Englewood Public School District
Science
Physics
Third Marking Period

Unit 3: Waves, Sound, and Electromagnetic Radiation

Overview: In this unit of study, students apply their understanding of how wave properties can be used to transfer information across long distances, store information, and investigate nature on many scales. Students are able to apply their understanding of wave properties to make sense of how electromagnetic radiation can be used to transfer information across long distances, store information, and be used to investigate nature on many scales. Models of electromagnetic radiation as both a wave of changing electrical and magnetic fields or as particles are developed and used. Students also demonstrate their understanding of engineering ideas by presenting information about how technological devices use the principles of wave behavior and wave interactions with matter to transmit and capture information and energy. The crosscutting concepts of *cause and effect; systems and system models*; *stability and change*; *interdependence of science, engineering, and technology; and influence of engineering, technology, and science on society and the natural world* are highlighted as organizing concepts. Students are expected to demonstrate proficiency in *asking questions, engaging in argument from evidence, and obtaining, evaluating, and communicating information*, and they are expected to use these practices to demonstrate understanding of the core ideas.

Time Frame: 40 to 45 days

Enduring Understandings:
The wavelength and frequency of a wave 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.
Waves can add or cancel one another as they cross, depending on their relative phase, but they emerge unaffected by each other.
Electromagnetic radiation 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.
Shorter wavelength electromagnetic radiation can ionize atoms and cause damage to living cells.
Information can be digitized; in this form, it can be stored reliably in computer memory and sent over long distances as a series of wave pulses.

Essential Questions:
How are waves used to transfer energy and send and store information?
Why has digital technology replaced analog technology?
How does a computer store and transmit information?

Standards	Topics and Objectives	Activities	Resources	Assessments
(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-PS4-3)** **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.***	**Topics** Vibrations and Wave Sound Light Electromagnetism Twenty-First Century Themes and Skills include: • The Four C's • Life and Career Skills • Information and Media literacy **Objectives** Students will: Use mathematical representations to support a claim regarding relationships among the frequency, wavelength, and speed of waves traveling in various media. Use models to simulate electromagnetic radiation systems and interactions within and between systems. Communicate qualitative technical information about how some technological devices use the principles of wave behavior and wave interactions with matter to	Students will complete hands on activities and labs for the following topics: 1. Speed of sound lab 2. Light Polarization lab 3. Diffraction lab Students will complete Chapter Launch Labs (see pgs. 375, 403, 431, 457, 485, and 697) to introduce concepts. Students will watch a wave on a string and adjust the amplitude, frequency, damping and tension to demonstrate wave properties in the simulation Wave on a String. (NJSLSA.R7) Students will observe patterns of waves and their interactions using a slinky in the Slinky Lab. Students will investigate wave properties (speed in a medium, reflection, diffraction, interference) using virtual ripple tanks in the Ripple Tank 1 and Ripple Tank 2 simulations. (HS-PS4-1) Students will watch the video The Coolest Things Sound Waves Do to introduce the topic of sound. (NJSLSA.R1)	**Text:** • Glencoe Science: Physics Principals and Problems **Materials:** For Speed of Sound Lab • Speed of sound Kit For Light Polarization and Diffraction labs • Pasco kits—See C&J physics for listings For Launch Labs (see pgs. 375, 403, 431, 457, 485, 697) • Coiled spring • Stemmed glasses of assorted thickness and stem height • Tumbers • Water • Lamp • Flat mirror • Index cards • Push pin • Clay • Concave mirror • Convex mirror • Flashlight • Three 400-mL beakers • 150 mL cooking oil • 150 mL corn syrup • 600 mL water • three straws For **Slinky Lab** • plastic spring toy (Slinky) For **Refraction through Glass**	**Formative Assessments:** • Response Logs • Journals • Conferencing • Discussion • Student prior knowledge will be evaluated after completing the *Launch Labs.* • Student portfolios will be used to monitor progress. **Summative Assessments:** • Models/Projects • Exercises with Extended Essay or Short Responses • Student needs will be assessed after completion of online simulations. • Students will receive a grade for completed lab reports generated in the scientific lab notebook. **Benchmark Assessment:** A Common Formative Assessment will be given at the close of this unit to assess students' mastery of the skills identified. **Alternative Assessments:** • Simulation Games • Questioning

(HS-PS4-2) **Evaluate questions about the advantages of using a digital transmission and storage of information.** **(HS-ETS1-1)** **Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants.** **(HS-ETS1-3)** **Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics as well as possible social, cultural, and environmental impacts.**	transmit and capture information and energy. Consider advantages and disadvantages in the use of digital transmission and storage of information.	Students will adjust the frequency to both see and hear how the wave changes to explain how different sounds are modeled, described, and produced in the Sound Waves simulation. (HS-PS4-3) Students will identify, through experimentation, cause and effect relationships that affect natural resonance of these system in the **Resonance** simulation. (HS-PS4-2) Students will explore the detection of sound waves from a moving source and the change in frequency of the detected wave via the **Doppler Effect** simulation. (HS-PS4-4) Student will interact with the simulation Stellar Velocity: The Doppler Effect to model how the Doppler effect is used to study distant galaxies. (HS-ETS1-1, MP.4, 6.1.12.C.3.a) Students will watch the videos The Sonic Boom Problem, Is Light a Particle or a Wave?, and Light Waves, Visible and Invisible and participate in an online quiz and discussion. (NJSLSA.R, MP.2) Students will trace the course of	• Drawing board • Sheet of paper • Board pins • Rectangular glass slab. **Websites:** • Wave on a String • Slinky Lab • Ripple Tank 1 • Ripple Tank 2 • Sound Waves • **Resonance** • **Doppler Effect** • Stellar Velocity: The Doppler Effect • Introduction to the Electromagnetic Spectrum • Technology for Imaging the Universe • NASA LAUNCHPAD: Making Waves • Interaction of Molecules with Electromagnetic Radiation • Radio Waves and Electromagnetic Fields **Videos:** • The Coolest Things Sound Waves Do • The Sonic Boom Problem • Is Light a Particle or a Wave? • Light Waves, Visible and Invisible • Analogue vs Digital as Fast as Possible	• Practice Presentations • Peer Assessments • Written Questions • Research theory • Observations • Students will analyze and evaluate technological devices that use the principles of wave behavior and wave interactions with matter. • Students will give qualitative descriptions of how photons associated with different frequencies of light have different energies and how the damage to living tissue from electromagnetic radiation depends on the energy of the radiation. • Students will 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. • Students will use models (e.g.,

		different rays of light through a rectangular glass slab at different angles of incidence, measure the angle of incidence, refraction, measure the lateral displacement to verify Snell`s law in the Refraction through Glass lab. Students will explore NASA's websites Introduction to the Electromagnetic Spectrum and Technology for Imaging the Universe to gather background information on the topic. (HS-PS4-5, NJSLSA.R9, A-SSE.A.1, 9.3.ST.2, CRP8) Students will watch NASA e-Clips on the electromagnetic spectrum in the NASA LAUNCHPAD: Making Waves activity. (CRP11) Student will complete the Interaction of Molecules with Electromagnetic Radiation simulation exploring the effect of microwave, infrared, visible and ultraviolet radiation on various molecules. (HS-ETS1-1, NJSLSA.W2, A-SSE.B.3, CRP4) Students will explore Radio Waves and Electromagnetic Fields in a simulation demonstrating wave generation, propagation and detection with antennas. (NJSLSA.W8, A-CED.A.4)	**Enrichment Lesson Plans:** See textbook Mini Labs, **Resonance Tube**, Photoelectric Effect, and Wave/Particle Dualism	physical, mathematical, computer models) to simulate electromagnetic radiation systems and interactions—including energy, matter, and information flows—within and between systems at different scales.

	Students will watch the video Analog vs Digital as Fast as Possible. Students will compare analogue and digital signals in the lesson Digital vs Analog. (9.3.ST.2) **Enrichment Activities:** Student will complete additional textbook Mini Labs. Students will observe the resonance phenomenon in an open ended cylindrical tube, and use the resonance to determine the velocity of sound in air at ordinary temperatures in the **Resonance Tube** activity. Students will use the Photoelectric Effect simulation addressing evidence for particle nature of electromagnetic radiation and the Wave/Particle Dualism simulation of wave and particle views of interference phenomena.	

Accommodations and Modifications:

Students with special needs: Support staff will be available to aid students related to IEP specifications. 504 accommodations will also be attended to by all instructional leaders. Physical expectations and modifications, alternative assessments, and scaffolding strategies will be used to support this learning. The use of Universal Design for Learning (UDL) will be considered for all students as teaching strategies are considered.

ELL/ESL students: Students will be supported according to the recommendations for "can do's" as outlined by WIDA – https://www.wida.us/standards/CAN_DOs/. This particular unit has limited language barriers due to the physical nature of the curriculum.

Students at risk of school failure: Formative and summative data will be used to monitor student success at first signs of failure student work will be reviewed to determine support. This may include parent consultation, basic skills review and differentiation strategies. With considerations to UDL, time may be a factor in overcoming developmental considerations. More time and will be made available with a certified instructor to aid students in reaching the standards.

Gifted and Talented Students: Students excelling in mastery of standards will be challenged with complex, high level challenges related to the complexity in planning and carrying out investigations and analyzing and interpreting data.

English Language Learners	**Special Education**	**At-Risk**	**Gifted and Talented**
• Repeat and rephrase directions as needed • Speak and display terminology • Teacher modeling • Peer modeling • Provide ELL students with multiple literacy strategies. • Word walls • Use peer readers • Give page numbers to help the students find answers • Provide a computer for written work • Provide two sets of textbooks, one for home and one for school • Provide visual aides • Provide additional time to complete a task • Use graphic organizers	• Increase one on one and small group time • Utilize modifications & accommodations delineated in the student's IEP • Work with paraprofessional • Use multi-sensory teaching approaches. • Work with a partner • Provide concrete examples • Restructure lesson using UDL principals (http://www.cast.org/our-work/about-udl.html#.VXmoXcfD_UA). • Provide students with multiple choices for how they can represent their understandings (e.g. multisensory techniques-auditory/visual aids; pictures, illustrations, graphs, charts, data tables, multimedia, modeling).	• Increase one on one and small group time • Using visual demonstrations, illustrations, and models • Give directions/instructions verbally and in simple written format. Oral prompts can be given. • Peer Support • Teachers may modify instructions by modeling what the student is expected to do • Instructions may be printed out in large print and hung up for the student to see during the time of the lesson. • Review behavior expectations and make adjustments for personal space or other behaviors as needed. • Structure lessons around questions that are authentic, relate to students' interests,	• Students can make quiz questions using supporting materials • Inquiry-based instruction • Independent study • Higher order thinking skills • Adjusting the pace of lessons • Interest based content • Real world scenarios • Student Driven Instruction • Engage students with a variety of Science and Engineering practices to provide students with multiple entry points and multiple ways to demonstrate their understandings. • Use project-based science learning to connect science with observable phenomena. • Structure the learning around explaining or solving a social or community-based issue. • Collaborate with after-school programs or clubs to extend learning opportunities.

		social/family background and knowledge of their community. • Provide opportunities for students to connect with people of similar backgrounds (e.g. conversations via digital tool such as SKYPE, experts from the community helping with a project, journal articles, and biographies).	

Interdisciplinary Connections:

ELA-NJSLS/ELA:
NJSLSA.R1: Read closely to determine what the text says explicitly and to make logical inferences and relevant connections from it; cite specific textual evidence when writing or speaking to support conclusions drawn from the text. RST.11-12.1 (HS-PS2-1)
NJSLSA.R7: Integrate and evaluate content presented in diverse media and formats, including visually and quantitatively, as well as in words. RST.11-12.7 (HS-PS2-1)
NJSLSA.R8: Delineate and evaluate the argument and specific claims in a text, including the validity of the reasoning as well as the relevance and sufficiency of the evidence. RST.11-12.8 (HS-ETS1-1), (HS-ETS1-3), (HS-PS4-2), (HS-PS4-3), (HS-PS4-4)
NJSLSA.R9: Analyze and reflect on how two or more texts address similar themes or topics in order to build knowledge or to compare the approaches the authors take. RST.11-12.9 (HS-ETS1-1), (HS-ETS1-3)
NJSLSA.W2: Write informative/explanatory texts to examine and convey complex ideas and information clearly and accurately through the effective selection, organization, and analysis of content. WHST.11-12.2 (HS-PS4-5)
NJSLSA.W8: Gather relevant information from multiple print and digital sources, assess the credibility and accuracy of each source, and integrate the information while avoiding plagiarism. WHST.11-12.8 (HS-PS4-4)

Mathematics:
MP.2: Reason abstractly and quantitatively. (HS-PS2-1)
MP.4: Model with mathematics. (HS-PS2-1)
A-SSE.A.1: Interpret expressions that represent a quantity in terms of its context. (HS-PS2-1)
A-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-PS2-1)
A-CED.A.4: Rearrange formulas to highlight a quantity of interest, using the same reasoning as in solving equations. (HS-PS2-1)

Integration of 21st Century Standards NJSLS 9:
9.3.ST-ET.2: Display and communicate STEM information.
9.3.ST.2: Use technology to acquire, manipulate, analyze and report data.

Social Studies:
6.1.12.C.3.a: Analyze how technological developments transformed the economy, created international markets, and affected the environment in New Jersey and the nation.

Career Ready Practices:
CRP4: Communicate clearly and effectively and with reason.
CRP8: Utilize critical thinking to make sense of problems and persevere in solving them.
CRP11: Use technology to enhance productivity.

Integration of Technology Standards NJSLS 8:
8.2.12.C.4: Explain and identify interdependent systems and their functions.
8.2.12.A.2: Analyze a current technology and the resources used, to identify the trade-offs in terms of availability, cost, desirability and waste.
8.2.12.C.2: Analyze a product and how it has changed or might change over time to meet human needs and wants.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Using Mathematics and Computational Thinking • Use mathematical representations of phenomena or design solutions to describe and/or support claims and/or explanations. (HS-PS4-1)	**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. (HS-PS4-1)	**Cause and Effect** • Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. (HS-PS4-1)

Engaging in Argument from Evidence

- Evaluate the claims, evidence, and reasoning behind currently accepted explanations or solutions to determine the merits of arguments. (HS-PS4-3)

Obtaining, Evaluating, and Communicating Information

- Evaluate the validity and reliability of multiple claims that appear in scientific and technical texts or media reports, verifying the data when possible. (HS-PS4-4)
- Communicate technical information or ideas (e.g. about phenomena and/or the process of development and the design and performance of a proposed process or system) in multiple formats (including orally, graphically, textually, and mathematically). (HS-PS4-5)

Asking Questions and Defining Problems

- Analyze complex real-world problems by specifying criteria and constraints for successful solutions. (HS-ETS1-1)
- Evaluate questions that challenge the premise(s) of an argument, the interpretation of a data set, or the suitability of a design. (HS-PS4-2)

Constructing Explanations and Designing Solutions

- Evaluate a solution to a complex real world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations. (HS-ETS1-3)

PS4.A: Wave Properties

- 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.) (HS-PS4-3)
- 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. (HS-PS4-5)
- 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. (HS-PS4-2)

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. (HS-PS4-3)
- 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. (HS-PS4-4)
- Photoelectric materials emit electrons when they absorb light of a high-enough frequency. (HS-PS45)

PS3.D: Energy in Chemical Processes

Systems and System Models

- Models (e.g., physical, mathematical, computer models) can be used to simulate systems and interactions—including energy, matter, and information flows—within and between systems at different scales. (HS-PS4-3)

Cause and Effect

- Cause and effect relationships can be suggested and predicted for complex natural and human designed systems by examining what is known about smaller scale mechanisms within the system. (HS-PS4-4)
- Systems can be designed to cause a desired effect. (HS-PS4-5)

Stability and Change

- Systems can be designed for greater or lesser stability. (HS-PS4-2)

Interdependence of Science, Engineering, and Technology

- Science and engineering complement each other in the cycle known as research and development (R&D). (HS-PS4-5)

Influence of Engineering, Technology, and Science on Society and the Natural World

- Modern civilization depends on major technological systems. (HS-PS4-5, HS-PS4-2)
- 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. (HS-ETS1-3)
- Engineers continuously modify these technological systems by applying scientific knowledge and engineering design practices to increase benefits while

	• Solar cells are human-made devices that likewise capture the sun's energy and produce electrical energy. (secondary to HS-PS4-5) **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. (HS-PS4-5) **ETS1.A: Defining and Delimiting Engineering Problems** • 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. (HS-ETS1-1) • Humanity faces major global challenges today, such as the need for supplies of clean water and food or for energy sources that minimize pollution, which can be addressed through engineering. These global challenges also may have manifestations in local communities. (HS-ETS1-1) **ETS1.B: Developing Possible Solutions** • When evaluating solutions, it is important to take into account a range of constraints, including cost, safety, reliability, and aesthetics, and to consider social, cultural, and environmental impacts. (HS-ETS1-3)	decreasing costs and risks. (HSPS4-2) **Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena** • A scientific theory is a substantiated explanation of some aspect of the natural world, based on a body of facts that have been repeatedly confirmed through observation and experiment. The science community validates each theory before it is accepted. If new evidence is discovered that the theory does not accommodate, the theory is generally modified in light of this new evidence. (HS-PS4-3)