimizes the force on a macroscopic object during a collision. In the design, students: 1. Incorporate the concept that for a given change in

objects outside the system. (HS-PS2-3) **ETS1.A: Defining and Delimiting an Engineering Problem** Criteria and constraints also include satisfying any requirements set by society, such as taking issues of risk mitigation into account, and they should be quantified to the extent possible and stated in such a way that one can tell if a given design meets them. (secondary)(HS-PS2-3) **ETS1.C: Optimizing the Design Solution** Criteria may need to be broken down into simpler ones that can be approached systematically, and decisions about the priority of certain criteria over others (tradeoffs) may be needed. (secondary)(HS-PS2-3)	appropriate) the criteria and constraints, along with the tradeoffs implicit in these design solutions. Examples of constraints to be considered are cost, mass, the maximum force applied to the object, and requirements set by society for widely used collision-mitigation devices (e.g., seatbelts, football helmets).	momentum, force in the direction of the change in momentum is decreased by increasing the time interval of the collision ($F\Delta t = m\Delta v$); and 2. Explicitly make use of the principle above so that the device has the desired effect of reducing the net force applied to the object by extending the time the force is applied to the object during the collision. In the design plan, students describe the scientific rationale for their choice of materials and for the structure of the device. Students systematically evaluate the proposed device design or design solution, including describing the rationales for the design and comparing the design to the list of criteria and constraints. Students test and evaluate the device based on its ability to minimize the force on the test object during a collision. Students identify any unanticipated effects or design performance issues that the device exhibits. Students use the test results to improve the device performance by extending the impact time, reducing the device mass, and/or considering cost-benefit analysis.
PS2.B: Types of Interactions Newton's law of universal gravitation and Coulomb's law provide the mathematical models to describe and predict the effects of gravitational and electrostatic forces between distant objects.(HS-PS2-4) Forces at a distance are explained by fields (gravitational, electric, and magnetic) permeating space that can transfer energy through space. Magnets or electric currents cause magnetic fields; electric charges or changing magnetic fields cause electric	Patterns Based on the given mathematical models, students recognize and describe that the ratio between gravitational and electric forces between objects with a given charge and mass is a pattern that is independent of distance . Students describe that the mathematical representation of the gravitational field (Fg=−Gm1m2d2) only predicts an attractive force because mass is always positive. Students describe* that the mathematical	Mathematical and computational thinking Students clearly define the system of the interacting objects that is mathematically represented. Using the given mathematical representations, students identify and describe the gravitational attraction between two objects as the product of their masses divided by the separation distance squared (Fg=−Gm1m2d2), where a negative force is understood to be attractive. Using the given mathematical representations, students identify and describe the electrostatic force between two objects as the product of their individual charges divided by

fields.(HS-PS2-4)	representation of the electric field (Fe=kq1q2d2) predicts both attraction and repulsion because electric charge can be either positive or negative. Students use the given formulas for the forces as evidence to describe that the change in the energy of objects interacting through electric or gravitational forces depends on the distance between the objects.	the separation distance squared (Fe=kq1q2d2), where a negative force is understood to be attractive. Students correctly use the given mathematical formulas to predict the gravitational force between objects or predict the electrostatic force between charged objects.
PS3.C: Relationship Between Energy and Forces When two objects interacting through a field change relative position, the energy stored in the field is changed. (HS-PS3-5)	Cause and Effect Cause and effect relationships can be suggested and predicted for complex natural and human-designed systems by examining what is known about smaller scale mechanisms within the system.	Develop and Use a Model Students develop a model in which they identify and describe the relevant components to illustrate the forces and changes in energy involved when two objects interact, including: i. The two objects in the system, including their initial positions and velocities (limited to one dimension). ii. The nature of the interaction (electric or magnetic) between the two objects.

Unit 2 Assessment:

<table>
<tr><th colspan="4">EVIDENCE of LEARNING</th></tr>
<tr>
<td><u>Understanding</u>
Structure and Function

Cause and Effect</td>
<td><u>Standards</u>
HSPS2-1
HSPS2-2
HSPS2-3</td>
<td><u>Unit Performance Assessment</u>:
Description of Performance Task: In the 2nd Quarter Engineering Challenge students will design, build, and refine a device that works within given constraints to protect an egg from a collision by means of reducing force/impact time. After completing the Engineering Challenge the students will individually complete the 2nd Quarter Performance Task Assessment. Teacher notes are provided.

Teacher will assess:
Student device will protect the egg from multiple collisions.
Students will appropriately model the device and aspects which dilute the force being applied to the egg:
Identifying the forces acting on an egg.
Demonstrating their is momentum of the egg apparatus or object approaching the egg.
Explaining how the device dilutes force applied to the egg.
Identifying the connection between force, momentum, and impulse.
Students will correctly complete calculations addressing Force, Momentum, and Impulse
CCC: Structure & Function; Cause & Effect
SEP: Developing & Using Models; Computational Thinking; Planning & Carrying Out Investigations, Constructing Explanations

<u>Performance:</u>
Mastery: Students can build a device that meets the design challenge, model and explain the force, momentum, and impulse as pertains to the egg and their device, and use mathematics to calculate force, momentum, and impulse.

Scoring Guide:
Rubric and scoring guide are provided in the 2nd quarter Engineering Challenge and 2nd Quarter Performance Task Assessment documents.</td>
<td><u>R/R Quadrant</u>
D
<u>21 Century</u>

critical thinking
collaboration
communication
creativity</td>
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Unit 2: Sample Activities

SAMPLE LEARNING PLAN				
Understanding	**Standards**	**Major Learning Activities:**	**Instructional Strategy Category:**	**R/R Quadrant: 21C:**
Cause and Effect	HSPS2-1 Analyzing & Interpreting Data, Mathematics & Computational Thinking, Constructing Explanations	**Lesson**: Newton's 2nd Law **Objective**: Analyze data to support the claim that Newton's second law of motion describes the mathematical relationship among the net force on a macroscopic object, its mass, and its acceleration. **Learning Activity:** Students will use the PhET simulation to gather and analyze data (by graphing data and calculating slope) to describe the mathematical relationship among net force, mass, and acceleration. **Check for understanding:** Analysis of student answers to questions 29-35 will determine understanding of the mathematical relationship between net force, mass, and acceleration.	Setting Objectives and providing feedback Non-linguistic representations	Rigor / Relevance: B 21C skills: Critical Thinking
Cause and Effect	HSPS2-1 Analyzing & Interpreting Data, Constructing Explanations	**Lesson**: Hovercraft Curling **Objective**: Analyze data to support the claim that Newton's second law of motion describes the mathematical relationship among the net force on a macroscopic object, its mass, and its acceleration. **Learning Activity:** Students will use a game of hovercraft curling to explore and explain Newton's Second Law of motion. A hovercraft the kids ride on can be used (constructed with a tarp, plywood, & a leaf blower), or tabletop hovercrafts could be used (either one built from a CD and a balloon or a toy one purchased from a catalogue). This is a two day activity, one day for the actual curling and initial follow-up questions and one day for the analysis. **Check for understanding:** Students ability to correctly complete the analysis will demonstrate their understanding of forces and motion.	Setting Objectives and providing feedback Non-linguistic representations Identifying Similarities and Differences	Rigor / Relevance: C 21C skills: Collaboration, Communication, Critical Thinking

Energy and Matter Cause and Effect	HSPS2-2 Constructing Explanations	**Lesson**: Momentum Lab **Objective**: Use mathematical representations to support the claim that the total momentum of a system of objects is conserved when there is no net force on the system. **Learning activity:** Students use common materials (straws, marbles, grooved rulers) to qualitatively explore conservation of momentum. Throughout this activity students should be adding to their mental model of conservation of momentum. This activity has them practice the concept of conservation of momentum in a few different situations. **Check for understanding:** Students ability to correctly explain how conservation of momentum in the different situations will demonstrate their qualitative understanding of the concept.	Setting Objectives and providing feedback Assigning Homework and Providing Practice	Rigor / Relevance: B 21C skills: Collaboration, Critical Thinking
Energy and Matter Cause and Effect	HSPS2-2 Analyzing & Interpreting Data, Mathematics & Computational Thinking, Constructing Explanations	**Lesson**: Collisions Lab **Objective**: Use mathematical representations to support the claim that the total momentum of a system of objects is conserved when there is no net force on the system. **Learning activity:** Students will use the PhET simulation to gather and analyze data to create mathematical representations to describe the momentum of objects in a system during elastic and inelastic collisions. Following the PhET activity, instructor could place students into groups and have each group whiteboard a different collision for discussion using socratic questioning. **Check for understanding:** Students ability to correctly demonstrate conservation of momentum during collisions using mathematical representations can assessed. Instructor could place students into groups and have each group whiteboard a different collision for discussion using socratic questioning.	Setting Objectives and providing feedback Non-linguistic representations Assigning Homework and Providing Practice Generating and Testing Hypotheses	Rigor / Relevance: B 21C skills: Communication, Critical Thinking
Energy and Matter Cause and Effect	HSPS2-3 , Constructing Explanations	**Lesson**: Understanding Car Crashes: It's Basic Physics Teacher's Guide to be used with Understanding Car Crashes: It's Basic Physics video **Objective**: Apply scientific and engineering ideas to design, evaluate, and refine a device that minimizes the force on a macroscopic object during a collision.	Setting Objectives and providing feedback	Rigor / Relevance: C

		Learning activity: This activity allows for students to practice construction explanations of how how force, momentum, and impulse tie into engineering products that reduce the force on an object during a collision. This is the real-world application of their engineering challenge to protect their egg. **Check for understanding:** Should be able to, in terms of force, momentum, and impulse, explain why crashes either do or do not result in injuries (just as they will have to do in their engineering challenge assessment).	Assigning Homework and Providing Practice	21C skills: Critical Thinking
Cause and Effect	HSPS2-4 Analyzing & Interpreting Data, Mathematics & Computational Thinking, Constructing Explanations ISTE Standard addressed	**Lesson**: Gravitation Interactive to be used with Gravitational Fields Interactive on the Physics Classroom **Objective**: Use mathematical representations of Newton's Law of Gravitation to describe and predict the gravitational forces between objects. **Learning Activity:** Students will use the Gravitational fields Interactive to derive the mathematical representation of Newton's Law of Gravitation to describe and predict the gravitational forces between objects. **Check for understanding:** Students can describe (mathematically) how mass and distance impact gravitational force.	Setting Objectives and providing feedback Non-linguistic representations	Rigor / Relevance: B 21C skills: Critical Thinking

UNIT RESOURCES
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Vocabulary: Displacement - The direction from the starting point and the length of a straight line from the starting point to the end point Instantaneous Speed- Rate at which an object is moving at a given moment in time Velocity - The speed and direction an object is moving measured relative to a starting point

Acceleration - the rate at which velocity changes
Magnitude - The size or quantity of something
Weight - the force that gravitation acts upon a mass
Magnitude - greatness of size or amount
Newton - the standard unit of force
Momentum - force or speed of movement

Unit 3: Structure and Properties of Matter

Content Area: Science	Course: Physical Science	UNIT: Structure and Properties of Matter

Unit Description:	Unit Timeline:
Students will understand the properties of elements based on their valence electrons and location on the periodic table. Students will use their understanding of the periodic table to later interpret and predict ion formation, chemical bonds, and basic network structures. Students will use knowledge to predict molecular properties such as boiling point, melting point, electrical conductivity, and reaction rates.	8 weeks

DESIRED Results

Transfer Goal - ***Students will be able to independently use their learning to……***

1. Ask questions and define problems.
2. Develop and use models.
3. Plan and carry out investigations
4. Analyze and interpret data.
5. Use mathematical and computational thinking.
6. Construct explanations and design solutions
7. Engage in an argument from evidence.
8. Obtain, evaluate, and communicate information.

Understandings (Cross Cutting Concepts) – *Students will understand… (Big Ideas)*

1. Patterns: Repeating cycles, shapes, or spatial features (What do I notice in this phenomenon or system after careful observation? What patterns do I observe? What questions do I have about these patterns? What additional observations could I make? How do these patterns compare to other patterns? How can I model these patterns? What might cause these patterns? What further investigations would help clarify these patterns and their cause?)
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relationships between events or patterns do I observe in this phenomenon or system? What can I explain about these relationships? Are any of these relationships cause and effect? What evidence supports a cause and effect relationship? Can my model provide a mechanism for this cause and effect relationship? What further investigations would help determine if these relationships are cause and effect?)

3. Scale, Proportion, & Quantity: It is critical to recognize what is relevant at different size, time, and energy scales, and to recognize proportional relationships between different quantities as scales change. (How can we investigate nature at this scale? What aspects of this system do we need to measure to describe it more precisely? On what scale must we make these measurements? What do we need to control as we make these measurements? What relationships between quantities do we observe?)
4. Systems & System Models: A system is an organized group of related objects or components; models can be used for understanding and predicting the behavior of systems. (What system or systems do we need to model to explain this phenomenon? What are the inputs and outputs of the system? What scale(s) within the system do we need these models to describe and represent? How can we delineate the boundary of the system? What are the components or sub-systems of this system? What are the relationships between the components in this system? What predictions can be make from our model? What are the limits of the system model?)
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7. Stability and Change: Conditions that affect stability and factors that control rates of change are critical elements to consider and understand in natural systems. (Under what range of conditions does this system operate effectively? What changes in conditions causes changes in its stable operation? What characteristics of the system change? What changes in conditions could cause it to become unstable or to fail? What feedback loops in the operation of this system enhance its range of stable operations? What feedback loops in the operation of the system tend to destabilize it?)

Essential Questions: ***Students will keep considering…***

- Why is the Declaration of Independence preserved in Argon?
- When you get a vaccine and the nurse cleans your skin with an alcohol wipe, why does it feel cold?
- How do insects walk on water?
- What types of materials are ideal for building a to rocket travel to Mars?

Anchoring Phenomena: Diamond and graphite are both only carbon.

Standards Addressed
Students who demonstrate understanding can: ● HS-PS1-1 Use the periodic table as a model to predict the relative properties of elements based on the patterns of electrons in the outermost energy level of atoms. [Clarification Statement: Examples of properties that could be predicted from patterns could include reactivity of metals, types of bonds formed, numbers of bonds formed, and reactions with oxygen.] [Assessment Boundary: Assessment is limited to main group elements. Assessment does not include quantitative understanding of ionization energy beyond relative trends.] (Linked to MLS 9-12-PS1-A-1) ● **HS-PS1-3 Plan and conduct an investigation to gather evidence to compare the structure of substances at the bulk scale to infer the strength of electrical forces between particles. [Clarification Statement: Emphasis is on understanding the strengths of forces between particles, not on naming specific intermolecular forces (such as dipole-dipole). Examples of particles could include ions, atoms, molecules, and networked materials (such as graphite). Examples of bulk properties of substances could include the melting point and boiling point, vapor pressure, and surface tension.] [Assessment Boundary: Assessment does not include Raoult's law calculations of vapor pressure.]** (Linked to MLS 9-12-PS1-A-3) ● HS-PS2-6 Communicate scientific and technical information about why the molecular-level structure is important in the functioning of designed materials.[Clarification Statement: Emphasis is on the attractive and repulsive forces that determine the functioning of the material. Examples could include why electrically conductive materials are often made of metal, flexible but durable materials are made up of long chained molecules, and pharmaceuticals are designed to interact with specific receptors.] [Assessment Boundary: Assessment is limited to provided molecular structures of specific designed materials.]

Disciplinary Core Ideas **Students will know...**	**Cross Cutting Concepts** **Students will understand….**	**Science and Engineering Practice** **Students will be able to...**
PS1.A: Structure and Properties of Matter Each atom has a charged substructure consisting of a nucleus, which is made of protons and neutrons, surrounded by electrons. (HS-PS1-1) ● The parts and structure of an atom. The periodic table orders elements horizontally by the number of	Patterns The periodic table is designed to make predictions of behavior based on size, attractive and repulsive forces, and the patterns of the outermost electrons that determine the typical reactivity of an atom. There is a causal relationship between the observable macroscopic patterns of reactivity of elements in the periodic table and the patterns of outermost	Develop and Use Models From the given model, students identify and describe the components of the model that are relevant for their predictions, including: 1. Elements and their arrangement in the periodic table 2. A positively-charged nucleus composed of both protons and neutrons, surrounded by negatively-charged electrons; 3. Electrons in the outermost energy level of atoms (i.e., valence electrons); and 4. The number of protons in each element.

protons in the atom's nucleus and places those with similar chemical properties in columns. The repeating patterns of this table reflect patterns of outer electron states. (HS-PS1-1)	electrons for each atom and its relative electronegativity. There is a relationship between measurable bulk properties like melting point, boiling point, vapor pressure, and surface tension that would allow inferences to be made about the strength of electrical forces between particles.	Students identify and describe the following relationships between components in the given model, including: 1. The arrangement of the main groups of the periodic table reflects the patterns of outermost electrons. 2. Elements in the periodic table are arranged by the numbers of protons in atoms. Students use the periodic table to predict the patterns of behavior of the elements based on the attraction and repulsion between electrically charged particles and the patterns of outermost electrons that determine the typical reactivity of an atom. Students predict the following patterns of properties: 1. The number and types of bonds formed (i.e. ionic, covalent, metallic) by an element and between elements; 2. The number and charges in stable ions that form from atoms in a group of the periodic table. 3. The trend in reactivity and electronegativity of atoms down a group, and across a row in the periodic table, based on attractions of outermost (valence) electrons to the nucleus; and 4. The relative sizes of atoms both across a row and down a group in the periodic table.
PS1.A: Structure and Properties of Matter **The structure and interactions of matter at the bulk scale are determined by electrical forces within and between atoms.(HS-PS1-3)**	**Patterns** **Students understand the patterns of interactions between particles at the molecular scale are reflected in the patterns of behavior at the macroscopic scale.** **Students understand together, patterns observed at multiple scales can provide evidence of the causal relationships between the strength of**	**Planning and carrying out investigations** **Students describe a phenomenon under investigation, which includes the following idea: the relationship between the measurable properties (e.g., melting point, boiling point, vapor pressure, surface tension) of a substance and the strength of the electrical forces between the particles of the substance.** **Students develop an investigation plan and describe the data that will be collected and the evidence to be derived**

	the electrical forces between particles and the structure of substances at the bulk scale.	**from the data, including bulk properties of a substance (e.g., melting point and boiling point, volatility, surface tension) that would allow inferences to be made about the strength of electrical forces between particles.** **Students describe why the data about bulk properties would provide information about strength of the electrical forces between the particles of the chosen substances, including the following descriptions:** **1. The spacing of the particles of the chosen substances can change as a result of the experimental procedure even if the identity of the particles does not change (e.g., when water is boiled the molecules are still present but further apart).** **2. Thermal (kinetic) energy has an effect on the ability of the electrical attraction between particles to keep the particles close together. Thus, as more energy is added to the system, the forces of attraction between the particles can no longer keep the particles close together.** **3. The patterns of interactions between particles at the molecular scale are reflected in the patterns of behavior at the macroscopic scale.** **4. Together, patterns observed at multiple scales can provide evidence of the causal relationships between the strength of the electrical forces between particles and the structure of substances at the bulk scale.** **In the investigation plan, students include:** **1. A rationale for the choice of substances to compare and a description of the composition of those substances at the atomic molecular scale.** **2. A description of how the data will be collected,**

		the number of trials, and the experimental set up and equipment required. **Students describe how the data will be collected, the number of trials, the experimental set up, and the equipment required.** **Students collect and record data — quantitative and/or qualitative — on the bulk properties of substances.** **Students evaluate their investigation, including evaluation of:** **1. Assessing the accuracy and precision of the data collected, as well as the limitations of the investigation; and** **2. The ability of the data to provide the evidence required.** **If necessary, students refine the plan to produce more accurate, precise, and useful data**
PS2.B: Types of Interactions Newton's law of universal gravitation and Coulomb's law provide the mathematical models to describe and predict the effects of gravitational and electrostatic forces between distant objects. (HS-PS2-4) Forces at a distance are explained by fields (gravitational, electric, and magnetic) permeating space that can transfer energy through space. Magnets or electric currents cause magnetic fields; electric charges or	Structure and Function Students understand the relationship between the material's function and its macroscopic properties (e.g., material strength, conductivity, reactivity, state of matter, durability) and each of the following: 1. Molecular level structure of the material; 2. Intermolecular forces and polarity of molecules; and 3. The ability of electrons to move relatively freely in metals.	Obtaining, evaluating, and communicating information Students use at least two different formats (including oral, graphical, textual and mathematical) to communicate scientific and technical information, including fully describing the structure, properties, and design of the chosen material(s). Students cite the origin of the information as appropriate. Students identify and communicate the evidence for why molecular level structure is important in the functioning of designed materials, including: 1. How the structure and properties of matter and the types of interactions of matter at the atomic scale determine the function of the chosen designed

changing magnetic fields cause electric fields. **PS3.A: Definitions of Energy** "Electrical energy" may mean energy stored in a battery or energy transmitted by electric currents. (secondary) (HS-PS2-4)		material(s); and 2. How the material's properties make it suitable for use in its designed function. Students explicitly identify the molecular structure of the chosen designed material(s) (using a representation appropriate to the specific type of communication — e.g., geometric shapes for drugs and receptors, ball and stick models for long-chained molecules). Students describe the intended function of the chosen designed material(s). Students describe the relationship between the material's function and its macroscopic properties (e.g., material strength, conductivity, reactivity, state of matter, durability) and each of the following: 4. Molecular level structure of the material; 5. Intermolecular forces and polarity of molecules; and 6. The ability of electrons to move relatively freely in metals. Students describe the effects that attractive and repulsive electrical forces between molecules have on the arrangement (structure) of the chosen designed material(s) of molecules (e.g., solids, liquids, gases, network solid, polymers). Students describe that, for all materials, electrostatic forces on the atomic and molecular scale results in contact forces (e.g., friction, normal forces, stickiness) on the macroscopic scale.

Unit 3 Assessment:

<table>
<tr><th colspan="4">EVIDENCE of LEARNING</th></tr>
<tr>
<td><u>Understanding</u>
Structure and Function
Cause and Effect
Patterns
Planning and Carrying out Investigations</td>
<td><u>Standards</u>
HSPS1-1
HSPS1-3
HSPS2-6</td>
<td><u>Unit Performance Assessment</u>:
Description of Performance Task: In the 3rd quarter Science Inquiry Practices students will design and conduct two experiments to determine the strength of the intermolecular forces in 3 unknown liquids. After completing the Inquiry Challenge the students will individually complete the 3rd Quarter Performance Task Assessment. Teacher notes are provided.

Teacher will assess:
Plan and conduct an investigation to gather evidence to compare the structure of substances at the bulk scale.
Students ability to recognize the relationship between bulk scale properties and the strength of electrical forces between particles
Students will correctly predict basic bond types.
Students can express answers using claim evidence reasoning.
CCC: Patterns; System Models; Cause and Effect; Energy and Matter
SEP: Obtaining, Evaluating, and Communicating Information; Planning and Carrying out Investigations

<u>Performance:</u>
Mastery: Students can construct experiments based on previously acquired knowledge of bulk scale properties and bonding. Students can analyze obtained knowledge of bulk scale properties to predict the bond strength of materials.

Scoring Guide:
Rubric and scoring guide are provided in the 3rd Quarter Performance Practice and 3rd Quarter Performance Task Assessment documents.</td>
<td><u>R/R Quadrant</u>
C
<u>21 Century</u>

critical thinking
collaboration
communication
creativity</td>
</tr>
</table>

SAMPLE LEARNING PLAN				
Understanding	**Standards**	**Major Learning Activities:**	**Instructional Strategy Category:**	**R/R Quadrant: 21C:**
Structure and function *Systems and System Models*	HS-PS2-6 *Developing and Using Models* *Constructing Explanations* *ISTE Standard addressed*	**Lesson**: Bulk Scale Properties **Objective**: Students will be able to recognize the relationship between molecular level structure, a material's properties, and its use in daily life. **Learning activity:** Students will carefully examine the materials, use a magnifying glass provided, a battery and multimeter, Bunsen burner following teacher instruction, and their hands to determine the bulk scale properties of the materials provided. They will be asked to determine the location on the periodic table and electron configuration of the main elements the material is made of. This may require a small amount of research and/or reading with instructor guidance **Check for understanding:** Each student will fill out a packet as they move from station to station expressing their knowledge. They will then answer the post lab questions using claim-evidence-reasoning.	Setting Objectives and providing feedback cooperative learning Cues, Questions, and Advance organizers Non-linguistic representations	Rigor / Relevance framework? B 21C skills: Critical Thinking
Structure and function *Patterns*	HS-PS1-1 *Developing and Using Models* *Analyzing and interpreting data*	**Lesson**: Periodic Trends Straw Activity **Objective**: Students will be able to use the periodic table to infer the properties of elements based on their location. **Activity:** Students will use information given by the instructor or ptable.com to create a three-dimensional model of periodic table trends: radius, electronegativity, and ionization energy. This model will consist of a small periodic table, well plates, and colored straws cut to lengths that correlate to	cooperative learning Cues, Questions, and Advance organizers Non-linguistic representations	Rigor / Relevance framework? B 21C skills: Critical Thinking Creativity

	ISTE Standard addressed	the properties of each element. **Check for understanding:** Students will answer post-lab questions as part of the activity packet which require knowledge of periodic trends.	Identifying Similarities and Differences	
Patterns Structure & Function	*HSPS1-1* *Developing & Using Models* *ISTE Standard addressed*	**Lesson**: Element Builder Gizmo **Objective**: Use the periodic table as a model to predict the relative properties of elements based on the patterns of electrons in the outermost energy level of atoms. **Learning Activity:** Students will use the element builder gizmo to use protons, neutrons, and electrons to build elements. As the number of protons, neutrons, and electrons changes, information such as the name and symbol of the element, the Z, N, and A numbers, the electron dot diagram, and the group and period from the periodic table are shown. Each element is classified as a metal, metalloid, or nonmetal, and its state at room temperature is also given. **Check for understanding:** Students will be able to use valence electrons to describe the properties of an atom.	Setting Objectives and providing feedback Nonlinguistic Representations Identifying Similarities and Differences	Rigor / Relevance B 21C skills: Critical Thinking
Patterns Structure & Function	*HSPS1-3* *Developing & Using Models Carrying Out Investigations Analyzing & Interpreting Data* *ISTE Standard addressed*	**Lesson**: Exploring Properties of Water **Objective**: Plan and conduct an investigation to gather evidence to compare the structure of substances at the bulk scale to infer the strength of electrical forces between particles.. **Learning Activity:** Students investigate the properties of water at several different stations, then use the information they gathered and their knowledge of intermolecular forces to create a model to explain what they saw in the lab. **Check for understanding:** This activity serves as a stepping stone to the performance task. In this activity students explore some of the properties they can observe to determine the strength of electrical forces between particles. They should have a good model of intermolecular forces when this activity is done so that they can use this to plan and conduct their investigation in the performance task.	Setting Objectives and providing feedback Nonlinguistic Representations Identifying Similarities and Differences	Rigor / Relevance B 21C skills: Critical Thinking; Collaboratio n

UNIT RESOURCES
Teacher Resources: ● *Physical Science Textbook and Teacher Resources* ● *PhET (Founded in 2002 by Nobel Laureate Carl Wieman, the PhET Interactive Simulations project at the University of Colorado Boulder creates free interactive math and science simulations. PhET sims are based on extensive education research and engage students through an intuitive, game-like environment where students learn through exploration and discovery.)* ● *The Physics Classroom (The Physics Classroom is an online, free to use physics website developed primarily for beginning physics students and their teachers. The website features a variety of sections intended to support both teachers and students in the tasks of learning and teaching physics.)* ● *Explore Learning (Gizmos are interactive math and science simulations for grades 3-12. Over 400 Gizmos aligned to the latest standards help educators bring powerful new learning experiences to the classroom.)* ● *NSTA NGSS Resource Hub (Includes NSTA vetted lessons for NGSS Standards)* ● *Next Generation Molecular Workbench (Molecular Workbench (MW) is powerful, award-winning software that provides visual, interactive computational experiments for teaching and learning science.)*
Student Resources: ● *Physical Science Textbook and Teacher Resources* ● *PhET (Founded in 2002 by Nobel Laureate Carl Wieman, the PhET Interactive Simulations project at the University of Colorado Boulder creates free interactive math and science simulations. PhET sims are based on extensive education research and engage students through an intuitive, game-like environment where students learn through exploration and discovery.)* ● *The Physics Classroom (The Physics Classroom is an online, free to use physics website developed primarily for beginning physics students and their teachers. The website features a variety of sections intended to support both teachers and students in the tasks of learning and teaching physics.)* ● *Explore Learning (Gizmos are interactive math and science simulations for grades 3-12. Over 400 Gizmos aligned to the latest standards help educators bring powerful new learning experiences to the classroom.)* ● *Next Generation Molecular Workbench (Molecular Workbench (MW) is powerful, award-winning software that provides visual, interactive computational experiments for teaching and learning science.)*
Vocabulary: Atomic Number- a unique number for each element that equals the number of protons in an atom of that element

Mass Number-total number of protons and neutrons in the nucleus of an element
Atomic mass- average mass of all the known isotopes of an element
Electron -negatively charged subatomic particle
Proton - positively charged subatomic particle in the nucleus of an atom
Neutron-neutrally charged particle in the nucleus of an atom
Ion - an atom or group of atoms with a positive or negative charge
Periodicity - the quality or character of being periodic; the tendency to recur at intervals.
Ionic compound - a bond that forms between a cation and an anion
Covalent bond: a bond that forms when atoms share valence electrons
Valence electron - an electron that occupies the highest energy level of an atom
Electronegativity - measure of the tendency of an atom to attract a bonding pair of electron
Atomic Radius - measure of the size of its atoms, usually the mean or typical distance from the center of the nucleus to the boundary of the surrounding cloud of electrons

Unit 4: Chemical Reactions

Content Area: Science	Course:Physical Science 9	UNIT: Chemical Reactions

Unit Description:	Unit Timeline:
Student will be able to predict ion formation, chemical bond formation, and the energy input and outputs associated with these chemical reactions. Additionally, students will be able to understand and determine the change in reaction rates due to change in energy, concentrations, etc. Students should demonstrate, quantitatively and qualitatively, that these reactions conserve mass.	10 Weeks

DESIRED Results

Transfer Goal - ***Students will be able to independently use their learning to……***

1. Ask questions and define problems.
2. Develop and use models.
3. Plan and carry out investigations
4. Analyze and interpret data.
5. Use mathematical and computational thinking.
6. Construct explanations and design solutions
7. Engage in an argument from evidence.
8. Obtain, evaluate, and communicate information.

Understandings (Cross Cutting Concepts) – ***Students will understand… (Big Ideas)***

1. Patterns: Repeating cycles, shapes, or spatial features (What do I notice in this phenomenon or system after careful observation? What patterns do I observe? What questions do I have about these patterns? What additional observations could I make? How do these patterns compare to other patterns? How can I model these patterns? What might cause these patterns? What further investigations would help clarify these patterns and their cause?)
2. Cause and Effect: Events have causes, sometimes simple, sometimes multifaceted. Correlation doesn't imply causation. (What relationships between events or patterns do I observe in this phenomenon or system? What can I explain about these relationships? Are any of these relationships cause and effect? What evidence supports a cause and effect

relationship? Can my model provide a mechanism for this cause and effect relationship? What further investigations would help determine if these relationships are cause and effect?)

3. Scale, Proportion, & Quantity: It is critical to recognize what is relevant at different size, time, and energy scales, and to recognize proportional relationships between different quantities as scales change. (How can we investigate nature at this scale? What aspects of this system do we need to measure to describe it more precisely? On what scale must we make these measurements? What do we need to control as we make these measurements? What relationships between quantities do we observe?)
4. Systems & System Models: A system is an organized group of related objects or components; models can be used for understanding and predicting the behavior of systems. (What system or systems do we need to model to explain this phenomenon? What are the inputs and outputs of the system? What scale(s) within the system do we need these models to describe and represent? How can we delineate the boundary of the system? What are the components or sub-systems of this system? What are the relationships between the components in this system? What predictions can be make from our model? What are the limits of the system model?)
5. Energy and Matter: Tracking energy and matter flows, into, out of, and within systems. (What matter flows into, out of, and within the system? What physical and chemical changes occur in this system? What energy transfer occurs into, out of, or within this system? What transformations of energy are important in this system? What are the needed inputs in this system? What are the desired outputs in this system? How are energy and matter related in this system?)
6. Structure and Function: The way an object is shaped or structured determines many of its properties and functions. (What shapes or structures are observed in this system at this scale? What roles do these structures play in the functioning of the system? How do the structures support the functions? How do different conditions relate to patterns of differences in structures or appearance?)
7. Stability and Change: Conditions that affect stability and factors that control rates of change are critical elements to consider and understand in natural systems. (Under what range of conditions does this system operate effectively? What changes in conditions causes changes in its stable operation? What characteristics of the system change? What changes in conditions could cause it to become unstable or to fail? What feedback loops in the operation of this system enhance its range of stable operations? What feedback loops in the operation of the system tend to destabilize it?)

Essential Questions: ***Students will keep considering…***

- What types of building materials should be used for outdoor projects?
- How does acid rain affect monuments?
- Are there places on earth where tombstones weather (become harder to read) faster than other places on earth?
- How does the amount of carbon dioxide in the atmosphere affect the pH of the oceans?

Anchoring Phenomena: Teacher's Choice of Totally Awesome Reaction Demonstration (i.e. Elephant's Toothpaste)
https://www.youtube.com/watch?v=p5qvi20J5IM

Standards Addressed
Students who demonstrate understanding can: ● HS-PS1-2 Construct and revise an explanation for the outcome of a simple chemical reaction based on the outermost electron states of atoms, trends in the periodic table, and knowledge of the patterns of chemical properties. [Clarification Statement: Examples of chemical reactions could include the reaction of sodium and chlorine, of carbon and oxygen, or of carbon and hydrogen.] [Assessment Boundary: Assessment is limited to chemical reactions involving main group elements and combustion reactions.] (linked to MLS 9-12-PS1-A-2) ● HS-PS1-4 Develop a model to illustrate that the release or absorption of energy from a chemical reaction system depends upon the changes in total bond energy. [Clarification Statement: Emphasis is on the idea that a chemical reaction is a system that affects the energy change. Examples of models could include molecular-level drawings and diagrams of reactions, graphs showing the relative energies of reactants and products, and representations showing energy is conserved.] [Assessment Boundary: Assessment does not include calculating the total bond energy changes during a chemical reaction from the bond energies of reactants and products.] (linked to MLS 9-12-PS1-A-5) ● **HS-PS1-5 Apply scientific principles and evidence to provide an explanation about the effects of changing the temperature or concentration of the reacting particles on the rate at which a reaction occurs. [Clarification Statement: Emphasis is on student reasoning that focuses on the number and energy of collisions between molecules.] [Assessment Boundary: Assessment is limited to simple reactions in which there are only two reactants; evidence from temperature, concentration, and rate data; and qualitative relationships between rate and temperature.]** (linked to MLS 9-12-PS1-B-6) ● HS-PS1-7 Use mathematical representations to support the claim that atoms, and therefore mass, are conserved during a chemical reaction. [Clarification Statement: Emphasis is on using mathematical ideas to communicate the proportional relationships between masses of atoms in the reactants and the products, and the translation of these relationships to the macroscopic scale using the mole as the conversion from the atomic to the macroscopic scale. Emphasis is on assessing students' use of mathematical thinking and not on memorization and rote application of problem-solving techniques.] [Assessment Boundary: Assessment does not include complex chemical reactions.] (linked to MLS 9-12-PS1-B-8)

Disciplinary Core Ideas **Students will know...**	**Cross Cutting Concepts** **Students will understand….**	**Science and Engineering Practice** **Students will be able to...**
PS1.A: Structure and Properties of Matter The periodic table orders elements horizontally by the number of protons in the atom's nucleus and places those with similar chemical properties in columns. The repeating patterns of this table reflect patterns of outer electron states. (HS-PS1-2)	Patterns Students understand how the patterns of attraction allow the prediction of the type of reaction that occurs (e.g., formation of ionic compounds, combustion of hydrocarbons). Students understand the causal	Constructing explanations and designing solutions Students construct an explanation of the outcome of the given reaction, including: 1. The idea that the total number of atoms of each element in the reactant and products is the same; 2. The numbers and types of bonds (i.e., ionic, covalent) that each atom forms, as determined by the outermost (valence) electron states and the electronegativity;

PS1.B: Chemical Reactions The fact that atoms are conserved, together with knowledge of the chemical properties of the elements involved, can be used to describe and predict chemical reactions. (HS-PS1-2) ● The periodic table can be used to predict the type of reaction that occurs. (ionic compound, combustion of hydrocarbons, etc.) ● Valence electrons determine different types and number of bonds. (ionic, covalent, metallic) ● Conservation of matter is shown in chemical equations/reactions by having the same number of each element in the reactants and products ● .As kinetic energy increases at the molecular level the number of collisions between molecules increases resulting in a faster reaction rate. ● The bonds being broken and formed are predictable. ● Breaking bonds requires an input of energy from the system or surroundings, and forming bonds releases energy to the system and the surroundings. ● A higher concentration means more particles per unit volume which means more particle collisions. ● The mass of a substance can be used to determine the number of atoms, molecules, or ions.	relationship between the observable macroscopic patterns of reactivity of elements in the periodic table and the patterns of outermost electrons for each atom and its relative electronegativity.	3. The outermost (valence) electron state of the atoms that make up both the reactants and the products of the reaction is based on their position in the periodic table; and 4. A discussion of how the patterns of attraction allow the prediction of the type of reaction that occurs (e.g., formation of ionic compounds, combustion of hydrocarbons). Students identify and describe the evidence to construct the explanation, including: 1. Identification of the products and reactants, including their chemical formulas and the arrangement of their outermost (valence) electrons; 2. Identification that the number and types of atoms are the same both before and after a reaction; 3. Identification of the numbers and types of bonds (i.e., ionic, covalent) in both the reactants and the products; 4. The patterns of reactivity (e.g., the high reactivity of alkali metals) at the macroscopic level as determined by using the periodic table 5. The outermost (valence) electron configuration and the relative electronegativity of the atoms that make up both the reactants and the products of the reaction based on their position in the periodic table Students describe their reasoning that connects the evidence, along with the assumption that theories and laws that describe their natural world operate today as they did in the past and will continue to do so in the future, to construct an explanation for how the patterns of outermost electrons and the electronegativity of elements can be used to predict the number and types of bonds each element forms. In the explanation, students describe the causal relationship between the observable macroscopic patterns of reactivity of elements in the periodic table and the patterns of outermost electrons for each atom and its relative electronegativity. Given new evidence or context, students construct a revised or expanded explanation about the outcome of a chemical reaction and justify the revision.

PS1.A: Structure and Properties of Matter A stable molecule has less energy than the same set of atoms separated; one must provide at least this energy in order to take the molecule apart. (HS-PS1-4) PS1.B: Chemical Reactions Chemical processes, their rates, and whether or not energy is stored or released can be understood in terms of the collisions of molecules and the rearrangements of atoms into new molecules, with consequent changes in the sum of all bond energies in the set of molecules that are matched by changes in kinetic energy.(HS-PS1-4)	Energy and Matter Students will understand the energy change within the system is accounted for by the change in the bond energies of the reactants and products. Students understand breaking bonds requires an input of energy from the system or surroundings, and forming bonds releases energy to the system and the surroundings. Students understand the energy transfer between systems and surroundings is the difference in energy between the bond energies of the reactants and the products. Students understand the overall energy of the system and surroundings is unchanged (conserved) during the reaction. Students understand energy transfer occurs during molecular collisions. Students understand the relative total potential energies of the reactants and products can be accounted for by the changes in bond energy.	Develop and Use a Model Students use evidence to develop a model in which they identify and describe the relevant components, including: 1. The chemical reaction, the system, and the surroundings under study; 2. The bonds that are broken during the course of the reaction; 3. The bonds that are formed during the course of the reaction; 4. The energy transfer between the systems and their components or the system and surroundings; 5. The transformation of potential energy from the chemical system interactions to kinetic energy in the surroundings (or vice versa) by molecular collisions; and 6. The relative potential energies of the reactants and the products. In the model, students include and describe the relationships between components, including: 1. The net change of energy within the system is the result of bonds that are broken and formed during the reaction (Note: This does not include calculating the total bond energy changes.); 2. The energy transfer between system and surroundings by molecular collisions; 3. The total energy change of the chemical reaction system is matched by an equal but opposite change of energy in the surroundings (Note: This does not include calculating the total bond energy changes.) 4. The release or absorption of energy depends on whether the relative potential energies of the reactants and products decrease or increase. Students use the developed model to illustrate: 1. The energy change within the system is accounted for by the change in the bond energies of the reactants and products. (Note: This does not include calculating the total bond energy changes.) 2. Breaking bonds requires an input of energy from the system or surroundings, and forming bonds releases energy to the system and the surroundings. 3. The energy transfer between systems and surroundings is

		the difference in energy between the bond energies of the reactants and the products. 4. The overall energy of the system and surroundings is unchanged (conserved) during the reaction. 5. Energy transfer occurs during molecular collisions. 6. The relative total potential energies of the reactants and products can be accounted for by the changes in bond energy.
PS1.B: Chemical Reactions **Chemical processes, their rates, and whether or not energy is stored or released can be understood in terms of the collisions of molecules and the rearrangements of atoms into new molecules, with consequent changes in the sum of all bond energies in the set of molecules that are matched by changes in kinetic energy. (HS-PS1-5**	**Patterns** **Students understand patterns increases in concentration (e.g., a change in one concentration while the other concentration is held constant) increase the reaction rate, and vice versa and can use this pattern as evidence.** **Students understand the pattern that increases in temperature usually increase the reaction rate, and vice versa and can use this pattern as evidence.**	**Constructing explanations and designing solutions** **Students construct an explanation that includes the idea that as the kinetic energy of colliding particles increases and the number of collisions increases, the reaction rate increases.** **Students identify and describe evidence to construct the explanation, including:** **1. Evidence (e.g., from a table of data) of a pattern that increases in concentration (e.g., a change in one concentration while the other concentration is held constant) increase the reaction rate, and vice versa; and** **2. Evidence of a pattern that increases in temperature usually increase the reaction rate, and vice versa.** **Students use and describe the following chain of reasoning that integrates evidence, facts, and scientific principles to construct the explanation:** **1. Molecules that collide can break bonds and form new bonds, producing new molecules.** **2. The probability of bonds breaking in the collision depends on the kinetic energy of the collision being sufficient to break the bond, since bond breaking requires energy.** **3. Since temperature is a measure of average kinetic energy, a higher temperature means that molecular collisions will, on average, be more likely to break bonds and form new bonds.** **4. At a fixed concentration, molecules that are moving faster also collide more frequently, so molecules with**

		higher kinetic energy are likely to collide more often. **5. A high concentration means that there are more molecules in a given volume and thus more particle collisions per unit of time at the same temperature.**
PS1.B: Chemical Reactions The fact that atoms are conserved, together with knowledge of the chemical properties of the elements involved, can be used to describe and predict chemical reactions (HS-PS1-7)	Energy and Matter Students understand how the mathematical representations support the claim that atoms, and therefore mass, are conserved during a chemical reaction. Students understand how the mass of a substance can be used to determine the number of atoms, molecules, or ions using moles and mole relationships (e.g., macroscopic to atomic molecular scale conversion using the number of moles and Avogadro's number).	Mathematical and computational thinking Students identify and describe the relevant components in the mathematical representations: 1. Quantities of reactants and products of a chemical reaction in terms of atoms, moles, and mass; 2. Molar mass of all components of the reaction; 3. Use of balanced chemical equation(s); and 4. Identification of the claim that atoms, and therefore mass, are conserved during a chemical reaction. The mathematical representations may include numerical calculations, graphs, or other pictorial depictions of quantitative information. Students identify the claim to be supported: that atoms, and therefore mass, are conserved during a chemical reaction. Students use the mole to convert between the atomic and macroscopic scale in the analysis. Given a chemical reaction, students use the mathematical representations to 1. Predict the relative number of atoms in the reactants versus the products at the atomic molecular scale; and 2. Calculate the mass of any component of a reaction, given any other component. Students describe how the mathematical representations (e.g., stoichiometric calculations to show that the number of atoms or number of moles is unchanged after a chemical reaction where a specific mass of reactant is converted to product) support the claim that atoms, and therefore mass, are conserved during a chemical reaction.

		Students describe how the mass of a substance can be used to determine the number of atoms, molecules, or ions using moles and mole relationships (e.g., macroscopic to atomic molecular scale conversion using the number of moles and Avogadro's number).

Unit 4: Assessment

<table>
<tr><th colspan="4">EVIDENCE of LEARNING</th></tr>
<tr>
<td><u>Understanding</u>
Planning and Carrying Out Investigations

Obtaining, Evaluating, and Communicating Information

Developing and using Models</td>
<td><u>Standards</u>
HS-PS1-2
HS-PS1-4
HS-PS1-5
HS-PS1-7</td>
<td><u>Unit Performance Assessment</u>:
Description of Performance Task: In the 4th Quarter Inquiry Performance Task students will apply scientific principles and evidence to provide an explanation about the effects of changing the temperature or concentration of the reacting particles on the rate at which a reaction occurs (students may work in groups for this portion). This will be accomplished by designing and conducting two experiments. After completing the scientific inquiry task, the students will individually complete the 4th Quarter Performance Task Assessment. Teacher notes provide information needed for the investigation.

Teacher will assess:
Students ability to plan and conduct an investigation to gather evidence for changing and determining the reaction rate of antacid tablets in water.
Students ability to recognize the relationship between different, testable variables (target is temperature and concentration) and reaction rates.
Students will correctly predict the effect of manipulating variables on the rate of chemical reactions.
Students can express answers using claim evidence reasoning.
CCC: Stability Change; Scale Proportion Quantity; Matter and Energy
SEP: Planning and Carrying Out Investigations, Obtaining, Evaluating, and Communicating Information, Developing and using Models

<u>Performance:</u>
Mastery: Students can build a device that meets the design challenge, model the energy in their device, and use mathematics to calculate energy.

Scoring Guide:
Rubric and scoring guide are provided in the 4th Quarter Inquiry Performance Task and 4th Quarter Performance Task Assessment documents.</td>
<td><u>R/R Quadrant</u>
C
<u>21 Century</u>

critical thinking
collaboration
communication
creativity</td>
</tr>
</table>

SAMPLE LEARNING PLAN				
Understanding	**Standards**	**Major Learning Activities:**	**Instructional Strategy Category:**	**R/R Quadrant: 21C:**
Planning and Carrying Out Investigations	HS-PS1-2 Cause and Effect Matter and Energy Systems and System Models ISTE Standard addressed	**Lesson**: Types of Chemical Reactions Lab Chemical Reaction Practice **Objective**: Students will be able to construct and revise an explanation for the outcome of a simple chemical reaction based on the outermost electron states of atoms, trends in the periodic table, and knowledge of the patterns of chemical properties. **Activity:** Students will conduct a lab testing several types of reactions (synthesis, decomposition, single replacement, double replacement, and combustion). This lab has several questions for the post lab. If uncomfortable with students doing the experiments, it is suggested for these, as well as others, to be modeled for the class. It is also an option to use videos such as this: Chemical Reactions Youtube. **Check for understanding:** Students lab write up and practice using Chemical Reaction Practice will give knowledge of student understanding. Also, the lab write up and post lab questions will show knowledge of reactions. Additionally, the teacher will model several chemical reactions for the class, tell them what the reactants are, and ask them to guess the products based on what type of chemical reaction they believe it to be. This may require guiding from the instructor. Reaction types could include, but are not limited to, hydrogen peroxide and manganese dioxide (3% then 30%), burn magnesium for synthesis, ethanol or methanol 10ml in a large water jug and a match, nitrate and potassium iodide for double replacement, and sodium in water.	Reinforcing Effort and Providing recognition cooperative learning Non-linguistic representations Summarizing and note taking Assigning Homework and Providing Practice Generating and Testing Hypotheses	**R/R Quadrant** B **21 Century** collaboration communication
Planning and Carrying Out Investigations Constructing	HS-PS1-4 Cause and Effect	**Lesson**: Endothermic and Exothermic Reactions **Objective**: Students investigate experiments that will aid in developing a model to illustrate that the release or absorption of energy from a chemical reaction system depends upon the changes in total bond energy.	Setting Objectives and providing feedback	**R/R Quadrant** B **21 Century**

Explanations Developing and Using Models	System and System Models Matter and Energy ISTE Standard addresed	**Activity:** Students will mix baking soda and vinegar as an example of an endothermic reaction. Students will mix calcium chloride with water as an example of an exothermic reaction. In the lab write up, students will write the chemical reaction, model the energy levels, and discuss reactions. Students will then work in groups to model the endothermic and exothermic reactions on a piece of cardstock paper in order to conduct a gallery walk. During the gallery walk, students will put sticky notes on each others posters giving one positive and one thing to be corrected. Students should not stand by their posters during the walk. **Check for understanding:** In the lab write up, students will write the chemical reaction, model the energy levels, and discuss reactions. During the gallery walk, students will put sticky notes on each others posters giving one positive and one thing to be corrected. Students should not stand by their posters during the walk. As a teacher, you can check for understanding by participating in the gallery walk and grading lab reports.	cooperative learning Cues, Questions, and Advance organizers Non-linguistic representations Identifying Similarities and Differences	collaboration communication
Developing and Using Models Planning and Carrying Out Investigations Constructing Explanations	HS-PS1-5 Cause and Effect System and System Models Stability Change Energy and Matter ISTE Standard addressed	**Lesson**: Modeling Molecular Collisions and Temperature **Objective**: Students will apply scientific principles and evidence to provide an explanation about the effects of changing the temperature of the reacting particles on the rate at which a reaction occurs. **Activity:** Students will begin with think pair share on their knowledge of how temperature affects the rate of chemical reactions.Students will put food coloring in cold water and hot water, then model the results. They will then swap with another group to identify misconceptions. The teacher can model this for students if they are not comfortable with students using a hot plate. **Check for understanding:** Teacher will view students' models, explanations, and the misconceptions identified by other students. The true formative assessment will be students ability to answer how temperature affects the rate at which chemicals collide due to temperature.	cooperative learning Cues, Questions, and Advance organizers Non-linguistic representations Generating and Testing Hypotheses	**R/R Quadrant** C **21 Century** Collaboration, Communication, Critical Thinking
Energy & Matter	HS-PS1-7	**Lesson**: Balancing Chemical Equations PhET Simulation **Objective**: Use mathematical representations to support the claim that atoms,	Setting Objectives and providing	Rigor / Relevance:

	Mathematics & Computational Thinking Developing & Using Models ISTE Standard addressed	and therefore mass, are conserved during a chemical reaction **Learning Activity:** Students will use the PhET Simulation to balance chemical equations. They will first go through the introduction, then through the three levels of the game. **Check for understanding:** Students are able to master level 3 of the game.	feedback Reinforcing Effort and Providing recognition Non-linguistic representations Assigning Homework and Providing Practice	B 21C skills: Critical Thinking

Unit 4: Resources

UNIT RESOURCES
Teacher Resources: ● *Physical Science Textbook and Teacher Resources* ● *PhET (Founded in 2002 by Nobel Laureate Carl Wieman, the PhET Interactive Simulations project at the University of Colorado Boulder creates free interactive math and science simulations. PhET sims are based on extensive education research and engage students through an intuitive, game-like environment where students learn through exploration and discovery.)* ● *The Physics Classroom (The Physics Classroom is an online, free to use physics website developed primarily for beginning physics students and their teachers. The website features a variety of sections intended to support both teachers and students in the tasks of learning and teaching physics.)* ● *Explore Learning (Gizmos are interactive math and science simulations for grades 3-12. Over 400 Gizmos aligned to the latest standards help educators bring powerful new learning experiences to the classroom.)* ● *NSTA NGSS Resource Hub (Includes NSTA vetted lessons for NGSS Standards)* ● *Next Generation Molecular Workbench (Molecular Workbench (MW) is powerful, award-winning software that provides visual, interactive computational experiments for teaching and learning science.)*
Student Resources: ● *Physical Science Textbook and Teacher Resources*

- *PhET (Founded in 2002 by Nobel Laureate Carl Wieman, the PhET Interactive Simulations project at the University of Colorado Boulder creates free interactive math and science simulations. PhET sims are based on extensive education research and engage students through an intuitive, game-like environment where students learn through exploration and discovery.)*
- *The Physics Classroom (The Physics Classroom is an online, free to use physics website developed primarily for beginning physics students and their teachers. The website features a variety of sections intended to support both teachers and students in the tasks of learning and teaching physics.)*
- *Explore Learning (Gizmos are interactive math and science simulations for grades 3-12. Over 400 Gizmos aligned to the latest standards help educators bring powerful new learning experiences to the classroom.)*
- *Next Generation Molecular Workbench (Molecular Workbench (MW) is powerful, award-winning software that provides visual, interactive computational experiments for teaching and learning science.)*

Vocabulary:
Product - substance form as the result of a chemical reaction
Reactant - a substance that undergoes a change in a chemical reaction
Endothermic- a description of a change in which a system absorbs energy from its surroundings
Exothermic- a description of a change in which a system releases energy from its surroundings