Orange Public Schools

Office of STEM-Focused Learning & Gifted Education
Science Curriculum Guide

Physics Honors

Unit 2: Forces at a Distance

45 Instructional Days

Board Approved: 9/13/23

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Table of Contents

YEARLONG SCOPE AND SEQUENCE

UNIT 1	UNIT 2	UNIT 3	UNIT 4	UNIT 5
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 2: Motion	**Duration**	45 days

UNIT OVERVIEW

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.

CONCEPTUAL FLOW

Anchoring Phenomenon	How does the moon shape our coastline?
Investigations	**Investigation #3:** Gravitational Forces • **Experience 1** - Universal Gravitation • **Experience 2** - Orbital Motion • **Experience 3** - Kepler's Laws **Investigation #4:** Electric Forces • **Experience 1** - Coulomb's Law • **Experience 2** - Electric Fields • **Experience 3** - Electric Current **Investigation #5:** Magnetic Forces • **Experience 1** - Magnetic Forces and Fields • **Experience 2** - Inducing Magnetism • **Experience 3** - Inducing Current **Investigation #6:** Forces in Materials • **Experience 1** - Atoms and Atomic Structure • **Experience 2** - Attractive and Repulsive Forces • **Experience 3** - Material Properties • **Experience 4** - Structure and Function

ESSENTIAL QUESTION(S) AND ENDURING UNDERSTANDINGS

Essential Questions /Focus Questions	Enduring Understandings
• How can one explain and predict interactions between objects and within systems of objects? • How can one predict an object's continued motion, changes in motion, or stability? • What underlying forces explain the variety of interactions observed? • What are the differences between vector and scalar quantities? • How many problems involving two-dimensional vectors and their components be solved? • When a force is applied to an object in a direction perpendicular to its motion, what are the effects on its speed and direction? • What are frames of reference and how do they relate to motion? • How can physicists use Newton's Laws of Motion and Universal Gravitation to predict objects' motions? • How do forces affect the motion of objects? • Why are some physical systems more stable than others? • In which situations are Newton's laws of motion not applicable? • How can Newton's laws of motion be applied to practical problems involving forces and motion? • How do physicists diagram the forces that affect the motion of an object? • What does it mean for an object to be in equilibrium? • How do physicists show the forces on two or more interacting objects? • How does an object's speed affect the distance it travels in time? • How can position, velocity, and acceleration be used to describe the motion of an object? • How can motion be represented graphically? • How do objects, such as a basketball, move in the air? • How can motion sensors be used to record and describe the motion of an object? • How does friction affect the motion of an object?	• Theories and laws provide explanations in science. • Laws are statements or descriptions of the relationships among observable phenomena. • Empirical evidence is required to differentiate between cause and correlation and to make claims about specific causes and effects. • Newton's second law accurately predicts changes in the motion of macroscopic objects. • 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. • When investigating or describing a system, the boundaries and initial conditions of the system need to be defined. • 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. • Criteria and constraints also include satisfying any requirements set by society, such as taking issues of risk mitigation into account, and the criteria and constraints should be quantified to the extent possible and stated in such a way that one can determine whether a given design meets them. • 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 (trade-offs) may be needed. • 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. • New technologies can have deep impacts on society and the environment, including some that were not anticipated. Analysis of costs and benefits is a critical aspect of decisions about technology. • Systems can be designed to cause a desired effect.

NGSS PERFORMANCE EXPECTATION(S)

Students who demonstrate understanding can:

HS-ESS1-4 Use mathematical or computational representations to predict the motion of orbiting objects in the solar system.

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.

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.

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-PS2-6 Communicate scientific and technical information about why the molecular-level structure is important in the functioning of designed materials.

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.

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**	**ESS1.B: Earth and the Solar System** Kepler's laws describe common features of the motions of orbiting objects, including their elliptical paths around the sun. Orbits may change due to the gravitational effects from, or collisions with, other objects in the solar system. **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. **PS2.B: Types of Interactions** Attraction and repulsion between electric charges at the atomic scale explain the structure, properties, and transformations of matter, as well as the contact forces between material objects. (secondary) 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)	☒ **Patterns** ☒ **Cause and Effect** ☒ **Scale, Proportion, and Quantity** ☐ **Systems and System Models** ☐ **Energy and Matter** ☒ **Structure and function.** ☐ **Stability and change**.

	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.	

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-PS1-3) (HS-PS2-6)*
SL.11-12.5: Make strategic use of digital media (e.g., textual, graphical, audio, visual, and interactive elements) in presentations to enhance understanding of findings, reasoning, and evidence and to add interest. *(HS-PS3-5)*
WHST.11-12.2: Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes. *(HS-PS2-6)*
WHST.9-12.7: Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation. *(HS-PS1-3) (HS-PS2-4) (HS-PS3-5)*
WHST.11-12.8: Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the strengths and limitations of each source in terms of the specific task, purpose, and audience; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and overreliance on any one source and following a standard format for citation. *(HS-PS1-3) (HS-PS2-4) (HS-PS3-5)*
WHST.9-12.9: Draw evidence from informational texts to support analysis, reflection, and research. *(HS-PS1-3) (HS-PS2-4) (HS-PS3-5)*

Mathematics

MP.2: Reason abstractly and quantitatively. *(HS-ESS1-4) (HS-PS2-4) (HS-PS3-5) (HS-ESS1-4)*
MP.4: Model with mathematics. *(HS-ESS1-4) (HS-PS2-4) (HS-PS3-5) (HS-ESS1-4)*
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-ESS1-4) (HS-PS1-3) (HS-PS2-4) (HS-PS2-5) (HS-PS2-6) (HS-ESS1-4)*
HSN-Q.A.2: Define appropriate quantities for the purpose of descriptive modeling. *(HS-ESS1-4) (HS-PS2-4) (HS-PS2-5) (HS-PS2-6) (HS-ESS1-4)*
HSN-Q.A.3: Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. *(HS-ESS1-4) (HS-PS1-3) (HS-PS2-4) (HS-PS2-5) (HS-PS2-6) (HS-ESS1-4)*
HSA-SSE.A.1: Interpret expressions that represent a quantity in terms of its context. *(HS-ESS1-4) (HS-PS2-4) (HS-ESS1-4)*
HSA.SSE.B.1: Choose and produce an equivalent form of an expression to reveal and explain properties of the quantity represented by the expression. *(HS-PS2-4)*
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. *(HS-PS2-4)*
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-ESS1-4) (HS-ESS1-4)*
HSA-CED.A.4: Rearrange formulas to highlight a quantity of interest, using the same reasoning as in solving equations. *(HS-ESS1-4) (HS-ESS1-4)*

INTEGRATED ACCOMMODATIONS & MODIFICATIONS

Special Education / 504

- 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

English Language Learners

- 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

Gifted and Talented

- 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.

Students at Risk for Failure

- 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

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 #3: Gravitational Forces	Students are introduced to Newton's laws of motion and the concepts of inertia and momentum.	**HS-PS2-4, HS-ESS1-4**	**10 days** (Plus, optional extension task(s) if time allows within the allotted 10-day window.)
Investigation #4: Electric Forces	Students use mathematical relationships, including Coulomb's law and the equations for series and parallel resistance, to describe and calculate electric forces and related phenomena.	**HS-PS1-3, HS-PS2-4, HS-PS2-6, HS-PS3-5**	**9.5 days** (Plus, optional extension task(s) if time allows within the allotted 9.5-day window.)
Investigation #5: Magnetic Forces	Students investigate the properties of the magnetic forces and how magnetic fields can induce a current.	**HS-PS2-4, HS-PS2-4, HS-PS3-5**	**11 days** (Plus, optional extension task(s) if time allows within the allotted 11-day window.)
Investigation #6: Forces in Materials	Students communicate explanations on the structure of atoms and describe the concept of electric forces in atoms.	**HS-PS1-3, HS-PS2-4, HS-PS2-6**	**14 days** (Plus, optional extension task(s) if time allows within the allotted 14-day window.)

LESSON #1 PACING GUIDE WITH EMBEDDED ASSESSMENTS

Suggested Instructional Days: (10)

Investigation #3: Gravitational Forces

Students explore the relationship between gravitational forces, orbits, and Kepler's Laws. Investigation 3 focuses on the use of mathematics to extend students' understanding of gravity and planetary motion. They explore how gravity is responsible for the motions of Earth, the moon, the planets, and other space objects.

NJSLS Specific to this Investigation/Lesson		
Performance Expectation	**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.	
Science & Engineering Practices	**Cross-Cutting Concepts**	**Disciplinary Core Ideas**
Using Mathematics and Computational Thinking	Patterns	**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. 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.
Performance Expectation	**HS-ESS1-4:** Use mathematical or computational representations to predict the motion of orbiting objects in the solar system.	
Science & Engineering Practices	**Cross-Cutting Concepts**	**Disciplinary Core Ideas**
Using Mathematical and Computational Thinking	Scale, Proportion, and Quantity	**ESS1.B: Earth and the Solar System** Kepler's laws describe common features of the motions of orbiting objects, including their elliptical paths around the sun. Orbits may change due to the gravitational effects from, or collisions with, other objects in the solar system.

Anchoring Phenomenon

How does the moon shape our coastline?	**Explaining Phenomena** To fully understand the phenomenon of how the moon shapes the coastline, students must understand gravitational acceleration and force in relation to Earth and the moon. Here, students explore how the gravitational force that the moon exerts on Earth affects ocean tide levels. As students further explore the forces between water and rock, they can construct an explanation for how the moon shapes the coastline. **Anchoring Phenomenon video** → How does the moon shape our coastline? **Student Handbook** → p. 112

Investigative Phenomenon

What causes the seasons?	**Explaining Phenomena** To fully understand the phenomenon of Earth's seasons, students must understand the role of gravitational force in determining Earth's orbital motion. Observing that Earth and the other planets have elliptical orbits will prompt students to seek patterns in planetary motion, which they then can relate to the cause of Earth's seasons. **Investigative Phenomenon video** → What causes the seasons?

Learning Goal	Teacher Preparation	Instructional Sequence	Assessments
	Teacher's Guide	**ENGAGE**	**Experience Assessment**

EXPERIENCE 1 (2.5 days) **Universal Gravitation** Students model gravitational forces using vector arrows and gravitational fields.	→ p. 70 **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** → Tidal stretching of Earth is due to differences in the strength of the moon's and sun's gravity on the near and far sides of Earth. **Connection to Investigative Phenomenon** → Students make a claim and argue from evidence about whether the difference in the energy input at aphelion compared to the intensity at perihelion affects the surface temperature from winter to summer.	**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:** → Investigate Gravity Using Pendulums ⊕ **PhET Simulation:** → Universal Gravitation **EXPLAIN** **Student Handbook:** → pgs. 116—128 **Claim-Evidence-Reasoning:** → Forces and Movement ⊕ **Explain Video:** → Newton's Law of Universal Gravitation ⊕ **Math Tutorial** **ELABORATE** **Discussion Rubric:** → Forces and Movement ⊕ **Writing About Science:** → Skills in Universal Gravitation **EVALUATE** **Quiz:** → Universal Gravitation	**Student Handbook** → Revisit Investigative Phenomenon **Quiz** **Investigation Assessment** **Performance-Based Assessment** **Virtual Lab PBA** **Engineering Workbench Investigation Assessment** **NJSLA Released Item/Question(s) link:** → Eccentricity (e) is a measure that indicates the extent to which an orbit is elliptical. The value of e equals the distance between the foci of an orbit (f) divided by the length of the semi-major axis of the orbit (R). Which is the orbital eccentricity of Halley's Comet?
EXPERIENCE 2 (2.5 days) **Orbital Motion** Students apply orbital motion concepts to orbiting satellites and the Earth—moon—sun system.	**Teacher's Guide** → p. 76 **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** → Tidal stretching of Earth is due to differences in the strength of the moon's and sun's gravity on the near and far sides of Earth. **Connection to Investigative Phenomenon** → Students use mathematical models, including equations and vector diagrams, to describe and predict the motion of orbiting objects in the solar system.	necessary to make sense of the Anchoring Phenomenon. **EXPLORE** **Inquiry Lab:** → Model the Orbital Motion of Planets ⊕ **Analyzing Data:** → Evidence for a Non-Circular Earth ⊕ **PhET Simulation:** → Orbital Motion **EXPLAIN** **Student Handbook:** → pgs. 129—141 **Claim-Evidence-Reasoning:** → Eccentric Orbits ⊕ **Explain Video:** → Tides ⊕ **Math Tutorial** **ELABORATE** **Peer Review Rubric:** → Evaluate Eccentric Orbits ⊕ **Writing About Science:** → Skills in Orbital Motion **EVALUATE** **Quiz:** → Orbital Motion	**Virtual Lab PBA** **Engineering Workbench** **Investigation** **Assessment** **NJSLA Released Item/Question(s) link:** → The orbital period is the amount of time it takes a body to make one complete revolution around the Sun. The square of the orbital period (T) is proportional to the cube of the length of the semi-major axis of orbit (R).
EXPERIENCE 3 (3 days) **Kepler's Laws** Students use Kepler's laws of planetary motion, focusing on the equations that represent each law to model Earth's orbit.	**Teacher's Guide** → p. 82 **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:** → Kepler's Laws of Planetary Motion ⊕ **Analyzing Data:** → Kepler's Law of Planetary Periods ⊕ **PhET Simulation:**	**Experience Assessment** **Student Handbook** → Revisit Investigative Phenomenon **Quiz** **Investigation Assessment** **Performance-Based Assessment** **Virtual Lab PBA** **Engineering Workbench** **Investigation** **Assessment** **NJSLA Released Item/Question(s) link:** → The gravitational force (F) between two objects is proportional

	can be personalized and assigned to enhance instruction, as time allows. **Connection to Anchoring Phenomenon** → Tidal stretching of Earth is due to differences in the strength of the moon's and sun's gravity on the near and far sides of Earth. **Connection to Investigative Phenomenon** → Students explain why the shape of Earth's orbit does not play a significant role in affecting the seasons but the shape of Mars's orbit does affect its climate.	→ Kepler's Laws **EXPLAIN** **Student Handbook:** → pgs. 142—153 **Claim-Evidence-Reasoning:** → Mercury's Resonant Orbit ⊕ **Explain Video:** → Kepler's Laws and Beyond ⊕ **Math Tutorial** **ELABORATE** **Peer Review Rubric:** → Evaluate Mercury's Resonant Orbit ⊕ **Writing About Science:** → Skills in Kepler's Laws **EVALUATE** **Quiz:** → Kepler's Laws	to their masses and distance, as shown in the equation. . .
OPTIONAL Alternate Phenomena by Performance Expectation			
HS-PS2-4, HS-ESS1-4 Note: Optional extension task (s) if time allows within the allotted 10-day window.			

LESSON #2 PACING GUIDE WITH EMBEDDED ASSESSMENTS

Suggested Instructional Days: (9.5)

Investigation #4: Electric Forces

In this investigation, students use mathematical relationships, including Coulomb's law, Ohm's law, and the equations for series and parallel resistance, to describe and calculate electric forces and related phenomena. They develop and use various types of models, such as free-body diagrams, sketches, graphs, and particle models, to explore the pattern of electron transfer between objects.

NJSLS Specific to this Investigation/Lesson		
Performance Expectation	**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.	
Science & Engineering Practices	**Cross-Cutting Concepts**	**Disciplinary Core Ideas**
Planning and Carrying Out Investigations	Patterns	**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. **PS2.B: Types of Interactions** Attraction and repulsion between electric charges at the atomic scale explain the structure, properties, and transformations of matter, as well as the contact forces between material objects. (secondary)
Performance Expectation	**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.	
Science & Engineering Practices	**Cross-Cutting Concepts**	**Disciplinary Core Ideas**
Using Mathematics and Computational Thinking	Patterns	**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. 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.
Performance Expectation	**HS-PS2-6:** Communicate scientific and technical information about why the molecular-level structure is important in the functioning of designed materials.	
Science & Engineering Practices	**Cross-Cutting Concepts**	**Disciplinary Core Ideas**
Obtaining, Evaluating, and Communicating Information	Structure and Function	**PS2.B: Types of Interactions** Attraction and repulsion between electric charges at the atomic scale explain the structure, properties, and transformations of matter, as well as the contact forces between material objects.
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** When two objects interacting through a field change relative position, the energy stored in the field is changed.

Anchoring Phenomenon

How does the moon shape our coastline?	**Explaining Phenomena** To fully understand the phenomenon of how the moon shapes the coastline, students must understand gravitational acceleration and force in relation to Earth and the moon. Here, students explore how the gravitational force that the moon exerts on

	Earth affects ocean tide levels. As students further explore the forces between water and rock, they can construct an explanation for how the moon shapes the coastline. **Anchoring Phenomenon video** → How does the moon shape our coastline? **Student Handbook** → p. 112
Investigative Phenomenon	
Why can't we walk through walls?	**Explaining Phenomena** To understand why a person cannot walk through walls, students must understand that electric fields exist and the effects of electric charge within materials. **Investigative Phenomenon video** → Why can't we walk through walls?

Learning Goal	Teacher Preparation	Instructional Sequence	Assessments
EXPERIENCE 1 (2.5 days) **Coulomb's Law** Students explore electric charge and electric force and model how distance relates to electric charge and force.	**Teacher's Guide** → p. 94 **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** → Electrostatic bonds between adjacent grains of sediment make them harder to dislodge. **Connection to Investigative Phenomenon** → Students learn that objects can have a positive or negative charge and how these charges can affect objects and help objects keep their integrity.	**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 Charges and Coulomb's Law ⊕ **PhET Simulation:** → Coulomb's Law **EXPLAIN** **Student Handbook:** → pgs. 156—170 **Claim-Evidence-Reasoning/Modeling:** → Repelling Water ⊕ **Explain Video:** → Introduction to Coulomb's Law ⊕ **Math Tutorial** **ELABORATE** **Discussion Rubric/Peer Review Rubric:** → Repelling Water ⊕ **Writing About Science:** → Skills in Coulomb's Law **EVALUATE** **Quiz:**	**Experience Assessment** **Student Handbook** → Revisit Investigative Phenomenon **Quiz** **Investigation Assessment** **Performance-Based Assessment** **Virtual Lab PBA** **Engineering Workbench Investigation Assessment** **NJSLA Released Item/Question(s) link:** → Which piece of information found in Figure 1 is most useful in determining the number of outer electrons present in an atom?

		→ Coulomb's Law	
EXPERIENCE 2 (2.5 days) **Electric Fields** Students explore electric fields and use models to describe the direction of the electric field at a point.	**Teacher's Guide** → p. 100 **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** → Electrostatic bonds between adjacent grains of sediment make them harder to dislodge. **Connection to Investigative Phenomenon** → Students learn that there are weak attractive electrostatic forces arising from the arrangement of charged particles in a neutral atom.	**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:** → Title ⊕ **Analyzing Data:** → Title ⊕ **PhET Simulation:** → Title **EXPLAIN** **Student Handbook:** → pgs. 171-182 **Claim-Evidence-Reasoning/Modeling:** → Modeling Electric Fields ⊕ **Explain Video:** → How to Survive a Lightning Strike ⊕ **Math Tutorial** **ELABORATE** **Discussion Rubric/Peer Review Rubric:** → Evaluate Modeling Electric Fields ⊕ **Writing About Science:** → Skills in Electric Fields **EVALUATE** **Quiz:** → Electric Fields	**Experience Assessment** **Student Handbook** → Revisit Investigative Phenomenon **Quiz** **Investigation Assessment** **Performance-Based Assessment** **Virtual Lab PBA** **Engineering Workbench Investigation Assessment** **NJSLA Released Item/Question(s) link:** → Which is the correct formula for strontium chloride, based on the placement of each element in the periodic table?
EXPERIENCE 3 (2.5 days) **Electric Current** Students investigate electrical conductors and insulators and the	**Teacher's Guide** → p. 106 **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 Phenomenon video. Its purpose is to	**Experience Assessment** **Student Handbook** → Revisit Investigative Phenomenon **Quiz** **Investigation Assessment**

motion of charges through them.	→ 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** → Electrostatic bonds between adjacent grains of sediment make them harder to dislodge. **Connection to Investigative Phenomenon** → Student learn that charges can flow, creating an electric current, which stays within a conductor.	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 Resistance and Resistivity ⊕ **Analyzing Data:** → Dielectric Materials ⊕ **PhET Simulation:** → Electric Current **EXPLAIN** **Student Handbook:** → pgs. 183—194 **Claim-Evidence-Reasoning/Modeling:** → Modeling Currents ⊕ **Explain Video:** → Series and Parallel Circuits ⊕ **Math Tutorial** **ELABORATE** **Discussion Rubric/Peer Review Rubric:** → Evaluate Modeling Currents ⊕ **Writing About Science:** → Skills in Electric Current **EVALUATE** **Quiz:** → Electric Current	**Performance-Based Assessment** **Virtual Lab PBA** **Engineering Workbench Investigation Assessment** **NJSLA Released Item/Question(s) link:** → Based on its position on the periodic table, predict the charge that strontium (Sr) will take when forming a compound. Complete the sentence by choosing the correct answers from the drop-down menus.
OPTIONAL Alternate Phenomena by Performance Expectation			
HS-PS1-3, HS-PS2-4, HS-PS2-6, HS-PS3-5 Note: Optional extension task (s) if time allows within the allotted 9.5-day window.			

LESSON #3 PACING GUIDE WITH EMBEDDED ASSESSMENTS

Suggested Instructional Days: (11)

Investigation #5: Magnetic Forces

In this investigation, students explore what causes magnetism and how magnetic fields and forces can be used within designed systems to do useful work. They observe the quantitative relationships represented by the Biot-Savart law and Faraday's law.

NJSLS Specific to this Investigation/Lesson		
Performance Expectation	**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.	
Science & Engineering Practices	**Cross-Cutting Concepts**	**Disciplinary Core Ideas**
Using Mathematics and Computational Thinking	Patterns	**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. 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.
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** 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)
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** When two objects interacting through a field change relative position, the energy stored in the field is changed.

Anchoring Phenomenon

How does the moon shape our coastline?	**Explaining Phenomena** To fully understand the phenomenon of how the moon shapes the coastline, students must understand gravitational acceleration and force in relation to Earth and the moon. Here, students explore how the gravitational force that the moon exerts on Earth affects ocean tide levels. As students further explore the forces between water and rock, they can construct an explanation for how the moon shapes the coastline. **Anchoring Phenomenon video** → How does the moon shape our coastline? **Student Handbook**

	→ p. 112
Investigative Phenomenon	
How does this egg cook if the stove does not get hot?	**Explaining Phenomena** To fully understand how a stove that is not hot can heat an object, students must understand how changing magnetic fields can transmit energy. They consider how electricity provided to the stove could be used to generate a magnetic field and how that field interacts with the metal pan to generate heat. **Investigative Phenomenon video** → How does this egg cook if the stove does not get hot?

Learning Goal	Teacher Preparation	Instructional Sequence	Assessments
EXPERIENCE 1 (3 days) **Magnetic Forces and Fields** Students explore magnetism at the atomic level and calculate magnetic force.	**Teacher's Guide** → p. 118 **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** → Magnetic forces and fields can affect materials, including those on a coastline. **Connection to Investigative 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:** → Magnetic Force and Separation Distance ⊕ **Analyzing Data:** → Geometric Polarity Reversal ⊕ **PhET Simulation:** → Magnetism **EXPLAIN** **Student Handbook:** → pgs. 198—212 **Claim-Evidence-Reasoning/Modeling:** → Breaking Magnets ⊕ **Explain Video:** → Where Is the True North Pole? ⊕ **Math Tutorial** **ELABORATE** **Discussion Rubric/Peer Review Rubric:** → Breaking Magnets ⊕ **Writing About Science:**	**Experience Assessment** **Student Handbook** → Revisit Investigative Phenomenon **Quiz** **Investigation Assessment** **Performance-Based Assessment** **Virtual Lab PBA** **Engineering Workbench Investigation Assessment** **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 learn that an induction stove uses a generated magnetic field to heat a pan and that the magnetic field is generated by moving electric charges.	→ Skills in Magnetic Forces and Fields **EVALUATE** **Quiz:** → Magnetic Forces and Fields	
EXPERIENCE 2 (3 days) **Inducing Magnetism** Students explore the relationship between electricity and magnetism. They use the Biot-Savart law.	**Teacher's Guide** → p. 124 **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** → Magnetic forces and fields can affect materials, including those on a coastline. **Connection to Investigative Phenomenon** → Students sketch a model for the force on a moving electron in a metal pan when a uniform magnetic field is applied perpendicular to the surface.	**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:** → Electromagnets and Magnetism ⊕ **PhET Simulation:** → Magnetic Fields **EXPLAIN** **Student Handbook:** → pgs. 213—226 **Claim-Evidence-Reasoning/Modeling:** → Combining Magnetic Fields ⊕ **Explain Video:** → World's First Electric Generator ⊕ **Math Tutorial** **ELABORATE** **Discussion Rubric/Peer Review Rubric:** → Evaluate Combining Magnetic Fields ⊕ **Writing About Science:** → Skills in Inducing Magnetism **EVALUATE** **Quiz:** → Inducing Magnetism	**Experience Assessment** **Student Handbook** → Revisit Investigative Phenomenon **Quiz** **Investigation Assessment** **Performance-Based Assessment** **Virtual Lab PBA** **Engineering Workbench Investigation Assessment** **NJSLA Released Item/Question(s) link:** → Identify the variables that should be measured to determine the relative change in energy within a bicycle tire if air molecules continue to be added once the pump handle becomes harder to push down.
EXPERIENCE 3 (3 days) **Inducing Current**	**Teacher's Guide** → p. 130	**ENGAGE** **Teachers' Guide:**	**Experience Assessment** **Student Handbook**

Students learn that changing magnetic flux causes an electromotive force that induces a current in a loop of wire.	**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** → Magnetic forces and fields can affect materials, including those on a coastline. **Connection to Investigative Phenomenon** → Students sketch a schematic model of an induction stove that they can use to explain how to cook an egg without the stove itself getting hot.	**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:** → Induction of Electrical Current ⊕ **PhET Simulation:** → Inducing Current **EXPLAIN** **Student Handbook:** → pgs. 226—238 **Claim-Evidence-Reasoning/Modeling:** → Magnetic Field in a Moving Wire ⊕ **Explain Video:** → Induction: An Introduction ⊕ **Math Tutorial** **ELABORATE** **Discussion Rubric/Peer Review Rubric:** → Evaluate Magnetic Field in a Moving Wire ⊕ **Writing About Science:** → Skills in Inducing Current **EVALUATE** **Quiz:** → Inducing Current	→ Revisit Investigative Phenomenon **Quiz** **Investigation Assessment** **Performance-Based Assessment** **Virtual Lab PBA** **Engineering Workbench Investigation Assessment** **NJSLA Released Item/Question(s) link:** → Select from the drop-down menus to correctly compare each given factor before and after air molecules are pumped into a bicycle tire. Complete the table by choosing the correct answers from the drop-down menus.
OPTIONAL Alternate Phenomena by Performance Expectation			
HS-PS2-4, HS-PS2-5, HS-PS3-5 Note: Optional extension task(s) if time allows within the allotted 11-day window.			

LESSON #4 PACING GUIDE WITH EMBEDDED ASSESSMENTS

Suggested Instructional Days: (14)

Investigation #6: Forces in Materials

In this investigation, students explore the nature of matter from the subatomic to the molecular level, including the application of Coulomb's law to describe and predict the effects of electrostatic forces between particles. Students relate atomic-level interactions to the properties and structure of materials at the bulk scale. They investigate how understanding these relationships is important to designing materials for specific purposes.

NJSLS Specific to this Investigation/Lesson		
Performance Expectation	**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.	
Science & Engineering Practices	**Cross-Cutting Concepts**	**Disciplinary Core Ideas**
Planning and Carrying Out Investigations	Patterns	**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. **PS2.B: Types of Interactions** Attraction and repulsion between electric charges at the atomic scale explain the structure, properties, and transformations of matter, as well as the contact forces between material objects. (secondary)
Performance Expectation	**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.	
Science & Engineering Practices	**Cross-Cutting Concepts**	**Disciplinary Core Ideas**
Using Mathematics and Computational Thinking	Patterns	**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. 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.
Performance Expectation	**HS-PS2-6:** Communicate scientific and technical information about why the molecular-level structure is important in the functioning of designed materials.	
Science & Engineering Practices	**Cross-Cutting Concepts**	**Disciplinary Core Ideas**
Obtaining, Evaluating, and Communicating Information	Structure and Function	**PS2.B: Types of Interactions** Attraction and repulsion between electric charges at the atomic scale explain the structure, properties, and transformations of matter, as well as the contact forces between material objects.

Anchoring Phenomenon

How does the moon shape our coastline?	**Explaining Phenomena** To fully understand the phenomenon of how the moon shapes the coastline, students must understand gravitational acceleration and force in relation to Earth and the moon. Here, students explore how the gravitational force that the moon exerts on Earth affects ocean tide levels. As students further explore the forces between water and rock, they can construct an explanation for how the moon shapes the coastline. **Anchoring Phenomenon video** → How does the moon shape our coastline? **Student Handbook** → p. 112

Investigative Phenomenon	
What happens to this pole as it bends?	**Explaining Phenomena** To fully understand the phenomenon of the bending pole, students must understand what happens at the molecular level to produce the properties of materials. **Investigative Phenomenon video** → What happens to this pole as it bends?

Learning Goal	Teacher Preparation	Instructional Sequence	Assessments
EXPERIENCE 1 (3 days) **Atoms and Atomic Structure** Students investigate the interactions of electrically charged and electrically neutral subatomic particles.	**Teacher's Guide** → p. 142 **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** → The properties of materials such as water and rock are determined by the forces between the atoms and affects how they interact. **Connection to Investigative Phenomenon** → Students describe the interactions among atoms, particularly the electrical interactions between electrons and protons and between different atoms.	**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:** → Indirect Observation of the Atom ⊕ **PhET Simulation:** → Atoms and Atomic Structure **EXPLAIN** **Student Handbook:** → pgs. 242—250 **Claim-Evidence-Reasoning/Modeling:** → Atomic Models ⊕ **Explain Video:** → Atomic Theory ⊕ **Math Tutorial** **ELABORATE** **Discussion Rubric/Peer Review Rubric:** → Evaluate Atomic Models ⊕ **Writing About Science:** → Skills in Atoms and Atomic Structure **EVALUATE** **Quiz:** → Atoms and Atomic Structure	**Experience Assessment** **Student Handbook** → Revisit Investigative Phenomenon **Quiz** **Investigation Assessment** **Performance-Based Assessment** → Title **Virtual Lab PBA** **Engineering Workbench Investigation Assessment** **NJSLA Released Item/Question(s) link:** → Which piece of information found in Figure 1 is most useful in determining the number of outer electrons present in an atom?
EXPERIENCE 2 (3 days) **Attractive and Repulsive Forces**	**Teacher's Guide** → p. 148	**ENGAGE** **Teachers' Guide:** **Everyday Phenomenon**	**Experience Assessment** **Student Handbook**

Students investigate the electrical interactions between atoms that result from the Coulomb force.	**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** → The properties of materials such as water and rock are determined by the forces between the atoms and affects how they interact. **Connection to Investigative Phenomenon** → Students identify different types of bonding and relate them to the structures and properties of materials.	→ 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:** → Cohesive Forces and Surface Tension ⊕ **Analyzing Data:** → Forces Between Atoms ⊕ **PhET Simulation:** → Attractive and Repulsive Forces **EXPLAIN** **Student Handbook:** → pgs. 251—260 **Claim-Evidence-Reasoning/Modeling:** → Soap Bubbles ⊕ **Explain Video:** → Is Glass a Liquid? ⊕ **Math Tutorial** **ELABORATE** **Discussion Rubric/Peer Review Rubric:** → Soap Bubbles ⊕ **Writing About Science:** → Skills in Attractive and Repulsive Forces **EVALUATE** **Quiz:** → Attractive and Repulsive Forces	→ Revisit Investigative Phenomenon **Quiz** **Investigation Assessment** **Performance-Based Assessment** **Virtual Lab PBA** **Engineering Workbench Investigation Assessment** **NJSLA Released Item/Question(s) link:** → Which is the correct formula for strontium chloride, based on the placement of each element in the periodic table?
EXPERIENCE 3 (3 days) **Material Properties** Students explore how designed materials function based on properties of the components.	**Teacher's Guide** → p. 155 **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.	**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.	**Experience Assessment** **Student Handbook** → Revisit Investigative Phenomenon **Quiz** **Investigation Assessment** **Performance-Based Assessment** **Virtual Lab PBA**

	→ 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** → The properties of materials such as water and rock are determined by the forces between the atoms and affects how they interact. **Connection to Investigative Phenomenon** → Students relate bulk properties to atomic-level interactions.	**EXPLORE** **Inquiry Lab:** → Physical Properties of Solid Materials ⊕ **PhET Simulation:** → Material Properties **EXPLAIN** **Student Handbook:** → pgs. 261—269 **Claim-Evidence-Reasoning/Modeling:** → Combining Materials ⊕ **Explain Video:** → Stronger, Stretchier, Stickier ⊕ **Math Tutorial** **ELABORATE** **Discussion Rubric/Peer Review Rubric:** → Combining Materials ⊕ **Writing About Science:** → Skills in Material Properties **EVALUATE** **Quiz:** → Material Properties	**Engineering Workbench Investigation Assessment** **NJSLA Released Item/Question(s) link:** → Based on its position on the periodic table, predict the charge that strontium (Sr) will take when forming a compound. Complete the sentence by choosing the correct answers from the drop-down menus.
EXPERIENCE 4 (3 days) **Structure and Function** Students are introduced to polymers as chain molecules that can exist due to the ability of carbon to form four bonds.	**Teacher's Guide** → p. 161 **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.	**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:** → Structures and Properties of Polymers ⊕ **Analyzing Data:** → Enantiomers ⊕ **PhET Simulation:** → Structure and Function **EXPLAIN** **Student Handbook:**	**Experience Assessment** **Student Handbook** → Revisit Investigative Phenomenon **Quiz** **Investigation Assessment** **Performance-Based Assessment** **Virtual Lab PBA** **Engineering Workbench Investigation Assessment** **NJSLA Released Item/Question(s) link:** → Describe the bonding between the elements. Complete the sentence by choosing the correct answer

	Connection to Anchoring Phenomenon → The properties of materials such as water and rock are determined by the forces between the atoms and affects how they interact. **Connection to Investigative Phenomenon** → Students explore why the molecular-level structure is important the functioning of designed materials.	→ pgs. 270—276 **Claim-Evidence-Reasoning/Modeling:** → Polymer Models ⊕ **Explain Video:** → How Do Geckos Defy Gravity? ⊕ **Math Tutorial** **ELABORATE** **Discussion Rubric/Peer Review Rubric:** → Evaluate Polymer Models ⊕ **Writing About Science:** → Skills in Structure and Function **EVALUATE** **Quiz:** → Structure and Function	from the drop-down menu. Based on the positions of both rubidium and bromine on the periodic table, a student could claim the bond that would form between these elements would be a(n). . .
OPTIONAL Alternate Phenomena by Performance Expectation			
HS-PS1-3, HS-PS2-4, HS-PS2-6 Note: Optional extension task(s) if time allows within the allotted 14-day window.			