Orange Public Schools

Office of STEM-Focused Learning & Gifted Education

Science Curriculum Guide

Physics Honors

Unit 3: Energy Conversion

48 Instructional Days

Board Approved: 9/13/23

Revised: 8/22/23

Table of Contents

YEARLONG SCOPE AND SEQUENCE				
UNIT 1	**UNIT 2**	**UNIT 3**	**UNIT 4**	**UNIT 6**
Forces and Motion	**Forces at a Distance**	**Energy Conversion**	**Waves and Electromagnetic Radiation**	**From the Nucleus to the Universe**
23.5 days	45 days	48 days	27.5 days	33.5 days
In Storyline 1, students learn how to model motion using models that are grounded in mathematical relationships. They investigate and model uniform motion, nonuniform motion, circular motion, and projectile motion. Students also explore how various forces affect the motion of objects. Students explore the relationship between forces and motion. *This unit addresses HS-PS2-1, HS-PS2-2, HS-PS2-4, and HS-ESS2-1.*	In Storyline 2, students investigate gravitational forces, electrical forces, magnetic forces, and forces in materials. They connect orbital motion to gravitational forces and construct explanations about electric fields and currents. Students investigate gravitational, electric, and magnetic forces, and the forces within atoms. *This unit addresses HS-PS1-3, HS-PS2-4, HS-PS2-5, HS-PS2-6, HS-PS3-5, and HS-ESS1-4.*	In Storyline 3, students explore energy conversions by quantifying how much energy transfers between objects and energy fields. They use bar charts and equations to define systems and to model energy conversions. They consider heat transfer in engines, heat pumps, and Earth's interior, connecting the convection of Earth's mantle to plate tectonics. Students evaluate the costs and benefits associated with different methods of energy production and identify variables essential to a sustainable energy future for Earth's growing human population. Students explore energy conversions in collisions, in engines and heat pumps, and in electromagnetic systems. *This unit addresses HS-PS2-2, HS-PS2-3, HS-PS2-5, HS-PS3-1, HS-PS3-2, HS-PS3-3, HS-PS3-4, HS-PS3-5, HS-ESS2-1, HS-ESS2-3, HS-ESS3-2, and HS-ESS3-3.*	In Storyline 4, students explore waves and electromagnetic radiation, as well as technological applications of transmitting and capturing information and energy. In Investigation 1 1, students experiment with waves. In Investigation 12, students explore electromagnetic radiation. In Investigation 13, students design instrumentation to transmit information. Students investigate the properties and behaviors of waves, using mathematical relationships. *This unit addresses HS-PS3-3, HS-PS4-1, HS-PS4-2, HS-PS4-3, HS-PS4-4, and HS-PS4-5.*	In Storyline 5, students investigate and model atomic nuclei and the processes they undergo. They learn how the predictable decay processes of specific atomic nuclei are used by scientists to date materials. They also explore evidence relating to the origin of the universe and compare the sun to other stars in the universe. Students explore the beginning of the universe, the death of stars, and the radioactive decay of atoms. *This unit addresses HS-PS1-8, HS-ESS1-1, HS-ESS1-2, HS-ESS1-3, HS-ESS1-5, HS-ESS1-6, and HS-ESS2-1.*

UNIT OVERVIEW AND CONCEPTUAL FLOW

Content Area	Science	**Course**	Physics Honors
Unit Plan Title	Unit 3: Energy Conversion	**Duration**	48 days

UNIT OVERVIEW

In Storyline 3, students explore energy conversions by quantifying how much energy transfers between objects and energy fields. They use bar charts and equations to define systems and to model energy conversions. They consider heat transfer in engines, heat pumps, and Earth's interior, connecting the convection of Earth's mantle to plate tectonics. Students evaluate the costs and benefits associated with different methods of energy production and identify variables essential to a sustainable energy future for Earth's growing human population.   Students explore energy conversions in collisions, in engines and heat pumps, and in electromagnetic systems.

This unit addresses HS-PS2-2, HS-PS2-3, HS-PS2-5, HS-PS3-1, HS-PS3-2, HS-PS3-3, HS-PS3-4, HS-PS3-5, HS-ESS2-1, HS-ESS2-3, HS-ESS3-2, and HS-ESS3-3.

CONCEPTUAL FLOW

Anchoring Phenomenon	How does this machine transfer energy?
Investigations	**Investigation #7:** Energy • **Experience 1** - Classifying Energy and Work • **Experience 2** - Mechanical Energy • **Experience 3** - Conservation of Energy **Investigation #8:** Collisions • **Experience 1** - Momentum and Impulse • **Experience 2** - Conservation of Momentum • **Experience 3** - Collisions in Earth's Crust **Investigation #9:** Thermal Energy • **Experience 1** - Temperature • **Experience 2** - Thermal Equilibrium and Heat Flow • **Experience 3** - Heat Flow Within Earth **Investigation #10:** Electromagnetic Energy • **Experience 1** - Electric Potential • **Experience 2** - Energy in Electric Circuits • **Experience 3** - Power Generation • **Experience 4** - Energy Resources and Conservation

ESSENTIAL QUESTION(S) AND ENDURING UNDERSTANDINGS	
Essential Questions /Focus Questions	**Enduring Understandings**
• How is energy transferred and conserved? • I have heard about it since kindergarten but what is energy? • How can we use mathematics to prove what happens in abiotic and biotic systems? • Superstorm Sandy devastated the New Jersey Shore and demonstrated to the public how vulnerable our infrastructure is. Using your understanding of energy, design a low technology system that would insure the availability of energy to residents if catastrophic damage to the grid occurs again.	• Energy is a quantitative property of a system that depends on the motion and interactions of matter and radiation within that system. • At the macroscopic scale, energy manifests itself in multiple ways, such as in motion, sound, light, and thermal energy. • 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). • Radiation is a phenomenon in which energy stored in fields moves across spaces. • Energy cannot be created or destroyed. It only moves between one place and another place, between objects and/or fields, or between systems. • There is a single quantity of energy 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. • 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. • The availability of energy limits what can occur in any system. • Models can be used to predict the behavior of a system, but these predictions have limited precision and reliability due to the assumptions and approximation inherent in models. • Science assumes that the universe is a vast single system in which basic laws are consistent. • At the macroscopic scale, energy manifests itself in multiple ways, such as in motion, sound, light, and thermal energy.

NGSS PERFORMANCE EXPECTATION(S)

Students who demonstrate understanding can:

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.

HS-PS2-5 Plan and conduct an investigation to provide evidence that an electric current can produce a magnetic field and that a changing magnetic field can produce an electric current.

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.

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).

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.

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).

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.

HS-ESS2-1 Develop a model to illustrate how Earth's internal and surface processes operate at different spatial and temporal scales to form continental and ocean-floor features.

HS-ESS2-3 Develop a model based on evidence of Earth's interior to describe the cycling of matter by thermal convection.

HS-ESS3-2 Evaluate competing design solutions for developing, managing, and utilizing energy and mineral resources based on cost-benefit ratios.

HS-ESS3-3 Create a computational simulation to illustrate the relationships among management of natural resources, the sustainability of human populations, and biodiversity.

3-DIMENSIONAL LEARNING

SCIENCE AND ENGINEERING PRACTICES	DISCIPLINARY CORE IDEAS	CROSSCUTTING CONCEPTS

☐ **Asking Questions and Defining Problems** ☒ **Developing and Using Models** ☒ **Planning and Carrying Out Investigations** ☐ **Analyzing and Interpreting Data** ☒ **Using Mathematics and Computational Thinking** ☒ **Constructing Explanations and Designing Solutions** ☒ **Engaging in Argument from Evidence** ☐ **Obtaining, Evaluating, and Communicating Information**	**PS2.A: Forces and Motion** Momentum is defined for a particular frame of reference; it is the mass times the velocity of the object. If a system interacts with objects outside itself, the total momentum of the system can change; however, any such change is balanced by changes in the momentum of objects outside the system. **PS2.B: Types of Interactions** Newton's law of universal gravitation and Coulomb's law provide the mathematical models to describe and predict the effects of gravitational and electrostatic forces between distant objects. (HS-PS2-4) Forces at a distance are explained by fields (gravitational, electric, and magnetic) permeating space that can transfer energy through space. Magnets or electric currents cause magnetic fields; electric charges or changing magnetic fields cause electric fields. **PS3.A: Definitions of Energy** "Electrical energy" may mean energy stored in a battery or energy transmitted by electric currents. (secondary) 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 is continually transferred from one object to another and between its various possible forms. At the macroscopic scale, energy manifests itself in multiple ways, such as in motion, sound, light, and thermal energy. 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. **PS3.B: Conservation of Energy and Energy Transfer**	☐ **Patterns** ☒ **Cause and Effect** ☐ **Scale, Proportion, and Quantity** ☒ **Systems and System Models** ☒ **Energy and Matter** ☐ **Structure and function.** ☒ **Stability and change**.

	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. 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). **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. **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. Although energy cannot be destroyed, it can be converted to less useful forms—for example, to thermal energy in the surrounding environment. **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) **ESS2.A: Earth Materials and Systems** Earth's systems, being dynamic and interacting, cause feedback effects that can increase or decrease the original changes. Evidence from deep probes and seismic waves, reconstructions of historical changes in Earth's surface and its magnetic field, and an understanding of physical and chemical	

	processes lead to a model of Earth with a hot but solid inner core, a liquid outer core, a solid mantle and crust. Motions of the mantle and its plates occur primarily through thermal convection, which involves the cycling of matter due to the outward flow of energy from Earth's interior and gravitational movement of denser materials toward the interior. **ESS2.B: Plate Tectonics and Large-Scale System Interactions** The radioactive decay of unstable isotopes continually generates new energy within Earth's crust and mantle, providing the primary source of the heat that drives mantle convection. Plate tectonics can be viewed as the surface expression of mantle convection. Plate tectonics is the unifying theory that explains the past and current movements of the rocks at Earth's surface and provides a framework for understanding its geologic history. Plate movements are responsible for most continental and ocean-floor features and for the distribution of most rocks and minerals within Earth's crust. (ESS2.B Grade 8 GBE) **PS4.A: Wave Properties** Geologists use seismic waves and their reflection at interfaces between layers to probe structures deep in the planet. (secondary to HS-ESS2-3) **ESS3.A: Natural Resources** All forms of energy production and other resource extraction have associated economic, social, environmental, and geopolitical costs and risks as well as benefits. New technologies and social regulations can change the balance of these factors. **ESS3.C: Human Impacts on Earth Systems** The sustainability of human societies and the biodiversity that supports them requires responsible management of natural resources. **ETS1.B: Developing Possible Solutions** When evaluating solutions, it is important to take into account a range of constraints, including cost, safety, reliability, and aesthetics, and to consider social, cultural, and environmental impacts. (secondary)	

INTERDISCIPLINARY CONNECTIONS

English Language Arts

RST.11-12.1
Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account. (HS-PS2-1)
RST.11-12.7
Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem. (HS-PS2-1)
RST.11-12.8
Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information. (HS-ETS1-3)
RST.11-12.9
Synthesize information from a range of sources (e.g., texts, experiments, simulations) into a coherent understanding of a process, phenomenon, or concept, resolving conflicting information when possible. (HS-ETS1-3)
WHST.11-12.7
Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.(HS-PS2-3),(HS-ETS1-3)
WHST.11-12.9
Draw evidence from informational texts to support analysis, reflection, and research. (HS-PS2-1)

Mathematics

MP.2
Reason abstractly and quantitatively. (HS-PS2-1), (HS-PS2-2)
MP.4
Model with mathematics. (HS-PS2-1), (HS-PS2-2)
HSN-Q.A.1
Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. (HS-PS2-1), (HS-PS2-2)
HSN-Q.A.2
Define appropriate quantities for the purpose of descriptive modeling. (HS-PS2-1), (HS-PS2-2)
HSN-Q.A.3
Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. (HS-PS2-1), (HS-PS2-2)
HSA.SSE.A.1
Interpret expressions that represent a quantity in terms of its context. (HS-PS2-1)
HSA.SSE.B.3
Choose and produce an equivalent form of an expression to reveal and explain properties of the quantity represented by the expression.
HSA.CED.A.1
Create equations and inequalities in one variable and use them to solve problems. (HS-PS2-1), (HS-PS2-2)
HSA.CED.A.2
Create equations in two or more variables to represent relationships between quantities; graph equations on coordinate axes with labels and scales. (HS-PS2-1), (HS-PS2-2)
HSA.CED.A.4
Rearrange formulas to highlight a quantity of interest, using the same reasoning as in solving equations. (HS-PS2-1),(HS-PS2-2)
HSF-IF.C.7

Graph functions expressed symbolically and show key features of the graph, by in hand in simple cases and using technology for more complicated cases. (HS-PS2-1)

HSS-IS.A.1

Represent data with plots on the real number line (dot plots, histograms, and box plots). (HS-PS2-1)

INTEGRATED ACCOMODATIONS & MODIFICATIONS

<table>
<tr><th>Special Education / 504</th><th>English Language Learners</th></tr>
<tr><td>

Adhere to all modifications and health concerns stated in each IEP.
Give students a MENU of options, allowing them to choose assignments from different levels based on difficulty.
Accommodate Instructional Strategies: use of post-its, reading aloud text, graphic organizers, one-on-one instruction, class website (Google Classroom), handouts, definition list with visuals, extended time
Allow extra time to complete assignments or tests
Allow students to demonstrate understanding of a problem by drawing a functional model of the answer and then explaining the reasoning orally and/or writing.
Provide breaks between tasks, use positive reinforcement, use proximity
Work in a small group
Use large print books, Braille, or digital texts

Strategies for students with 504 plans
</td><td>

Simplify written and verbal instructions
Use manipulatives to promote conceptual understanding and enhance vocabulary usage
Allow for alternate forms of responses- drawing or speaking instead of writing to demonstrate knowledge when you are not specifically assessing writing
Allow the use of an online dictionary to look up the definition and hear the pronunciation of unknown words
Provide graphic representations, gestures, drawings, equations, and pictures during all segments of instruction
Utilize program translations tools such as Snap and Read (if available)
Utilize graphic organizers which are concrete, pictorial ways of constructing knowledge and organizing information
Use sentence frames and questioning strategies so that students will explain their thinking/ process of how to solve real life problems.
Reword questions in simpler language
Provide class notes ahead of time to allow students to preview material and increase comprehension
Provide extended time

</td></tr>
<tr><th>Gifted and Talented</th><th>Students at Risk for Failure</th></tr>
<tr><td>

Organize and offer flexible small group learning opportunities / activities.
Utilize elevated contextual complexity
Inquiry based or open-ended assignments, performance tasks and projects
Allow more time to study concepts with greater depth
Provide options, alternatives and choices to differentiate and broaden the curriculum.
Promote the synthesis of concepts and making real world connections
Provide students with enrichment practice that are imbedded in the curriculum

allowing students to design problems to be addressed by the class
allowing students to modify the lesson by introducing a related phenomenon
allow for interest-based extension activities

Utilize an enhanced set of introductory activities (e.g. phenomena, organizers, concept maps etc.)
Provide whole group enrichment explorations.
Teach cognitive and methodological skills
Allow for the use of stations
Organize integrated problem-solving simulations.

</td><td>

Assure students have experiences that are on the Concrete- Pictorial- Abstract spectrum
Modify Instructional Strategies; extended time, reading aloud text, graphic organizers, flexible grouping, one-on-one instruction, class website (Google Classroom), inclusion of more visuals and manipulatives, Utilize Scaffolded Questioning, Field Trips, Google Expeditions, Peer Support, Modified Assignments, Chunking of Information, Peer Buddies
Assure constant parental/ guardian contact throughout the year with successes/ challenges
Provide academic contracts to students and guardians
Create an interactive notebook with samples, key vocabulary words, student goals/ objectives.
Always plan to address students at risk in the designing of learning tasks, instructions, and directions.
Try to anticipate where the needs will be and then address them prior to lessons.
Teacher should allow for preferential seating
Include Visual Cues/Modeling
Allow for technology Integration, especially Assistive Technology

</td></tr>
</table>

21ST CENTURY SKILLS
NJSLS CAREER READINESS, LIFE LITERACIES AND KEY SKILLS

An education in career readiness, life literacies, and key skills fosters a population that: continually self-reflects and seeks to improve the essential life and career practices that lead to success; uses effective communication and collaboration skills and resources to interact with a global society; possesses financial literacy and responsibility at home and in the broader community; plans, executes, and alters career goals in response to changing societal and economic conditions; and seeks to attain skill and content mastery to achieve success in a chosen career path.

New Jersey Student Learning Standards for Career Readiness, Life Literacies and Key Skills

9.1 Personal Financial Literacy

Civic Responsibility:
You can give back in areas that matter to you.

- **9.1.12.CFR.1:** Compare and contrast the role of philanthropy, volunteer service, and charities in community development and quality of life in a variety of cultures.

9.2 Career Awareness, Exploration and Preparation

Career Awareness and Planning:
An individual's passions, aptitude and skills can affect his/her employment and earning potential.

- **9.2.12.CAP.2:** Develop college and career readiness skills by participating in opportunities such as structured learning experiences, apprenticeships, and dual enrollment programs.

9.3 Career and Technical Education

Engineering and Technology Career Pathway

- **9.3.ST-ET.5:** Apply the knowledge learned in STEM to solve problems.

Science and Mathematics Career Pathway

- **9.3.ST-SM.2:** Apply science and mathematics concepts to the development of plans, processes and projects that address real world problems.
- **9.3.ST-SM.3:** Analyze the impact that science and mathematics has on society.

9.4 Life Literacies and Key Skills

Creativity and Innovation:
Collaboration with individuals with diverse perspectives can result in new ways of thinking and/or innovative solutions. Curiosity and a willingness to try new ideas (intellectual risk-taking) contributes to the development of creativity and innovation skills.

- **9.4.12.CI.1:** Demonstrate the ability to reflect, analyze and use creative skills and ideas.
- **9.4.12.CI.3:** Investigate new challenges and opportunities for personal growth, advancement and transition.

Critical Thinking and Problem-solving:
The ability to solve problems effectively begins with gathering data, seeking resources, and applying critical thinking skills.

- **9.4.12.CT.1:** Identify problem-solving strategies used in the development of an innovative product or practice.
- **9.4.12.CT.3:** Collaborate with individuals to analyze a variety of potential solutions to climate change effects and determine why solutions may work better than others (e.g., political. economic, cultural).

Digital Citizenship:
Sending and receiving copies of media on the internet creates the opportunity for unauthorized use of data, such as personally owned video, photos, and music. Digital identities must be managed in order to create a positive digital footprint.

- **9.4.12.DC.4:** Explain the privacy concerns related to the collection of data (e.g. cookies) and generation of data through automated processes that may not be evident to users

Information and Media Literacy:
Digital tools can be used to modify and display data in various ways that can be organized to communicate ideas.

- **9.4.12.IML.2:** Evaluate digital sources for timeliness, accuracy, perspective, credibility of the source, and relevance of information, in media, data, or other resources.

Technology Literacy:
Different digital tools have different purposes. Collaborating digitally as a team can often develop a better artifact than an individual working alone.

	• **9.4.12.TL.1**: Assess digital tools based on features such as accessibility options, capacities and utility for accomplishing a specified task • **9.4.12.TL.3**: Analyze the effectiveness of the process and quality of collaborative environments. • **9.4.12.TL.4**: Collaborate in online learning communities or social networks or virtual worlds to analyze and propose a resolution to a real-world problem.

Practices

- Act as a responsible and contributing community member and employee.
- Consider the environmental, social and economic impacts of decisions.
- Demonstrate creativity and innovation.
- Utilize critical thinking to make sense of problems and persevere in solving them.
- Model integrity, ethical leadership and effective management.
- Plan education and career paths aligned to personal goals.
- Use technology to enhance productivity increase collaboration and communicate effectively.

NJSLS COMPUTER SCIENCE & DESIGN THINKING

All students will be prepared to succeed in today's knowledge-based economy by providing equitable and expanded access to high-quality, standards-based computer science and technological design education.
https://www.nj.gov/education/standards/compsci/Docs/2020%20NJSLS-CSDT.pdf

8.1 Computer Science

Data & Analysis: Computing systems exist to process data. The amount of digital data generated in the world is rapidly expanding, so the need to process data effectively is increasingly important. Data is collected and stored so that it can be analyzed to better understand the world and make more accurate predictions.

- **8.1.12.DA.5**: Create data visualizations from large data sets to summarize, communicate, and support different interpretations of real-world phenomena.
- **8.1.12.DA.6**: Create and refine computational models to better represent the relationships among different elements of data collected from a phenomenon or process.

Algorithms & Programming: An algorithm is a sequence of steps designed to accomplish a specific task. Algorithms are translated into programs, or code, to provide instructions for computing devices. Algorithms and programming control all computing systems, empowering people to communicate with the world in new ways and solve compelling problems.

- **8.1.12.AP.1**: Design algorithms to solve computational problems using a combination of original and existing algorithms.
- **8.1.12.AP.2**: Create generalized computational solutions using collections instead of repeatedly using simple variables.
- **8.1.12.AP.3**: Select and combine control structures for a specific application based upon performance and readability, and identify trade-offs to justify the choice.
- **8.1.12.AP.5**: Decompose problems into smaller components through systematic analysis, using constructs such as procedures, modules, and/or objects.
- **8.1.12.AP.6**: Create artifacts by using procedures within a program, combinations of data and procedures, or independent but interrelated programs.

8.2 Design Thinking

Engineering Design:
People design for enjoyment and to solve problems, extend human capabilities, satisfy needs and wants, and improve the human condition. Engineering Design, a systematic approach to creating solutions to technological problems and finding ways to meet people's needs and desires, allows for the effective and efficient development of products and systems.

- **8.2.12.ED.1**: Use research to design and create a product or system that addresses a problem and make modifications based on input from potential consumers.
- **8.2.12.ED.4**: Design a product or system that addresses a global problem and document decisions made based on research, constraints, trade-offs, and aesthetic and ethical considerations and share this information with an appropriate audience.

Interaction of Technology and Humans:
Societies influence technological development. Societies are characterized by common elements such as shared values, differentiated roles, and cultural norms, as well as by entities such as community institutions, organizations, and businesses. Interaction of Technology and Humans concerns the ways society drives the improvement and creation of new technologies, and how technologies both serve and change society.

- **8.2.12.ITH.1**: Analyze a product to determine the impact that economic, political, social, and/or cultural factors have had on its design, including its design constraints.
- **8.2.12.ITH.2**: Propose an innovation to meet future demands supported by an analysis of the potential costs, benefits, trade-offs, and risks related to the use of the innovation.

UNIT PACING GUIDE			
Lesson/ Investigation	**Learning Goal(s)**	**NGSS Performance Expectation(s)**	**Pacing**
Investigation #7: Energy	Students relate changes in a system to the flow of energy through the system. Students explore work, kinetic energy, the work-energy theorem, and power. Students investigate potential and kinetic energy and the role of friction. Students model energy flow in open and closed systems. Students consider the connection between power and work, and between power and friction.	**HS-PS3-1, HS-PS3-2, HS-PS3-3**	**8.5 days** (Plus, optional extension task(s) if time allows within the allotted 8.5-day window.)
Investigation #8: Collisions	Students apply Newton's laws of motion to the interactions between objects. Students define momentum and use vector addition to find the net momentum of a system. Students investigate conservation of momentum and the impulse-momentum theorem. Students explore how the movements and collisions of lithospheric plates are responsible for many of Earth's surface features.	**HS-PS2-2, HS-PS2-3, HS-ESS2-1**	**13 days** (Plus, optional extension task(s) if time allows within the allotted 13-day window.)
Investigation #9: Thermal Energy	Students focus on the movement of thermal energy and the laws of thermodynamics. Students explore the effect of heat on the temperature, pressure, and volume of ideal gases. Students observe that systems will reach thermodynamic equilibrium spontaneously over time. Students explore how the movement of thermal energy from Earth's core to its surface drives geologic processes.	**HS-PS3-2, HS-PS3-4, HS-ESS2-3**	**11 days** (Plus, optional extension task(s) if time allows within the allotted 11-day window.)
Investigation #10: Electromagnetic Energy	Students explore electricity, from the energy in the electric field around a point charge to electrical energy at power plants. Students explore how to analyze the potential energy stored in electrical fields. Students investigate the relationships between voltage current, resistance, and electric power. Students construct explanations about the role of electromagnetic induction in other designed devices. Students explore how humans use energy and how energy production, storage, and use impact the biosphere.	**HS-PS2-5, HS-PS3-3, HS-PS3-5, HS-ESS3-2, HS-ESS3-3**	**15 days** (Plus, optional extension task(s) if time allows within the allotted 15-day window.)

LESSON #1 PACING GUIDE WITH EMBEDDED ASSESSMENTS

Suggested Instructional Days: (8.5)

Investigation #7: Energy

In this investigation, students tie together different concepts relating to energy. They relate changes in a system to the flow of energy through the system. Students relate changes in a system to the flow of energy through the system.

NJSLS Specific to this Investigation/Lesson		
Performance Expectation	**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.	
Science & Engineering Practices	**Cross-Cutting Concepts**	**Disciplinary Core Ideas**
Using Mathematics and Computational Thinking	Systems and System Models	PS3.A: Definitions of Energy PS3.B: Conservation of Energy and Energy Transfer
Performance Expectation	**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).	
Science & Engineering Practices	**Cross-Cutting Concepts**	**Disciplinary Core Ideas**
Developing and Using Models	Energy and Matter	PS3.A: Definitions of Energy
Performance Expectation	**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.	
Science & Engineering Practices	**Cross-Cutting Concepts**	**Disciplinary Core Ideas**
Constructing Explanations and Designing Solutions	Energy and Matter	PS3.A: Definitions of Energy PS3.D: Energy in Chemical Processes ETS1.A: Defining and Delimiting an Engineering Problem

Anchoring Phenomenon

How does this machine transfer energy?	**Explaining Phenomena** To fully understand the phenomenon of energy conversions, students must be able to define a system and relate energy to work in a system. They calculate momentum and impulse for collisions they observe. **Anchoring Phenomenon video** → How does this machine transfer energy? **Student Handbook** → p. 278

Investigative Phenomenon

Why does a bungee jumper bounce up and down?	**Explaining Phenomena** To understand the phenomenon of a bungee jumper bouncing up and down, students must understand the ways that energy flows during the jump and that the system's energy changes form, but energy is not created or destroyed. **Investigative Phenomenon video** → Why does a bungee jumper bounce up and down?

Learning Goal	Teacher Preparation	Instructional Sequence	Assessments
EXPERIENCE 1 (2.5 days) **Classifying Work and Energy** Students explore work, kinetic energy, the work-energy theorem, and power.	**Teacher's Guide** → p. 176 **Differentiation** → Review the versions of each lab; select the appropriate version(s) for each student/student group → See "Address Misconceptions" section of Teacher Guide; provides	**ENGAGE** **Teachers' Guide:** **Everyday Phenomenon** → See Teacher Preparation for page number **NOTE:** Introduce students to this investigation with the Investigative Phenomenon video. Its purpose is to provide students with another	**Experience Assessment** **Student Handbook** → Revisit Investigative Phenomenon **Quiz** **Investigation Assessment** **Performance-Based Assessment**

	ideas to address common student preconceptions with tips and explanations. → See "Differentiated Instruction" section of Teacher Guide for advice and tips for special needs students → See "Remediation Suggestions" section of Teacher Guide; provides multiple suggestions for students struggling with specific concepts. → ⊕**Analyzing Data/** ⊕**Phet Simulation/** ⊕**Explain Video/** ⊕**Math Tutorial/**⊕**Writing About Science** These OPTIONAL activities can be personalized and assigned to enhance instruction, as time allows. **Connection to Anchoring Phenomenon** → Students identify the types of energy transfers shown in the photo of the chain-reaction machine and use the concepts of closed systems and work to describe the machine. **Connection to Investigative Phenomenon** → Students relate the concepts of energy and work to the phenomenon. They learn how kinetic energy changes as a result of work done on the system.	opportunity to interact with an engaging event and gather knowledge necessary to make sense of the Anchoring Phenomenon. **EXPLORE** **Inquiry Lab:** → Gas Particles and Work ⊕ **Analyzing Data:** → Hooke's Law and Elastic Potential Energy ⊕ **PhET Simulation:** → Classifying Energy and Work **EXPLAIN** **Student Handbook:** → pgs. 282—293 **Modeling:** → Energy in a Moving Cart ⊕ **Explain Video:** → Introduction to Kinetic Energy ⊕ **Math Tutorial Video** **ELABORATE** **Review Rubric:** → Evaluate Energy in a Moving Cart ⊕ **Writing About Science:** → Skills in Classifying Work and Energy **EVALUATE** **Quiz:** → Classifying Work and Energy	→ Design, Build, and Refine a Wind-Turbine Rotor **Virtual Lab PBA** **Engineering Workbench** **Investigation Assessment** → Energy Conversion **NJSLA Released Item/Question(s) link:** → Which question, if answered, would best support an explanation of why the tire gets warmer as air is added?
EXPERIENCE 2 (2 days) **Mechanical Energy** Students investigate potential and kinetic energy and the role of friction.	**Teacher's Guide** → p. 182 **Differentiation** → Review the versions of each lab; select the appropriate version(s) for each student/student group → See "Address Misconceptions" section of Teacher Guide; provides ideas to address common student preconceptions with tips and explanations. → See "Differentiated Instruction" section of Teacher Guide for advice and tips for special needs students → See "Remediation Suggestions" section of Teacher Guide; provides	**ENGAGE** **Teachers' Guide:** **Everyday Phenomenon** → See Teacher Preparation for page number **NOTE:** Introduce students to this investigation with the Investigative Phenomenon video. Its purpose is to provide students with another opportunity to interact with an engaging event and gather knowledge necessary to make sense of the Anchoring Phenomenon. **EXPLORE** **Inquiry Lab:**	**Experience Assessment** **Student Handbook** → Revisit Investigative Phenomenon **Quiz** **Investigation Assessment** **Performance-Based Assessment** → Design, Build, and Refine a Wind-Turbine Rotor **Virtual Lab PBA** **Engineering Workbench** **Investigation Assessment** → Energy Conversion

	multiple suggestions for students struggling with specific concepts. → ⊕**Analyzing Data/** ⊕**Phet Simulation/** ⊕**Explain Video/** ⊕**Math Tutorial/**⊕**Writing About Science** These OPTIONAL activities can be personalized and assigned to enhance instruction, as time allows. **Connection to Anchoring Phenomenon** → Students identify the types of energy transfers shown in the photo of the chain-reaction machine and use the concepts of closed systems and work to describe the machine. **Connection to Investigative Phenomenon** → Students describe the energy transformations that occur during a bungee jump.	→ The Impact of Position on Energy ⊕ **PhET Simulation:** → Mechanical Energy **EXPLAIN** **Student Handbook:** → pgs. 294—308 **Modeling:** → Asteroid Impact Models ⊕ **Explain Video:** → All of the Energy in the Universe ⊕ **Math Tutorial** **ELABORATE** **Peer Review Rubric:** → Evaluate Asteroid Impact Models ⊕ **Writing About Science:** → Skills in Mechanical Energy **EVALUATE** **Quiz:** → Mechanical Energy	**NJSLA Released Item/Question(s) link:** → Which question, if answered, would best support an explanation of why the tire gets warmer as air is added?
EXPERIENCE 3 (2 days) **Conservation of Energy** Students model energy flow in open and closed systems. Students consider the connection between power and work, and between power and friction.	**Teacher's Guide** → p. 188 **Differentiation** → Review the versions of each lab; select the appropriate version(s) for each student/student group → See "Address Misconceptions" section of Teacher Guide; provides ideas to address common student preconceptions with tips and explanations. → See "Differentiated Instruction" section of Teacher Guide for advice and tips for special needs students → See "Remediation Suggestions" section of Teacher Guide; provides multiple suggestions for students struggling with specific concepts. → ⊕**Analyzing Data/** ⊕**Phet Simulation/** ⊕**Explain Video/** ⊕**Math Tutorial/**⊕**Writing About Science** These OPTIONAL activities can be personalized and assigned to enhance instruction, as time allows. **Connection to Anchoring Phenomenon**	**ENGAGE** **Teachers' Guide:** **Everyday Phenomenon** → See Teacher Preparation for page number **NOTE:** Introduce students to this investigation with the Investigative Phenomenon video. Its purpose is to provide students with another opportunity to interact with an engaging event and gather knowledge necessary to make sense of the Anchoring Phenomenon. **EXPLORE** **Inquiry Lab:** → Pendulums and the Conservation of Energy ⊕ **Analyzing Data:** → Simple Harmonic Motion ⊕ **PhET Simulation:** → Conservation of Energy **EXPLAIN** **Student Handbook:** → pgs. 309—318 **Claim-Evidence-Reasoning:**	**Experience Assessment** **Student Handbook** → Revisit Investigative Phenomenon **Quiz** **Investigation Assessment** **Performance-Based Assessment** → Design, Build, and Refine a Wind-Turbine Rotor **Virtual Lab PBA** **Engineering Workbench** **Investigation Assessment** → Energy Conversion **NJSLA Released Item/Question(s) link:** → Which question, if answered, would best support an explanation of why the tire gets warmer as air is added?

	→ Students identify the types of energy transfers shown in the photo of the chain-reaction machine and use the concepts of closed systems and work to describe the machine. **Connection to Investigative Phenomenon** → Students make an energy-bar chart to show the relative amounts of gravitational potential energy, elastic potential energy in the bungee cord, and kinetic energy of the jumper.	→ Pendulum Decay ⊕ **Explain Video:** → Conservation of Energy ⊕ **Math Tutorial** **ELABORATE** **Discussion Rubric:** → Pendulum Decay ⊕ **Writing About Science:** → Skills in Conservation of Energy **EVALUATE** **Quiz:** → Conservation of Energy	

OPTIONAL Alternate Phenomena by Performance Expectation

HS-PS3-1, HS-PS3-2, HS-PS3-3

Note: Optional extension task(s) if time allows within the allotted 8.5-day window.

LESSON #2 PACING GUIDE WITH EMBEDDED ASSESSMENTS

Suggested Instructional Days: (13)

Investigation #8: Collisions

In this investigation, students apply Newton's laws of motion to the interactions between objects. Students use systems analysis to evaluate whether momentum is conserved during elastic and inelastic collisions. They also evaluate energy transformations during collisions and observe how some collisions cause permanent deformation,

NJSLS Specific to this Investigation/Lesson		
Performance Expectation	**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.	
Science & Engineering Practices	**Cross-Cutting Concepts**	**Disciplinary Core Ideas**
Using Mathematics and Computational Thinking	Systems and System Models	PS2.A: Forces and Motion
Performance Expectation	**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.	
Science & Engineering Practices	**Cross-Cutting Concepts**	**Disciplinary Core Ideas**
Constructing Explanations and Designing Solutions	Cause and Effect	PS2.A: Forces and Motion ETS1.A: Defining and Delimiting an Engineering Problem ETS1.C: Optimizing the Design Solution
Performance Expectation	**HS-ESS2-1** Develop a model to illustrate how Earth's internal and surface processes operate at different spatial and temporal scales to form continental and ocean-floor features.	
Science & Engineering Practices	**Cross-Cutting Concepts**	**Disciplinary Core Ideas**
Developing and Using Models	Stability and Change	ESS2.A: Earth Materials and Systems ESS2.B: Plate Tectonics and Large-Scale System Interactions

Anchoring Phenomenon

How does this machine transfer energy?	**Explaining Phenomena** To fully understand the phenomenon of energy conversions, students must be able to define a system and relate energy to work in a system. They calculate momentum and impulse for collisions they observe. **Anchoring Phenomenon video** → How does this machine transfer energy? **Student Handbook** → p. 278

Investigative Phenomenon

How does the collision affect the motion?	**Explaining Phenomena** To fully understand the phenomenon of collisions and motion, students must understand Newton's laws of motion and how they apply to the interactions of the hockey players and the objects around them. **Investigative Phenomenon video** → How does the collision affect the motion?

Learning Goal	Teacher Preparation	Instructional Sequence	Assessments
EXPERIENCE 1 (3 days) **Momentum and Impulse** Students define momentum and use vector addition	**Teacher's Guide** → p. 200 **Differentiation** → Review the versions of each lab; select the appropriate version(s) for each student/student group	**ENGAGE** **Teachers' Guide:** **Everyday Phenomenon** → See Teacher Preparation for page number **NOTE:** Introduce students to this investigation with the Investigative	**Experience Assessment** **Student Handbook** → Revisit Investigative Phenomenon **Quiz** **Investigation Assessment**

to find the net momentum of a system.	→ See "Address Misconceptions" section of Teacher Guide; provides ideas to address common student preconceptions with tips and explanations. → See "Differentiated Instruction" section of Teacher Guide for advice and tips for special needs students → See "Remediation Suggestions" section of Teacher Guide; provides multiple suggestions for students struggling with specific concepts. → ⊕**Analyzing Data/** ⊕**Phet Simulation/** ⊕**Explain Video/** ⊕**Math Tutorial/**⊕**Writing About Science** These OPTIONAL activities can be personalized and assigned to enhance instruction, as time allows. **Connection to Anchoring Phenomenon** → Students choose and analyze one collision in the chain-reaction machine. They also describe how processes involved in collisions in Earth's crust are like a chain-reaction machine. **Connection to Investigative Phenomenon** → Students think about the mass and velocity of the players and the forces they experience during the collision.	Phenomenon video. Its purpose is to provide students with another opportunity to interact with an engaging event and gather knowledge necessary to make sense of the Anchoring Phenomenon. **EXPLORE** **Inquiry Lab:** → Momentum and Impulse During Collisions ⊕ **PhET Simulation:** → Momentum and Impulse **EXPLAIN** **Student Handbook:** → pgs. 322—329 **Modeling:** → Momentum and Baseball ⊕ **Explain Video:** → Helmets and Impulse ⊕ **Math Tutorial Video** **ELABORATE** **Peer Review Rubric:** → Evaluate Momentum and Baseball ⊕ **Writing About Science:** → Skills in Momentum and Impulse **EVALUATE** **Quiz:** → Momentum and Impulse	**Performance-Based Assessment** → Design, Build, and Refine a Wind-Turbine Rotor **Virtual Lab PBA** **Engineering Workbench Investigation Assessment** → Build Your Own Egg-Transport Vehicle **NJSLA Released Item/Question(s) link:** → Using Newton's second law (F = ma), complete the table to describe the relationships between force, mass, and acceleration of airplanes. Type your answer in the box provided.
EXPERIENCE 2 (4 days) **Conservation of Momentum** Students investigate conservation of momentum and the impulse-momentum theorem.	**Teacher's Guide** → p. 206 **Differentiation** → Review the versions of each lab; select the appropriate version(s) for each student/student group → See "Address Misconceptions" section of Teacher Guide; provides ideas to address common student preconceptions with tips and explanations. → See "Differentiated Instruction" section of Teacher Guide for advice and tips for special needs students → See "Remediation Suggestions" section of Teacher Guide; provides multiple suggestions for students struggling with specific concepts. → ⊕**Analyzing Data/** ⊕**Phet Simulation/** ⊕**Explain Video/** ⊕**Math**	**ENGAGE** **Teachers' Guide:** **Everyday Phenomenon** → See Teacher Preparation for page number **NOTE:** Introduce students to this investigation with the Investigative Phenomenon video. Its purpose is to provide students with another opportunity to interact with an engaging event and gather knowledge necessary to make sense of the Anchoring Phenomenon. **EXPLORE** **Inquiry Lab:** → Elastic and Inelastic Collisions ⊕ **PhET Simulation:** → Conservation of Momentum	**Experience Assessment** **Student Handbook** → Revisit Investigative Phenomenon **Quiz** **Investigation Assessment** **Performance-Based Assessment** → Design, Build, and Refine a Wind-Turbine Rotor **Virtual Lab PBA** **Engineering Workbench Investigation Assessment**

	Tutorial/⊕Writing About Science These OPTIONAL activities can be personalized and assigned to enhance instruction, as time allows. **Connection to Anchoring Phenomenon** → Students choose and analyze one collision in the chain-reaction machine. They also describe how processes involved in collisions in Earth's crust are like a chain-reaction machine. **Connection to Investigative Phenomenon** → Students must think about how kinetic energy is transformed during the collision, which will drive them to ask if momentum is conserved.	**EXPLAIN** **Student Handbook:** → pgs. 330—347 **Claim-Evidence-Reasoning:** → Kinetic Energy and Collisions ⊕ **Explain Video:** → Elastic and Inelastic Collisions ⊕ **Math Tutorial** **ELABORATE** **Discussion Rubric/Peer Review Rubric:** → Kinetic Energy and Collisions ⊕ **Writing About Science:** → Skills in Conservation of Momentum **EVALUATE** **Quiz:** → Conservation of Momentum	→ Build Your Own Egg-Transport Vehicle **NJSLA Released Item/Question(s) link:** → Which question is best addressed by analyzing the data?
EXPERIENCE 3 (4 days) **Collisions in Earth's Crust** Students explore how the movements and collisions of lithospheric plates are responsible for many of Earth's surface features.	**Teacher's Guide** → p. 212 **Differentiation** → Review the versions of each lab; select the appropriate version(s) for each student/student group → See "Address Misconceptions" section of Teacher Guide; provides ideas to address common student preconceptions with tips and explanations. → See "Differentiated Instruction" section of Teacher Guide for advice and tips for special needs students → See "Remediation Suggestions" section of Teacher Guide; provides multiple suggestions for students struggling with specific concepts. → ⊕**Analyzing Data/** ⊕**Phet Simulation/** ⊕**Explain Video/** ⊕**Math Tutorial/**⊕**Writing About Science** These OPTIONAL activities can be personalized and assigned to enhance instruction, as time allows. **Connection to Anchoring Phenomenon** → Students choose and analyze one collision in the chain-reaction machine. They also describe how processes involved in collisions in	**ENGAGE** **Teachers' Guide:** **Everyday Phenomenon** → See Teacher Preparation for page number **NOTE:** Introduce students to this investigation with the Investigative Phenomenon video. Its purpose is to provide students with another opportunity to interact with an engaging event and gather knowledge necessary to make sense of the Anchoring Phenomenon. **EXPLORE** **Inquiry Lab:** → Collisions at a Fault Line ⊕ **Analyzing Data:** → Magnitude and Intensity of Earthquakes ⊕ **PhET Simulation:** → Earth's Tectonic Collisions **EXPLAIN** **Student Handbook:** → pgs. 348—362 **Modeling:** → Plate Boundaries ⊕ **Explain Video:** → Earthquakes ⊕ **Math Tutorial Video**	**Experience Assessment** **Student Handbook** → Revisit Investigative Phenomenon **Quiz** **Investigation Assessment** **Performance-Based Assessment** → Design, Build, and Refine a Wind-Turbine Rotor **Virtual Lab PBA** **Engineering Workbench** **Investigation Assessment** → Build Your Own Egg-Transport Vehicle **NJSLA Released Item/Question(s) link:** → Describe the formation of seamounts. Complete the sentence by choosing the correct answers from the drop-down menus.

	Earth's crust are like a chain-reaction machine. **<u>Connection to Investigative Phenomenon</u>** → Students explain that the velocities of a group of skaters pushing off each other is similar to the no-net-rotation reference frame of tectonic plate velocities.	**<u>ELABORATE</u>** **Discussion Rubric/Peer Review Rubric:** → Evaluate Plate Boundaries ⊕ **Writing About Science:** → Skills in Collisions in Earth's Crust **<u>EVALUATE</u>** **Quiz:** → Collisions in Earth's Crust	
OPTIONAL Alternate Phenomena by Performance Expectation			
HS-PS2-2, **HS-PS2-3**, **HS-ESS2-1** Note: Optional extension task(s) if time allows within the allotted 13-day window.			

LESSON #3 PACING GUIDE WITH EMBEDDED ASSESSMENTS

Suggested Instructional Days: (11)

Investigation #9: Thermal Energy

In this investigation, students focus on the movement of thermal energy and the laws of thermodynamics. Students have an opportunity to connect what they learn about thermal energy to designed systems, such as heat engines and heat pumps, and to how these systems might be optimized to conserve energy.

NJSLS Specific to this Investigation/Lesson		
Performance Expectation	**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).	
Science & Engineering Practices	**Cross-Cutting Concepts**	**Disciplinary Core Ideas**
Developing and Using Models	Energy and Matter	PS3.A: Definitions of Energy
Performance Expectation	**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).	
Science & Engineering Practices	**Cross-Cutting Concepts**	**Disciplinary Core Ideas**
Planning and Carrying Out Investigations	Systems and System Models	PS3.B: Conservation of Energy and Energy Transfer PS3.D: Energy in Chemical Processes
Performance Expectation	**HS-ESS2-3** Develop a model based on evidence of Earth's interior to describe the cycling of matter by thermal convection.	
Science & Engineering Practices	**Cross-Cutting Concepts**	**Disciplinary Core Ideas**
Developing and Using Models	Energy and Matter	ESS2.A: Earth Materials and Systems ESS2.B: Plate Tectonics and Large-Scale System Interactions PS4.A: Wave Properties

Anchoring Phenomenon

How does this machine transfer energy?	**Explaining Phenomena** To fully understand the phenomenon of energy conversions, students must be able to define a system and relate energy to work in a system. They calculate momentum and impulse for collisions they observe. **Anchoring Phenomenon video** → How does this machine transfer energy? **Student Handbook** → p. 278

Investigative Phenomenon

Why does sand warm faster than water on a sunny day?	**Explaining Phenomena** To fully understand the phenomenon of the uneven heating of sand and water, students must understand the relationship between thermal energy and temperature, and how heat transfers between materials. **Investigative Phenomenon video** → Why does sand warm faster than water on a sunny day?

Learning Goal	Teacher Preparation	Instructional Sequence	Assessments
EXPERIENCE 1 (3 days) **Temperature** Students explore the effect of heat on the temperature, pressure, and volume of ideal gases.	**Teacher's Guide** → p. 224 **Differentiation** → Review the versions of each lab; select the appropriate version(s) for each student/student group	**ENGAGE** **Teachers' Guide:** **Everyday Phenomenon** → See Teacher Preparation for page number **NOTE:** Introduce students to this investigation with the Investigative	**Experience Assessment** **Student Handbook** → Revisit Investigative Phenomenon **Quiz** **Investigation Assessment**

	→ See "Address Misconceptions" section of Teacher Guide; provides ideas to address common student preconceptions with tips and explanations. → See "Differentiated Instruction" section of Teacher Guide for advice and tips for special needs students → See "Remediation Suggestions" section of Teacher Guide; provides multiple suggestions for students struggling with specific concepts. → ⊕**Analyzing Data/** ⊕**Phet Simulation/** ⊕**Explain Video/** ⊕**Math Tutorial/**⊕**Writing About Science** These OPTIONAL activities can be personalized and assigned to enhance instruction, as time allows. **Connection to Anchoring Phenomenon** → Students describe each step in a chain-reaction machine that relies on thermal energy transfers. The conservation of energy and the change in the system's entropy are considered. **Connection to Investigative Phenomenon** → Students learn that water requires approximately five times the amount of energy that sand needs to increase its temperature the same amount.	Phenomenon video. Its purpose is to provide students with another opportunity to interact with an engaging event and gather knowledge necessary to make sense of the Anchoring Phenomenon. **EXPLORE** **Inquiry Lab:** → Kinetic Energy ⊕ **PhET Simulation:** → Temperature **EXPLAIN** **Student Handbook:** → pgs. 366—380 **Modeling:** → Gasoline Expansion ⊕ **Explain Video:** → Celsius Didn't Invent Celsius ⊕ **Math Tutorial Video** **ELABORATE** **Discussion Rubric/Peer Review Rubric:** → Evaluate Gasoline Expansion ⊕ **Writing About Science:** → Skills in Temperature **EVALUATE** **Quiz:** → Temperature	**Performance-Based Assessment** → Design, Build, and Refine a Wind-Turbine Rotor **Virtual Lab PBA** **Engineering Workbench** **Investigation Assessment** → Heating Curve of Water **NJSLA Released Item/Question(s) link:** → Which question, if answered, would best support an explanation of why the tire gets warmer as air is added?
EXPERIENCE 2 (3 days) **Thermal Equilibrium and Heat Flow** Students observe that systems will reach thermodynamic equilibrium spontaneously over time.	**Teacher's Guide** → p. 230 **Differentiation** → Review the versions of each lab; select the appropriate version(s) for each student/student group → See "Address Misconceptions" section of Teacher Guide; provides ideas to address common student preconceptions with tips and explanations. → See "Differentiated Instruction" section of Teacher Guide for advice and tips for special needs students → See "Remediation Suggestions" section of Teacher Guide; provides multiple suggestions for students struggling with specific concepts.	**ENGAGE** **Teachers' Guide:** **Everyday Phenomenon** → See Teacher Preparation for page number **NOTE:** Introduce students to this investigation with the Investigative Phenomenon video. Its purpose is to provide students with another opportunity to interact with an engaging event and gather knowledge necessary to make sense of the Anchoring Phenomenon. **EXPLORE** **Inquiry Lab:** → Heat Transfer ⊕ **PhET Simulation:**	**Experience Assessment** **Student Handbook** → Revisit Investigative Phenomenon **Quiz** **Investigation Assessment** **Performance-Based Assessment** → Design, Build, and Refine a Wind-Turbine Rotor **Virtual Lab PBA** **Engineering Workbench** **Investigation Assessment**

	→ ⊕**Analyzing Data/** ⊕**Phet Simulation/** ⊕**Explain Video/** ⊕**Math Tutorial/**⊕**Writing About Science** These OPTIONAL activities can be personalized and assigned to enhance instruction, as time allows. **Connection to Anchoring Phenomenon** → Students describe each step in a chain-reaction machine that relies on thermal energy transfers. The conservation of energy and the change in the system's entropy are considered. **Connection to Investigative Phenomenon** → Students explore how thermal energy is transferred between materials according to the second law of thermodynamics.	→ Thermal Equilibrium and Heat Flow **EXPLAIN** **Student Handbook:** → pgs. 381-393 **Claim-Evidence-Reasoning:** → Why Metals Feel Cool ⊕ **Explain Video:** → Misconceptions About Heat ⊕ **Math Tutorial Video** **ELABORATE** **Discussion Rubric:** → Why Metals Feel Cool ⊕ **Writing About Science:** → Skills in Thermal Equilibrium and Heat Flow **EVALUATE** **Quiz:** → Thermal Equilibrium and Heat Flow	→ Heating Curve of Water **NJSLA Released Item/Question(s) link:** → Based on Figure 1, which statement best summarizes the pattern of sunspot activity over the past 2,000 years?
EXPERIENCE 3 (3 days) **Heat Flow Within Earth** Students explore how the movement of thermal energy from Earth's core to its surface drives geologic processes.	**Teacher's Guide** → p. 236 **Differentiation** → Review the versions of each lab; select the appropriate version(s) for each student/student group → See "Address Misconceptions" section of Teacher Guide; provides ideas to address common student preconceptions with tips and explanations. → See "Differentiated Instruction" section of Teacher Guide for advice and tips for special needs students → See "Remediation Suggestions" section of Teacher Guide; provides multiple suggestions for students struggling with specific concepts. → ⊕**Analyzing Data/** ⊕**Phet Simulation/** ⊕**Explain Video/** ⊕**Math Tutorial/**⊕**Writing About Science** These OPTIONAL activities can be personalized and assigned to enhance instruction, as time allows. **Connection to Anchoring Phenomenon** → Students describe each step in a chain-reaction machine that relies on thermal energy transfers.	**ENGAGE** **Teachers' Guide:** **Everyday Phenomenon** → See Teacher Preparation for page number **NOTE:** Introduce students to this investigation with the Investigative Phenomenon video. Its purpose is to provide students with another opportunity to interact with an engaging event and gather knowledge necessary to make sense of the Anchoring Phenomenon. **EXPLORE** **Inquiry Lab:** → Convection, Conduction, and Radiation ⊕ **Analyzing Data:** → Heat Flow on Earth's Surface ⊕ **PhET Simulation:** → Heat Flow Within Earth **EXPLAIN** **Student Handbook:** → pgs. 394—406 **Modeling:** → Convection Currents ⊕ **Explain Video:**	**Experience Assessment** **Student Handbook** → Revisit Investigative Phenomenon **Quiz** **Investigation Assessment** **Performance-Based Assessment** → Design, Build, and Refine a Wind-Turbine Rotor **Virtual Lab PBA** **Engineering Workbench Investigation Assessment** → Heating Curve of Water **NJSLA Released Item/Question(s) link:** → Figure 2 shows tectonic plate boundaries on Earth, with areas labeled W, X, Y, and Z.

	The conservation of energy and the change in the system's entropy are considered. **<u>Connection to Investigative Phenomenon</u>** → Students explore convection, conduction, and radiation.	→ Why Is It Hot Underground? ⊕ **Math Tutorial** **<u>ELABORATE</u>** **Discussion Rubric/Peer Review Rubric:** → Evaluate Convection Currents ⊕ **Writing About Science:** → Skills in Heat Flow Within Earth **<u>EVALUATE</u>** **Quiz:** → Heat Flow Within Earth	<u>Identify the location in Figure 2 that best represents the boundary between plates C and D in Figure 1.</u>

OPTIONAL Alternate Phenomena by Performance Expectation

<u>HS-PS3-2</u>, **<u>HS-PS3-4</u>**, **<u>HS-ESS2-3</u>**

Note: Optional extension task(s) if time allows within the allotted 11-day window.

LESSON #4 PACING GUIDE WITH EMBEDDED ASSESSMENTS

Suggested Instructional Days: (15)

Investigation 10: Electromagnetic Energy

In this investigation, students explore electricity at multiple levels, from the energy stored in the electric field around a point charge to the large-scale production of electrical energy at power plants around the world.

NJSLS Specific to this Investigation/Lesson		
Performance Expectation	**HS-PS2-5** Plan and conduct an investigation to provide evidence that an electric current can produce a magnetic field and that a changing magnetic field can produce an electric current.	
Science & Engineering Practices	**Cross-Cutting Concepts**	**Disciplinary Core Ideas**
Planning and Carrying Out Investigations	Cause and Effect	PS2.B: Types of Interactions PS3.A: Definitions of Energy
Performance Expectation	**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.	
Science & Engineering Practices	**Cross-Cutting Concepts**	**Disciplinary Core Ideas**
Constructing Explanations and Designing Solutions	Energy and Matter	PS3.A: Definitions of Energy PS3.D: Energy in Chemical Processes ETS1.A: Defining and Delimiting an Engineering Problem
Performance Expectation	**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.	
Science & Engineering Practices	**Cross-Cutting Concepts**	**Disciplinary Core Ideas**
Developing and Using Models	Cause and Effect	PS3.C: Relationship Between Energy and Forces
Performance Expectation	**HS-ESS3-2** Evaluate competing design solutions for developing, managing, and utilizing energy and mineral resources based on cost-benefit ratios.	
Science & Engineering Practices	**Cross-Cutting Concepts**	**Disciplinary Core Ideas**
Engaging in Argument from Evidence	NA	ESS3.A: Natural Resources ETS1.B: Developing Possible Solutions
Performance Expectation	**HS-ESS3-3** Create a computational simulation to illustrate the relationships among management of natural resources, the sustainability of human populations, and biodiversity.	
Science & Engineering Practices	**Cross-Cutting Concepts**	**Disciplinary Core Ideas**
Using Mathematics and Computational Thinking	Stability and Change	ESS3.C: Human Impacts on Earth Systems

Anchoring Phenomenon

How does this machine transfer energy?	**Explaining Phenomena** To fully understand the phenomenon of energy conversions, students must be able to define a system and relate energy to work in a system. They calculate momentum and impulse for collisions they observe. **Anchoring Phenomenon video** → How does this machine transfer energy? **Student Handbook** → p. 278

Investigative Phenomenon

How can we sustainably generate electrical energy?	**Explaining Phenomena** To fully understand how to sustainably generate electrical energy, students must understand how energy production, storage, and use impact the biosphere, and the role of engineering in sustainable energy production. **Investigative Phenomenon video** → How can we sustainably generate electrical energy?

Learning Goal	Teacher Preparation	Instructional Sequence	Assessments
EXPERIENCE 1 (3 days) **Electric Potential** Students explore how to analyze the potential energy stored in electric fields.	**Teacher's Guide** → p. 248 **Differentiation** → Review the versions of each lab; select the appropriate version(s) for each student/student group → See "Address Misconceptions" section of Teacher Guide; provides ideas to address common student preconceptions with tips and explanations. → See "Differentiated Instruction" section of Teacher Guide for advice and tips for special needs students → See "Remediation Suggestions" section of Teacher Guide; provides multiple suggestions for students struggling with specific concepts. → ⊕**Analyzing Data/** ⊕**Phet Simulation/** ⊕**Explain Video/** ⊕**Math Tutorial/**⊕**Writing About Science** These OPTIONAL activities can be personalized and assigned to enhance instruction, as time allows. **Connection to Anchoring Phenomenon** → Students describe the energy transformations that occur to bring electricity to an outlet in a home when the electricity is produced by a coal-powered plant. **Connection to Investigative Phenomenon** → Students learn that technologies used to generate electric power involve electric potential and electric fields.	**ENGAGE** **Teachers' Guide:** **Everyday Phenomenon** → See Teacher Preparation for page number **NOTE:** Introduce students to this investigation with the Investigative Phenomenon video. Its purpose is to provide students with another opportunity to interact with an engaging event and gather knowledge necessary to make sense of the Anchoring Phenomenon. **EXPLORE** **Inquiry Lab:** → Build a Battery ⊕ **PhET Simulation:** → Electric Potential **EXPLAIN** **Student Handbook:** → pgs. 410-420 **Claim-Evidence-Reasoning/Modeling:** → Potential Difference in a Battery ⊕ **Explain Video:** → How Batteries Work ⊕ **Math Tutorial Video** **ELABORATE** **Discussion Rubric/Peer Review Rubric:** → Evaluate Potential Difference in a Battery ⊕ **Writing About Science:** → Skills in Electric Potential **EVALUATE** **Quiz:** → Electric Potential	**Experience Assessment** **Student Handbook** → Revisit Investigative Phenomenon **Quiz** **Investigation Assessment** **Performance-Based Assessment** → Design, Build, and Refine a Wind-Turbine Rotor **Virtual Lab PBA** **Engineering Workbench** **Investigation Assessment** → Design, Build, and Refine a Wind-Turbine Rotor **NJSLA Released Item/Question(s) link:** → Along with using new technology to extract copper, conserving copper through recycling also has long-lasting benefits. Indicate which claims about the potential benefits of recycling copper are supported by Table 2 and which are not supported by Table 2. Select all of the correct answers.
EXPERIENCE 2 (3 days) **Energy in Electric Circuits** Students investigate the relationships between voltage, current, resistance, and electric power.	**Teacher's Guide** → p. 254 **Differentiation** → Review the versions of each lab; select the appropriate version(s) for each student/student group → See "Address Misconceptions" section of Teacher Guide; provides ideas to address common student	**ENGAGE** **Teachers' Guide:** **Everyday Phenomenon** → See Teacher Preparation for page number **NOTE:** Introduce students to this investigation with the Investigative Phenomenon video. Its purpose is to provide students with another opportunity to interact with an engaging event and gather knowledge	**Experience Assessment** **Student Handbook** → Revisit Investigative Phenomenon **Quiz** **Investigation Assessment** **Performance-Based Assessment**

	preconceptions with tips and explanations. → See "Differentiated Instruction" section of Teacher Guide for advice and tips for special needs students → See "Remediation Suggestions" section of Teacher Guide; provides multiple suggestions for students struggling with specific concepts. → ⊕**Analyzing Data/** ⊕**Phet Simulation/** ⊕**Explain Video/** ⊕**Math Tutorial/**⊕**Writing About Science** These OPTIONAL activities can be personalized and assigned to enhance instruction, as time allows. **Connection to Anchoring Phenomenon** → Students describe the energy transformations that occur to bring electricity to an outlet in a home when the electricity is produced by a coal-powered plant. **Connection to Investigative Phenomenon** → description	necessary to make sense of the Anchoring Phenomenon. **EXPLORE** **Inquiry Lab:** → Energy Transmission in Circuits ⊕ **Analyzing Data:** → Electric Circuits ⊕ **PhET Simulation:** → Energy in Electric Circuits **EXPLAIN** **Student Handbook:** → pgs. 421—434 **Modeling:** → Senes and Parallel Circuits ⊕ **Explain Video:** → Electric Power, Current, and Resistance ⊕ **Math Tutorial Video** **ELABORATE** **Peer Review Rubric:** → Evaluate Series and Parallel Circuits ⊕ **Writing About Science:** → Skills in Energy in Electric Circuits **EVALUATE** **Quiz:** → Energy in Electric Circuits	→ Design, Build, and Refine a Wind-Turbine Rotor **Virtual Lab PBA** **Engineering Workbench** **Investigation Assessment** → Design, Build, and Refine a Wind-Turbine Rotor **NJSLA Released Item/Question(s) link:** → Which statement correctly answers the question of whether electrical plants that use wind power instead of fossil fuels would maximize power production and minimize GHG emissions?
EXPERIENCE 3 (3 days) **Power Generation** Students construct explanations about the role of electromagnetic induction in other designed devices.	**Teacher's Guide** → p. 260 **Differentiation** → Review the versions of each lab; select the appropriate version(s) for each student/student group → See "Address Misconceptions" section of Teacher Guide; provides ideas to address common student preconceptions with tips and explanations. → See "Differentiated Instruction" section of Teacher Guide for advice and tips for special needs students → See "Remediation Suggestions" section of Teacher Guide; provides multiple suggestions for students struggling with specific concepts. → ⊕**Analyzing Data/** ⊕**Phet Simulation/** ⊕**Explain Video/** ⊕**Math Tutorial/**⊕**Writing About Science** These OPTIONAL activities	**ENGAGE** **Teachers' Guide:** **Everyday Phenomenon** → See Teacher Preparation for page number **NOTE:** Introduce students to this investigation with the Investigative Phenomenon video. Its purpose is to provide students with another opportunity to interact with an engaging event and gather knowledge necessary to make sense of the Anchoring Phenomenon. **EXPLORE** **Inquiry Lab:** → Electric Motors and Generators ⊕ **PhET Simulation:** → Power Generation **EXPLAIN** **Student Handbook:**	**Experience Assessment** **Student Handbook** → Revisit Investigative Phenomenon **Quiz** **Investigation Assessment** **Performance-Based Assessment** → Design, Build, and Refine a Wind-Turbine Rotor **Virtual Lab PBA** **Engineering Workbench** **Investigation Assessment** → Design, Build, and Refine a Wind-Turbine Rotor

	can be personalized and assigned to enhance instruction, as time allows. **Connection to Anchoring Phenomenon** → Students describe the energy transformations that occur to bring electricity to an outlet in a home when the electricity is produced by a coal-powered plant. **Connection to Investigative Phenomenon** → Students conduct an investigation that leads them to the conclusion that mechanical energy can be transformed into electrical energy.	→ pgs. 435-444 **Claim-Evidence-Reasoning/Modeling:** → Properties of Electric Motors ⊕ **Explain Video:** → How Power Gets to Your House ⊕ **Math Tutorial Video** **ELABORATE** **Discussion Rubric/Peer Review Rubric:** → Properties of Electric Motors ⊕ **Writing About Science:** → Skills in Power Generation **EVALUATE** **Quiz:** → Power Generation	**NJSLA Released Item/Question(s) link:** → Choose the option that shows the energy sources that have been arranged from the greatest (top) to the least (bottom) amount of electricity produced per facility.
EXPERIENCE 4 (4 days) **Energy Resources and Conservation** Students explore how humans use energy and how energy production, storage, and use impact the biosphere.	**Teacher's Guide** → p. 266 **Differentiation** → Review the versions of each lab; select the appropriate version(s) for each student/student group → See "Address Misconceptions" section of Teacher Guide; provides ideas to address common student preconceptions with tips and explanations. → See "Differentiated Instruction" section of Teacher Guide for advice and tips for special needs students → See "Remediation Suggestions" section of Teacher Guide; provides multiple suggestions for students struggling with specific concepts. → ⊕**Analyzing Data/** ⊕**Phet Simulation/** ⊕**Explain Video/** ⊕**Math Tutorial/**⊕**Writing About Science** These OPTIONAL activities can be personalized and assigned to enhance instruction, as time allows. **Connection to Anchoring Phenomenon** → Students describe the energy transformations that occur to bring electricity to an outlet in a home when the electricity is produced by a coal-powered plant.	**ENGAGE** **Teachers' Guide:** **Everyday Phenomenon** → See Teacher Preparation for page number **NOTE:** Introduce students to this investigation with the Investigative Phenomenon video. Its purpose is to provide students with another opportunity to interact with an engaging event and gather knowledge necessary to make sense of the Anchoring Phenomenon. **EXPLORE** **Inquiry Lab:** → Natural Resource Management ⊕ **Analyzing Data:** → Resource Use and Biodiversity Trade-Offs ⊕ **PhET Simulation:** → Energy Resources and Conservation **EXPLAIN** **Student Handbook:** → pgs. 445-460 **Claim-Evidence-Reasoning/Modeling:** → Energy Choices ⊕ **Explain Video:** → A Guide to the Energy of Earth ⊕ **Math Tutorial Video**	**Experience Assessment** **Student Handbook** → Revisit Investigative Phenomenon **Quiz** **Investigation Assessment** **Performance-Based Assessment** → Design, Build, and Refine a Wind-Turbine Rotor **Virtual Lab PBA** **Engineering Workbench** **Investigation Assessment** → Design, Build, and Refine a Wind-Turbine Rotor **NJSLA Released Item/Question(s) link:** → Based on Figure 1, which questions, if answered, would best help scientists determine the long-term economic and environmental impacts of using this

	Connection to Investigative Phenomenon → Students focus on the importance of developing solutions for a sustainable energy future.	**ELABORATE** **Peer Review Rubric:** → Energy Choices ⊕ **Writing About Science:** → Skills in Energy Resources and Conservation **EVALUATE** **Quiz:** → Energy Resources and Conservation	process for extracting copper? Select two of the six questions.

OPTIONAL Alternate Phenomena by Performance Expectation
HS-PS2-5, **HS-PS3-3**, **HS-PS3-5**, **HS-ESS3-2**, **HS-ESS3-3** Note: Optional extension task(s) if time allows within the allotted 15-day window.