Orange Public Schools

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

Physics Honors

Unit 4: Waves and Electromagnetic Radiation

27.5 Instructional Days

Board Approved: 9/13/23

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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 4: Waves and Electromagnetic Radiation	**Duration**	27.5 days

UNIT OVERVIEW

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.

CONCEPTUAL FLOW

Investigation #11: Waves

- **Experience 1** - Wave Properties
- **Experience 2** - Wave Behavior and Energy
- **Experience 3** - Wave Optics

Investigation #12: Electromagnetic Radiation

- **Experience 1** - Electromagnetic Waves and Their Properties
- **Experience 2** - Particle—Wave Duality
- **Experience 3** - Electromagnetic Radiation and Matter

Investigation #13: Information and Instrumentation

- **Experience 1** - Digital Information
- **Experience 2** - Capturing and Transmitting Information
- **Experience 3** - Capturing and Transmitting Energy

ESSENTIAL QUESTION(S) AND ENDURING UNDERSTANDINGS

Essential Questions /Focus Questions	Enduring Understandings
• How do waves transfer energy? • How do waves change the coastline? • How does a lens remove glare? • How does a mobile device transmit information?	• Waves can add or cancel one another as they cross, depending on their relative phase (i.e., relative position of peaks and troughs of the waves), but they emerge unaffected by each other. (Boundary: The discussion at this grade level is qualitative only; it can be based on the fact that two different sounds can pass a location in different directions without getting mixed up.) • Electromagnetic radiation (e.g., radio, microwaves, light) can be modeled as a wave of changing electric and magnetic fields or as particles called photons. The wave model is useful for explaining many features of electromagnetic radiation, and the particle model explains other features. • When light or longer wavelength electromagnetic radiation is absorbed in matter, it is generally converted into thermal energy (heat). Shorter wavelength electromagnetic radiation (ultraviolet, X-rays, gamma rays) can ionize atoms and cause damage to living cells. • Photoelectric materials emit electrons when they absorb light of a high-enough frequency. • Solar cells are human-made devices that likewise capture the sun's energy and produce electrical energy.

NGSS PERFORMANCE EXPECTATION(S)

Students who demonstrate understanding can:

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-PS4-1 **Use mathematical representations to support a claim regarding relationships among the frequency, wavelength, and speed of waves traveling in various media.**

HS-PS4-2 **Evaluate questions about the advantages of using digital transmission and storage of information.**

HS-PS4-3 **Evaluate the claims, evidence, and reasoning behind the idea that electromagnetic radiation can be described either by a wave model or a particle model, and that for some situations one model is more useful than the other.**

HS-PS4-4 **Evaluate the validity and reliability of claims in published materials of the effects that different frequencies of electromagnetic radiation have when absorbed by matter.**

HS-PS4-5 **Communicate technical information about how some technological devices use the principles of wave behavior and wave interactions with matter to transmit and capture information and energy.***

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**	**PS3.A: Definitions of Energy** At the macroscopic scale, energy manifests itself in multiple ways, such as in motion, sound, light, and thermal energy. **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. **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) **PS4.A: Wave Properties** The wavelength and frequency of a wave are related to one another by the speed of travel of the wave, which depends on the type of wave and the medium through which it is passing. Information can be digitized (e.g., a picture stored as the values of an array of pixels); in this form, it can be stored reliably in computer memory and sent over long distances as a series of wave pulses.	☐ **Patterns** ☒ **Cause and Effect** ☐ **Scale, Proportion, and Quantity** ☒ **Systems and System Models** ☒ **Energy and Matter** ☐ **Structure and function.** ☐ **Stability and change**.

	[From the 3–5 grade band endpoints] Waves can add or cancel one another as they cross, depending on their relative phase (i.e., relative position of peaks and troughs of the waves), but they emerge unaffected by each other. (Boundary: The discussion at this grade level is qualitative only; it can be based on the fact that two different sounds can pass a location in different directions without getting mixed up.) **PS4.B: Electromagnetic Radiation** Electromagnetic radiation (e.g., radio, microwaves, light) can be modeled as a wave of changing electric and magnetic fields or as particles called photons. The wave model is useful for explaining many features of electromagnetic radiation, and the particle model explains other features. When light or longer wavelength electromagnetic radiation is absorbed in matter, it is generally converted into thermal energy (heat). Shorter wavelength electromagnetic radiation (ultraviolet, X-rays, gamma rays) can ionize atoms and cause damage to living cells. Photoelectric materials emit electrons when they absorb light of a high-enough frequency. **PS3.D: Energy in Chemical Processes** Solar cells are human-made devices that likewise capture the sun's energy and produce electrical energy. (secondary) **PS4.C: Information Technologies and Instrumentation** Multiple technologies based on the understanding of waves and their interactions with matter are part of everyday experiences in the modern world (e.g., medical imaging, communications, scanners) and in scientific research. They are essential tools for producing, transmitting, and capturing signals and for storing and interpreting the information contained in them.	

INTERDISCIPLINARY CONNECTIONS

English Language Arts

RST.9-10.8
Assess the extent to which the reasoning and evidence in a text support the author's claim or a recommendation for solving a scientific or technical problem. (HS-PS4-2) (HS-PS4-3) (HS-PS4-4)

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-PS4-2) (HS-PS4-3) (HS-PS4-4)

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-PS4-4)

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-PS4-2) (HS-PS4-3) (HS-PS4-4)

WHST.11-12.2
Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes. (HS-PS4-5)

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-PS4-1)

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-PS4-4)

Mathematics

MP.2
Reason abstractly and quantitatively. (HS-PS4-1) (HS-PS4-3) (HS-ETS1-3) (HS-ETS1-4)

MP.4
Model with mathematics. (HS-PS4-1)

HSA.SSE.A.1
Interpret expressions that represent a quantity in terms of its context. (HS-PS4-1) (HS-PS4-3)

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-PS4-1) (HS-PS4-3)

HSA.CED.A.4
Rearrange formulas to highlight a quantity of interest, using the same reasoning as in solving equations. (HS-PS4-1) (HS-PS4-3)

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 #11: Waves	Students identify and describe the properties of transverse and longitudinal waves. Students explore the interactions of waves with one another and with objects in their environment. Students use models to construct explanations about the interactions between light and matter. They perform calculations using Snell's law.	**HS-PS3-3, HS-PS4-1, HS-PS4-3, HS-PS4-5**	**8.5 days** (Plus, optional extension task(s) if time allows within the allotted 8.5-day window.)
Investigation #12: Electromagnetic Radiation	Students explore how EM radiation can be modeled, and they investigate behaviors of EM radiation. Students investigate how EM radiation can also be modeled as a particle and explore quanta. Students compare the properties and effects of longer wavelength EM radiation to shorter wavelength EM radiation.	**HS-PS4-3, HS-PS4-4**	**9 days** (Plus, optional extension task(s) if time allows within the allotted 9-day window.)
Investigation #13: Information and Instrumentation	Students learn that information must be encoded before it can be stored, transmitted, or reproduced. Students explore instruments that send and receive audio and visual information. Students explore how wave energy can be converted into useful forms. They develop system models to solve a problem related to solar power efficiency.	**HS-PS4-2, HS-PS4-5**	**9.5 days** (Plus, optional extension task(s) if time allows within the allotted 9.5-day window.)

LESSON #1 PACING GUIDE WITH EMBEDDED ASSESSMENTS

Suggested Instructional Days: (8.5)

Investigation #11: Waves

In this investigation, students explore the properties of mechanical waves. They construct models of wave properties to support claims about the relationships among wave frequency, wavelength, and speed in various med m Students explore the interactions of waves with one another and with objects in their environment. They describe the interactions between light and matter that result in phenomena observable at a macroscopic level.

NJSLS Specific to this Investigation/Lesson		
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-PS4-1** Use mathematical representations to support a claim regarding relationships among the frequency, wavelength, and speed of waves traveling in various media.	
Science & Engineering Practices	**Cross-Cutting Concepts**	**Disciplinary Core Ideas**
Using Mathematics and Computational Thinking	Cause and Effect	PS4.A: Wave Properties
Performance Expectation	**HS-PS4-3** Evaluate the claims, evidence, and reasoning behind the idea that electromagnetic radiation can be described either by a wave model or a particle model, and that for some situations one model is more useful than the other.	
Science & Engineering Practices	**Cross-Cutting Concepts**	**Disciplinary Core Ideas**
Engaging in Argument from Evidence	Systems and System Models	PS4.A: Wave Properties PS4.B: Electromagnetic Radiation
Performance Expectation	**HS-PS4-5** Communicate technical information about how some technological devices use the principles of wave behavior and wave interactions with matter to transmit and capture information and energy.	
Science & Engineering Practices	**Cross-Cutting Concepts**	**Disciplinary Core Ideas**
Obtaining, Evaluating, and Communicating Information	Cause and Effect	PS3.D: Energy in Chemical Processes PS4.A: Wave Properties PS4.B: Electromagnetic Radiation PS4.C: Information Technologies and Instrumentation

Anchoring Phenomenon

How do waves transfer energy?	**Explaining Phenomena** To fully understand the phenomenon of wave-particle duality, students must understand how light can sometimes exhibit the properties of a wave but at other times can exhibit the properties of a particle. Here, students can explore how a particle such as an electron sometimes acts like a wave. As students explore the behavior of waves, they can construct an explanation of wave-particle duality. **Anchoring Phenomenon video** → How do waves transfer energy? **Student Handbook** → p. 462

Investigative Phenomenon

How do waves change the coastline?	**Explaining Phenomena** To fully understand the phenomenon of how waves change the coastline, students must understand the properties and behaviors of waves. As students explore the energy transmitted by waves and how waves interact with objects, they can construct an explanation of the processes of waves changing the coastline.

	Investigative Phenomenon video → How do waves change the coastline?		
Learning Goal	**Teacher Preparation**	**Instructional Sequence**	**Assessments**
EXPERIENCE 1 (2 days) **Wave Properties** Students identify and describe the properties of transverse and longitudinal waves.	**Teacher's Guide** → p. 282 **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 Video/**⊕**Writing About Science** These OPTIONAL activities can be personalized and assigned to enhance instruction, as time allows. **Connection to Anchoring Phenomenon** → The electrons in the quantum corral can transmit energy as waves even though they are usually considered particles. **Connection to Investigative Phenomenon** → Students determine the frequency of a wave using time intervals of wave crests and complete a graph of wave speed as a function of depth.	**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:** → Mechanical Waves ⊕ **PhET Simulation:** → Properties of Waves **EXPLAIN** **Student Handbook:** → pgs. 466—478 **Claim-Evidence-Reasoning:** → Wave Speed ⊕ **Explain Video:** → Graphs of Waves ⊕ **Math Tutorial Video** **ELABORATE** **Discussion Rubric:** → Wave Speed ⊕ **Writing About Science:** → Skills in Wave Properties **EVALUATE** **Quiz:** → Wave Properties	**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?
EXPERIENCE 2 (2.5 days) **Wave Behavior and Energy** Students explore the interactions of waves with one another and with objects in their environment.	**Teacher's Guide** → p. 288 **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	**Experience Assessment** **Student Handbook** → Revisit Investigative Phenomenon **Quiz** **Investigation Assessment** **Performance-Based Assessment** **Virtual Lab PBA**

	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 Video/**⊕**Writing About Science** These OPTIONAL activities can be personalized and assigned to enhance instruction, as time allows. **Connection to Anchoring Phenomenon** → The electrons in the quantum corral can transmit energy as waves even though they are usually considered particles. **Connection to Investigative Phenomenon** → Students consider the properties of water waves during storms and explain why beach erosion can increase during storms. They also consider design choices for a seawall.	opportunity to interact with an engaging event and gather knowledge necessary to make sense of the Anchoring Phenomenon. **EXPLORE** **Inquiry Lab:** → Interference of Sound Waves ⊕ **PhET Simulation:** → Wave Behavior and Energy **EXPLAIN** **Student Handbook:** → pgs. 479—492 **Claim-Evidence-Reasoning/Modeling:** → Interference ⊕ **Explain Video:** → Harnessing Wave Energy From the Ocean ⊕ **Math Tutorial Video** **ELABORATE** **Discussion Rubric/Peer Review Rubric:** → Evaluate Interference ⊕ **Writing About Science:** → Skills in Wave Behavior and Energy **EVALUATE** **Quiz:** → Wave Behavior and Energy	**Engineering Workbench Investigation Assessment** **NJSLA Released Item/Question(s) link:** → Which wavelength (λ) of the light results as it passes from water into the polymer ball?
EXPERIENCE 3 (2 days) **Wave Optics** Students use models to construct explanations about the interactions between light and matter. They perform calculations using Snell's law.	**Teacher's Guide** → p. 294 **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	**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**	**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:**

	→ See "Remediation Suggestions" section of Teacher Guide; provides multiple suggestions for students struggling with specific concepts. → ⊕**Analyzing Data/** ⊕**Phet Simulation/** ⊕**Explain Video/** ⊕**Math Tutorial Video/**⊕**Writing About Science** These OPTIONAL activities can be personalized and assigned to enhance instruction, as time allows. **Connection to Anchoring Phenomenon** → The electrons in the quantum corral can transmit energy as waves even though they are usually considered particles. **Connection to Investigative Phenomenon** → Students use the concepts of wave refraction and wave energy to construct an explanation for why sand and sediment may be carried to a shoreline.	**Inquiry Lab:** → Reflection and Refraction ⊕ **Analyzing Data:** → Refraction—Snell's Law ⊕ **PhET Simulation:** → Wave Optics **EXPLAIN** **Student Handbook:** → pgs. 493—508 **Claim-Evidence-Reasoning:** → Refraction ⊕ **Explain Video:** → Refraction in Animals ⊕ **Math Tutorial Video** **ELABORATE** **Discussion Rubric:** → Refraction ⊕ **Writing About Science:** → Skills in Wave Optics **EVALUATE** **Quiz:** → Wave Optics	→ What is most important to the process of storing information on a hard disk drive? Select two of the five statements.
OPTIONAL Alternate Phenomena by Performance Expectation			
HS-PS3-3, HS-PS4-1, HS-PS4-3, HS-PS4-5 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: (9)

Investigation #12: Electromagnetic Radiation

In this investigation, students explore the nature of electromagnetic (EM) radiation and its properties. They investigate the concept of quanta and Planck's energy equation for determining the energy of a photon based on its frequency. Students describe how EM radiation and matter interact. They explore models that explain the processes of emission, absorption, and ionization.

NJSLS Specific to this Investigation/Lesson		
Performance Expectation	**HS-PS4-3** Evaluate the claims, evidence, and reasoning behind the idea that electromagnetic radiation can be described either by a wave model or a particle model, and that for some situations one model is more useful than the other.	
Science & Engineering Practices	**Cross-Cutting Concepts**	**Disciplinary Core Ideas**
Engaging in Argument from Evidence	**Systems and System Models**	PS4.A: Wave Properties PS4.B: Electromagnetic Radiation
Performance Expectation	**HS-PS-4-4** Evaluate the validity and reliability of claims in published materials of the effects that different frequencies of electromagnetic radiation have when absorbed by matter.	
Science & Engineering Practices	**Cross-Cutting Concepts**	**Disciplinary Core Ideas**
Obtaining, Evaluating, and Communicating Information	Cause and Effect	PS4.B: Electromagnetic Radiation

Anchoring Phenomenon

How do waves transfer energy?	**Explaining Phenomena** To fully understand the phenomenon of wave-particle duality, students must understand how light can sometimes exhibit the properties of a wave but at other times can exhibit the properties of a particle. Here, students can explore how a particle such as an electron sometimes acts like a wave. As students explore the behavior of waves, they can construct an explanation of wave-particle duality. **Anchoring Phenomenon video** → How do waves transfer energy? **Student Handbook** → p. 462

Investigative Phenomenon

How does this lens remove the glare?	**Explaining Phenomena** To fully understand the phenomenon of how a lens reduces glare, students must understand the properties and behaviors of visible light. As students explore particle-wave duality and electromagnetic radiation, they can construct an explanation of the ways the lens reduces glare. **Investigative Phenomenon video** → How does this lens remove the glare?

Learning Goal	Teacher Preparation	Instructional Sequence	Assessments
EXPERIENCE 1 (2 days) **Electromagnetic Waves and Their Properties** Students explore how EM radiation can be modeled, and they investigate behaviors of EM radiation.	**Teacher's Guide** → p. 308 **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 Video/**⊕**Writing About Science** These OPTIONAL activities can be personalized and assigned to enhance instruction, as time allows. **Connection to Anchoring Phenomenon** → Light can act as both a particle and a wave, just as the electrons in the quantum corral can act as either a wave or a particle. **Connection to Investigative Phenomenon** → Students develop a model to explain how long polymer molecules that are parallel enable polarizers to block certain light waves.	necessary to make sense of the Anchoring Phenomenon. **EXPLORE** **Inquiry Lab:** → Diffraction ⊕ **PhET Simulation:** → Electromagnetic Waves and Their Properties **EXPLAIN** **Student Handbook:** → pgs. 512—519 **Claim-Evidence-Reasoning:** → Laser Interference ⊕ **Explain Video:** → The Original Double-Slit Experiment ⊕ **Math Tutorial Video** **ELABORATE** **Discussion Rubric/Peer Review Rubric:** → Laser Interference ⊕ **Writing About Science:** → Skills in Electromagnetic Waves and Their Properties **EVALUATE** **Quiz:** → Electromagnetic Waves and Their Properties	**Virtual Lab PBA** **Engineering Workbench Investigation** **Assessment** **NJSLA Released Item/Question(s) link:** → Which wavelength (λ) of the light results as it passes from water into the polymer ball?
EXPERIENCE 2 (2.5 days) **Particle-Wave Duality** Students investigate how EM radiation can also be modeled as a particle and explore quanta.	**Teacher's Guide** → p. # **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/**	**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:** → Particle Nature of Light ⊕ **Analyzing Data:** → Particle-Wave Duality ⊕ **PhET Simulation:** → Particle-Wave Duality	**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:**

	⊕**Math Tutorial Video/⊕Writing About Science** These OPTIONAL activities can be personalized and assigned to enhance instruction, as time allows. **Connection to Anchoring Phenomenon** → Light can act as both a particle and a wave, just as the electrons in the quantum corral can act as either a wave or a particle. **Connection to Investigative Phenomenon** → Students describe the functionality of an anti-glare window and make a claim about whether the effectiveness of polarizing sunglasses supports the wave or particle nature of light.	**EXPLAIN** **Student Handbook:** → pgs. 520—528 **Claim-Evidence-Reasoning:** → Light Intensity and Energy ⊕ **Explain Video:** → Single-Photon Interference ⊕ **Math Tutorial Video** **ELABORATE** **Discussion Rubric/Peer Review Rubric:** → Light Intensity and Energy ⊕ **Writing About Science:** → Skills in Particle-Wave Duality **EVALUATE** **Quiz:** → Particle-Wave Duality	→ Which observations are consistent with the given information and diagrams, and could help explain why the polymer ball is visible in air but invisible in water?
EXPERIENCE 3 (2.5 days) **Electromagnetic Radiation and Matter** Students compare the properties and effects of longer wavelength EM radiation to shorter wavelength EM radiation.	**Teacher's Guide** → p. 321 **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 Video/⊕Writing About Science** These OPTIONAL activities can be personalized and assigned to enhance instruction, as time allows. **Connection to Anchoring Phenomenon** → Light can act as both a particle and a wave, just as the electrons	**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:** → Electromagnetic Radiation and Matter ⊕ **Analyzing Data:** → Sunscreen and UV Protection ⊕ **PhET Simulation:** → EM Radiation and Matter **EXPLAIN** **Student Handbook:** → pgs. 529—536 **Modeling:** → Light Interactions with Molecules ⊕ **Explain Video:**	**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 observations are consistent with the given information and diagrams, and could help explain why the polymer ball is visible in air but invisible in water?

	in the quantum corral can act as either a wave or a particle. **Connection to Investigative Phenomenon** → Students compare models of polarized sunglasses and explain which they would purchase.	→ How Microwaving Grapes Makes Plasma ⊕ **Math Tutorial Video** **ELABORATE** **Peer Review Rubric:** → Evaluate Light Interactions with Molecules ⊕ **Writing About Science:** → Skills in EM Radiation and Matter **EVALUATE** **Quiz:** → Electromagnetic Radiation and Matter	

OPTIONAL Alternate Phenomena by Performance Expectation

HS-PS4-3, HS-PS4-4

Note: Optional extension task(s) if time allows within the allotted 9-day window.

LESSON #3 PACING GUIDE WITH EMBEDDED ASSESSMENTS

Suggested Instructional Days: (9.5)

Investigation #13: Information and Instrumentation

In this investigation, students explore how engineers use the transfer-encoded information from waves and electric current as they design digital instruments. They distinguish between analog and digital information.

NJSLS Specific to this Investigation/Lesson			
Performance Expectation	**HS-PS4-2** Evaluate questions about the advantages of using a digital transmission and storage of information.		
Science & Engineering Practices	**Cross-Cutting Concepts**	**Disciplinary Core Ideas**	
Asking Questions and Defining Problems	Stability and Change	PS4.A: Wave Properties	
Performance Expectation	**HS-PS4-5** Communicate technical information about how some technological devices use the principles of wave behavior and wave interactions with matter to transmit and capture information and energy.		
Science & Engineering Practices	**Cross-Cutting Concepts**	**Disciplinary Core Ideas**	
Obtaining, Evaluating, and Communicating Information	Cause and Effect	PS3.D: Energy in Chemical Processes PS4.A: Wave Properties PS4.B: Electromagnetic Radiation PS4.C: Information Technologies and Instrumentation	

Anchoring Phenomenon

How do waves transfer energy?	**Explaining Phenomena** To fully understand the phenomenon of wave-particle duality, students must understand how light can sometimes exhibit the properties of a wave but at other times can exhibit the properties of a particle. Here, students can explore how a particle such as an electron sometimes acts like a wave. As students explore the behavior of waves, they can construct an explanation of wave-particle duality. **Anchoring Phenomenon video** → How do waves transfer energy? **Student Handbook** → p. 462

Investigative Phenomenon

How does a mobile device transmit information?	**Explaining Phenomena** To fully understand the phenomenon of how a mobile device transmits information, students must understand features associated with digital storage of information. As students explore how information and energy is transmitted and captured, they can construct an explanation of how a mobile device transmits information. **Investigative Phenomenon video** → How does a mobile device transmit information?

Learning Goal	Teacher Preparation	Instructional Sequence	Assessments
EXPERIENCE 1 (2.5 days) **Digital Information** Students learn that information must be encoded before it can be stored, transmitted, or reproduced.	**Teacher's Guide** → p. 332 **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	**Experience Assessment** **Student Handbook** → Revisit Investigative Phenomenon **Quiz** **Investigation Assessment** **Performance-Based Assessment** **Virtual Lab PBA** **Engineering Workbench Investigation 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 Video/**⊕**Writing About Science** These OPTIONAL activities can be personalized and assigned to enhance instruction, as time allows. **Connection to Anchoring Phenomenon** → The quantum corral shows how information can be transmitted as either a wave or a particle. **Connection to Investigative Phenomenon** → Students explore how images and sound may be encoded into bits of information (digital data).	engaging event and gather knowledge necessary to make sense of the Anchoring Phenomenon. **EXPLORE** **Inquiry Lab:** → Binary Logic ⊕ **Analyzing Data:** → Transistors and Integrated Circuits ⊕ **PhET Simulation:** → Digital Information **EXPLAIN** **Student Handbook:** → pgs. 540—548 **Claim-Evidence-Reasoning/Modeling:** → Creating Code ⊕ **Explain Video:** → Amazing Hard Drives of the Future ⊕ **Math Tutorial Video** **ELABORATE** **Discussion Rubric/Peer Review Rubric:** → Evaluate Creating Code ⊕ **Writing About Science:** → Skills in Digital Information **EVALUATE** **Quiz:** → Digital Information	**NJSLA Released Item/Question(s) link:** → Which wavelength (λ) of the light results as it passes from water into the polymer ball?
EXPERIENCE 2 (2.5 days) **Transmitting and Capturing Information** Students explore instruments that send and receive audio and visual information.	**Teacher's Guide** → p. 338 **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	**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** **Virtual Lab PBA** **Engineering Workbench Investigation Assessment** **NJSLA Released Item/Question(s) link:** → The polymer marble is placed in a glass full of water. A beam of light

	→ See "Remediation Suggestions" section of Teacher Guide; provides multiple suggestions for students struggling with specific concepts. → ⊕**Analyzing Data/** ⊕**Phet Simulation/** ⊕**Explain Video/** ⊕**Math Tutorial Video/**⊕**Writing About Science** These OPTIONAL activities can be personalized and assigned to enhance instruction, as time allows. **Connection to Anchoring Phenomenon** → The quantum corral shows how information can be transmitted as either a wave or a particle. **Connection to Investigative Phenomenon** → Students describe the energy transformations and different forms a signal takes as it travels from your voice box to a friend's ear on the other end.	→ Converting Electrical Signals to Sound ⊕ **PhET Simulation:** → Capturing and Transmitting Information **EXPLAIN** **Student Handbook:** → pgs. 549—556 **Claim-Evidence-Reasoning:** → Antennas ⊕ **Explain Video:** → The Wow! Signal ⊕ **Math Tutorial Video** **ELABORATE** **Discussion Rubric:** → Antennas ⊕ **Writing About Science:** → Skills in Transmitting and Capturing Information **EVALUATE** **Quiz:** → Transmitting and Capturing Information	passes through the different materials, as shown in Figure 2.
EXPERIENCE 3 (2.5 days) **Capturing and Transmitting Energy** Students explore how wave energy can be converted into useful forms. They develop system models to solve a problem related to solar power efficiency.	**Teacher's Guide** → p. 344 **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 Video/**⊕**Writing About Science** These OPTIONAL activities can be	**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:** → Converting Sunlight to Electricity ⊕ **PhET Simulation:** → Capturing and Transmitting Energy **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:** → What is most important to the process of storing information on a hard disk drive?

	personalized and assigned to enhance instruction, as time allows. **Connection to Anchoring Phenomenon** → The quantum corral shows how information can be transmitted as either a wave or a particle. **Connection to Investigative Phenomenon** → Students use provided information to estimate the electricity generated by a solar cell used to charge a mobile device.	→ pgs. 557—564 **Claim-Evidence-Reasoning/Modeling:** → Solar Panels on a Cloudy Day ⊕ **Explain Video:** → Do Cell Phones Cause Brain Tumors? ⊕ **Math Tutorial Video** **ELABORATE** **Discussion Rubric:** → Solar Panels on a Cloudy Day ⊕ **Writing About Science:** → Skills in Capturing and Transmitting Energy **EVALUATE** **Quiz:** → Capturing and Transmitting Energy	
OPTIONAL Alternate Phenomena by Performance Expectation			
HS-PS4-2, HS-PS4-5 Note: Optional extension task(s) if time allows within the allotted 9.5-day window.			