Unit 3: Waves, Sound, and Light

Content Area: **Science**
Course(s): **Physics H/Lab**
Time Period: **JanFeb**
Length: **Sample Length & Grade Level**
Status: **Published**

Title Section

Department of Curriculum and Instruction

Belleville Public Schools

Curriculum Guide

Unit 3

Waves, Sound, and Light

Belleville Board of Education

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Board Approved: October 17, 2016

Unit Overview

In this unit, students will investigate the nature of vibrational motion in the form of waves and wave phenomena. This unit will build on prior knowledge gained in the previous unit on motion by analyzing simple harmonic motion as a natural outgrowth of prior knowledge. Students will examine systems such as a pendulum and a mass on a spring, and will be able to describe how simple harmonic motion relates to wave-like behavior. Building on this knowledge with specialized vocabulary, students will be able to determine how a wave moves through space, what the various forms of waves are, and how those waves can be generated. Ideas of period, frequency, wavelength, and wave speed will be crucial to this development. In addition, students will examine the nature of sound waves, and how sound propagates through space via a medium. Students will be able to describe and explain the nature of sound and the human perception of sound through various phenomena such as reverberation, echo, resonance, pitch, harmonics, timbre, and loudness. Finally, students will investigate the nature of light as a wave and how it moves through space. Students will be able to describe and explain the wave theory of light, the ray model of light, the nature of color and pigment, and various light phenomena such as Doppler Effect and reflection in mirrors.

NJSLS

SEP.1	Asking Questions and Defining Problems
CCC.2	Cause and effect: Mechanism and explanation.
CCC.4	Systems and system models.
CCC.7	Stability and change.
SEP.5	Using Mathematics and Computational Thinking

SEP.7	Engaging in Argument from Evidence
SEP.8	Obtaining, Evaluating, and Communicating Information
SCI.HS-PS4-1	Use mathematical representations to support a claim regarding relationships among the frequency, wavelength, and speed of waves traveling in various media.
SCI.HS-PS4	Waves and Their Applications in Technologies for Information Transfer
SCI.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.
SCI.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.
SCI.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.
SCI.HS-PS4-2	Evaluate questions about the advantages of using a digital transmission and storage of information.

Exit Skills

By the end of Unit 3 Students will:

1. Describe the force in an elastic spring.
2. Determine the energy stored in an elastic spring.
3. Compare simple harmonic motion and the motion of a pendulum.
4. Identify how waves transfer energy without transferring matter.
5. Contrast transverse and longitudinal waves.
6. Relate wave speed, wavelength, and frequency.
7. Relate a wave's speed to the medium and refracted at boundaries between media.
8. Apply the principle of superposition to the phenomenon of interference.
9. Demonstrate the properties that sound shares with other waves.
10. Relate the physical properties of sound waves to our perception of sound.
11. Identify some applications of the Doppler Effect.
12. Describe the origin of sound.
13. Demonstrate an understanding of resonance, especially as applied to air columns and strings.
14. Explain why there are variations in sound among instruments and among voices.
15. Develop the ray model of light.
16. Predict the effect of distance on light's illuminance.
17. Solve problems involving the speed of light.
18. Describe how diffraction demonstrates that light is a wave.
19. Predict the effect of mixing colors of light and pigments.
20. Explain phenomena such as polarization and the Doppler Effect.
21. Explain the law of reflection.
22. Distinguish between specular and diffuse reflection.
23. Locate the images formed by plane mirrors.
24. Explain how concave and convex mirrors form images.
25. Describe properties and uses of spherical mirrors.
26. Determine the locations and sizes spherical mirror images.
27. Solve problems involving refraction.
28. Explain total internal reflection.

29. Explain some optical effects caused by refraction.
30. Describe how real and virtual images are formed by single convex and concave lenses.
31. Locate images formed by lenses using ray tracing and equations.
32. Explain how chromatic aberration can be reduced.
33. Describe how the eye focuses light to form an image.
34. Explain nearsightedness and farsightedness and how eyeglass lenses correct these defects.
35. Describe the optical systems in some common optical instruments.
36. Explain how light falling on two slits produces and interference pattern.
37. Calculate light wavelengths from interference patterns.
38. Apply modeling techniques to thin-film interference.
39. Explain how diffraction gratings form diffraction patterns.
40. Describe how diffraction gratings are used in grating spectrometers.
41. Discuss how diffraction limits the ability to distinguish two closely spaced objects with a lens.

Enduring Understanding

Unit Enduring Understandings:

• Students will relate to their world in a more detailed and scientific manner.
• Students will identify how their new understandings can be applied to real-world phenomena.
• Sound waves are longitudinal waves that travel parallel to the direction in which they move. In order to do so, these types of waves need to vibrate a medium.

Definition: *Enduring Understandings*

Enduring understandings are statements summarizing important ideas and core processes that are central to a discipline and have lasting value beyond the classroom. They synthesize what students should understand—not just know or do—as a result of studying a particular content area. Moreover, they articulate what students should "revisit" over the course of their lifetimes in relationship to the content area.

Enduring understandings:

1. Frame the big ideas that give meaning and lasting importance to such discrete curriculum elements as facts and skills
2. Can transfer to other fields as well as adult life
3. "Unpack" areas of the curriculum where students may struggle to gain understanding or demonstrate misunderstandings and misconceptions
4. Provide a conceptual foundation for studying the content area and
5. Are deliberately framed as declarative sentences that present major curriculum generalizations and recurrent ideas.

Example:

Reading/Literature

This is an Enduring Understanding

Reading is a process by which we construct meaning about the information being communicated by an author within a print or non-print medium.

This is an Essential Question

How is reading a process of constructing meaning from text?

Essential Questions

Unit Essential Questions:

What are the different ways energy can be transmitted through space?
How do physicists describe wave behavior, specifically with respect to sound and light?
Where do waves come from?
How do you know that waves carry energy?
Explain how knowledge of waves helps us understand our world better and improve the quality of our lives?
Why do sound waves need a medium through which to travel?
What are the differences between infrasonic, audible and ultrasonic sound waves?

Essential Question: A question that lies at the heart of a subject or a curriculum and one that promotes inquiry and the discovery of a subject.

•They can help students discover patterns in knowledge and solve problems.
•They support inductive teaching—guiding students to discover meaning, which increases motivation to learn.
•They are one of the most powerful tools for helping students think at more complex levels.
•They engage the personal intellect—something that traditional objectives usually fail to do.
•Have no obvious "right" answer
•Raise other important questions, often across subject-area boundaries
•Address a concept
•Raise other important questions
•Naturally and appropriately recur
•Stimulate critical, ongoing rethinking
•Are framed to provoke and sustain student interest

What makes a Questions "Essential?"
•Continues throughout all our lives
•Refers to core ideas and inquiries within a discipline
•Helps students effectively ask questions and make sense of important and complex ideas, knowledge, and know-how
•Engages a specific and diverse set of learners

Two Types of Essential Questions:

•Overarching: The overall "Big Idea"
- •More general, broader
- •Point beyond specific topics or skills
- •Promote the transfer of understanding

•Topical: Unit or lesson specific but still promotes inquiry
- •Unit or lesson specific - used to guide individual units or lessons
- •Promote inquiry
- •Resist obvious answers
- •Require explanation and justification

Examples:

•What is a true friend?
•What makes an artist amazing?
•In what sense is the body a system?
•What is the law of nature, and how is it like or unlike social laws?
•To what extent is US history a history of progress?
•In what ways do diet and exercise affect health?
•Must heroes be flawless?
•How do effective writers hook and hold their readers?
•How do cultures affect one another?
•Does practice make perfect?
•What is healthy eating? Healthy living?
•How and when do we use mathematics?
•How does something acquire value?

Learning Objectives

Students will be able to...

Compare simple harmonic motion and the motion of a pendulum.
Describe the force in an elastic spring.
Determine the energy stored in an elastic spring.
Identify how waves transfer energy without transferring matter.
Relate wave speed, wavelength, and frequency.
Contrast transverse and longitudinal waves.
Relate a wave's speed to the medium and refracted at boundaries between media.
Apply the principle of superposition to the phenomenon of interference.
Demonstrate the properties that sound shares with other waves.
Relate the physical properties of sound waves to our perception of sound.
Identify some applications of the Doppler Effect.
Describe the origin of sound.
Demonstrate an understanding of resonance, especially as applied to air columns and strings.
Explain why there are variations in sound among instruments and among voices.
Develop the ray model of light.
Solve problems involving the speed of light.
Describe how diffraction demonstrates that light is a wave.

Predict the effect of mixing colors of light and pigments.
Explain phenomena such as the Doppler Effect.
Explain the law of reflection.
Distinguish between specular and diffuse reflection.
Locate the images formed by plane mirrors.
Explain how concave and convex mirrors form images.
Describe properties and uses of spherical mirrors.
Solve problems involving refraction.
Explain total internal reflection.
Explain some optical effects caused by refraction.
Describe how real virtual images are formed by single convex and concave lenses.
Locate images formed by lenses using ray tracing and equations.
Explain how chromatic aberration can be reduced.
Describe how the eye focuses light to form an image.
Explain nearsightedness and farsightedness and how eyeglass lenses correct these defects.
Describe the optical systems in some common optical instruments.
Explain how light falling on two slits produces and interference pattern.
Calculate light wavelengths from interference patterns.
Apply modeling techniques to thin-film interference.

Tips on Writing Good Learning Objectives

Bloom's Taxonomy

Applying Bloom's Taxonomy to Learning Objectives

Effective learning objectives need to be observable and/or measureable, and using action verbs is a way to achieve this. Verbs such as "identify", "argue," or "construct" are more measureable than vague or passive verbs such as "understand" or "be aware of". As you develop your syllabus focus on articulating clear learning objectives and then use these objectives to guide class assignments, exams and overall course assessment questions.

Sample Learning Objectives for a Lower Division Course

After completing Nutrition 101 *Humans and Food*, students will be able to:

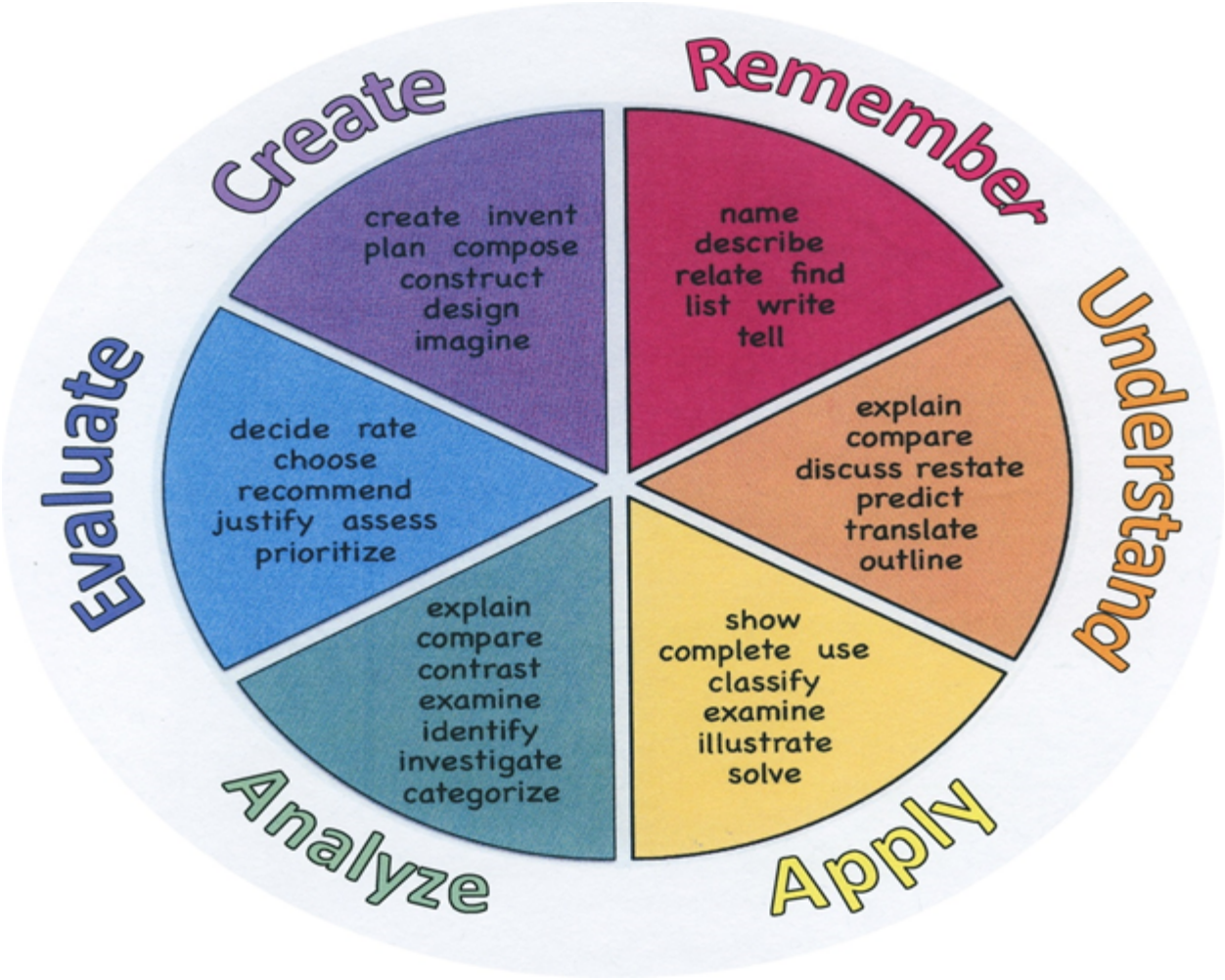
- **Identify** nutrients found in common food sources via the product's nutrition label
- Use computer dietary analysis to assess a 2-day dietary intake and **summarize** results
- **Locate** nutrition-related information on the Internet and use **evaluative** criteria to **identify** reliability of the information

Action Verbs

Below are examples of action verbs associated with each level of the Revised Bloom's Taxonomy. These are useful in writing learning objectives, assignment objectives and exam questions.

Remember	Understand	Apply	Analyze	Evaluate	Create
Choose	Classify	Choose	Categorize	Appraise	Combine

Describe	Defend	Dramatize	Classify	Judge	Compose
Define	Demonstrate	Explain	Compare	Criticize	Construct
Label	Distinguish	Generalize	Differentiate	Defend	Design
List	Explain	Judge	Distinguish	Compare	Develop
Locate	Express	Organize	Identify	Assess	Formulate
Match	Extend	Paint	Infer	Conclude	Hypothesize
Memorize	Give Examples	Prepare	Point out	Contrast	Invent
Name	Illustrate	Produce	Select	Critique	Make
Omit	Indicate	Select	Subdivide	Determine	Originate
Recite	Interrelate	Show	Survey	Grade	Organize
Select	Interpret	Sketch	Arrange	Justify	Plan
State	Infer	Solve	Breakdown	Measure	Produce
Count	Match	Use	Combine	Rank	Role Play
Draw	Paraphrase	Add	Detect	Rate	Drive
Outline	Represent	Calculate	Diagram	Support	Devise
Point	Restate	Change	Discriminate	Test	Generate
Quote	Rewrite	Classify	Illustrate		Integrate
Recall	Select	Complete	Outline		Prescribe
Recognize	Show	Compute	Point out		Propose
Repeat	Summarize	Discover	Separate		Reconstruct
Reproduce	Tell	Divide			Revise
	Translate	Examine			Rewrite
	Associate	Graph			Transform
	Compute	Interpolate			
	Convert	Manipulate			
	Discuss	Modify			
	Estimate	Operate			
	Extrapolate	Subtract			
	Generalize				
	Predict				



Interdisciplinary Connections

Please list all and any cross-curricular content standards that link to this Unit.

MA.K-12.2	Reason abstractly and quantitatively.
MA.K-12.4	Model with mathematics.
MA.N-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.
MA.N-Q.A.2	Define appropriate quantities for the purpose of descriptive modeling.
MA.N-Q.A.3	Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.
LA.RST.11-12.1	Accurately cite strong and thorough evidence from the text to support analysis of science and technical texts, attending to precise details for explanations or descriptions.
LA.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.

LA.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.
LA.WHST.11-12.9	Draw evidence from informational texts to support analysis, reflection, and research.
LA.SL.11-12.4	Present information, findings and supporting evidence clearly, concisely, and logically. The content, organization, development, and style are appropriate to task, purpose, and audience.
LA.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.

Alignment to 21st Century Skills & Technology

Key SUBJECTS AND 21st CENTURY THEMES

Mastery of key subjects and 21st century themes is essential for all students in the 21stcentury.

Key subjects include:

- English, reading or language arts
- World languages
- Arts
- Mathematics
- Economics
- Science
- Geography
- History
- Government and Civics

21st Century/Interdisciplinary Themes

- Civic Literacy
- Environmental Literacy
- Financial, Economic, Business and Entrepreneurial Literacy
- Global Awareness
- Health Literacy

21st Century Skills

- Communication and Collaboration
- Creativity and Innovation
- Critical thinking and Problem Solving

- ICT (Information, Communications and Technology) Literacy
- Information Literacy
- Life and Career Skills
- Media Literacy

Technology Infusion

What technology can be used in this unit to enhance learning?



Differentiation

As a Reminder:

The basis of good differentiation in a lesson lies in differentiating by content, process, and/or product.

Resources:

- NJDOE: Instructional Supports and Scaffolds for Success in Implementing the Common Core State Standards http://www.state.nj.us/education/modelcurriculum/success/math/k2/

Special Education

- printed copy of board work/notes provided
- additional time for skill mastery
- assistive technology
- behavior management plan
- Center-Based Instruction
- check work frequently for understanding
- computer or electronic device utilizes
- extended time on tests/ quizzes
- have student repeat directions to check for understanding
- highlighted text visual presentation
- modified assignment format
- modified test content
- modified test format
- modified test length
- multi-sensory presentation
- multiple test sessions
- preferential seating
- preview of content, concepts, and vocabulary
- reduced/shortened reading assignments
- Reduced/shortened written assignments
- secure attention before giving instruction/directions
- shortened assignments
- student working with an assigned partner
- teacher initiated weekly assignment sheet
- Use open book, study guides, test prototypes

ELL

- teaching key aspects of a topic. Eliminate nonessential information

- using videos, illustrations, pictures, and drawings to explain or clarif
- allowing products (projects, timelines, demonstrations, models, drawings, dioramas, poster boards, charts, graphs, slide shows, videos, etc.) to demonstrate student's learning;
- allowing students to correct errors (looking for understanding)
- allowing the use of note cards or open-book during testing
- decreasing the amount of workpresented or required
- having peers take notes or providing a copy of the teacher's notes
- modifying tests to reflect selected objectives
- providing study guides
- reducing or omitting lengthy outside reading assignments
- reducing the number of answer choices on a multiple choice test
- tutoring by peers
- using computer word processing spell check and grammar check features
- using true/false, matching, or fill in the blank tests in lieu of essay tests

Intervention Strategies

- allowing students to correct errors (looking for understanding)
- teaching key aspects of a topic. Eliminate nonessential information
- allowing products (projects, timelines, demonstrations, models, drawings, dioramas, poster boards, charts, graphs, slide shows, videos, etc.) to demonstrate student's learning
- allowing students to select from given choices
- allowing the use of note cards or open-book during testing
- collaborating (general education teacher and specialist) to modify vocabulary, omit or modify items to reflect objectives for the student, eliminate sections of the test, and determine how the grade will be determined prior to giving the test.
- decreasing the amount of workpresented or required
- having peers take notes or providing a copy of the teacher's notes
- marking students' correct and acceptable work, not the mistakes
- modifying tests to reflect selected objectives
- providing study guides
- reducing or omitting lengthy outside reading assignments
- reducing the number of answer choices on a multiple choice test
- tutoring by peers
- using authentic assessments with real-life problem-solving
- using true/false, matching, or fill in the blank tests in lieu of essay tests
- using videos, illustrations, pictures, and drawings to explain or clarify

Evidence of Student Learning-CFU's

Please list ways educators may effectively check for understanding in this secion.

- Admit Tickets
- Anticipation Guide
- Common benchmarks
- Compare & Contrast
- Create a Multimedia Poster
- Define
- Describe
- Evaluate
- Evaluation rubrics
- Exit Tickets
- Explaining
- Fist- to-Five or Thumb-Ometer
- Illustration
- Journals
- KWL Chart
- Newspaper Headline
- Outline
- Question Stems
- Quickwrite
- Quizzes
- Red Light, Green Light
- Self- assessments
- Socratic Seminar
- Study Guide
- Teacher Observation Checklist
- Think, Pair, Share
- Think, Write, Pair, Share
- Top 10 List
- Unit tests

Primary Resources

Textbook

Internet

Science Department Video Library

Ancillary Resources

Teacher Prepared Materials

Lab Materials

Study Guide Materials

United Streaming Videos

The Physics Classroom: www.thephysicsclassroom.com

STEM Lab

Sample Lesson

One Lesson per Curriculum must bein this lesson plan template. I.e. one lesson in one unit

Unit Name:

NJSLS:

Interdisciplinary Connection:

Statement of Objective:

Anticipatory Set/Do Now:

Learning Activity:

Student Assessment/CFU's:

Materials:

21st Century Themes and Skills:

Differentiation/Modifications:

Integration of Technology: