UNIT 4: Waves

Content Area: **Science**
Course(s): **IB physics, SL**
Time Period: **Second Marking period**
Length: **4 Week**
Status: **Published**

Unit Overview

Oscillations are a very common phenomenon in all areas of physics. Oscillations play a great part in our lives, from the tides to the motion of the swinging pendulum that once governed our perception of time. The simple harmonic oscillator is of great importance to physicists because all periodic oscillations can be described through the mathematics of simple harmonic motion. Scientists have discovered common features of wave motion through careful observations of the natural world, looking for patterns, trends and discrepancies and asking further questions based on these findings. Waves interact with media and each other in a number of ways that can be unexpected and useful.

STAGE 1- DESIRED RESULTS

2020 New Jersey Student Learning Standards- Science

SCI.9-12.HS-PS3-2	Develop and use models to illustrate that energy at the macroscopic scale can be accounted for as a combination of energy associated with the motion of particles (objects) and energy associated with the relative position of particles (objects).
SCI.9-12.HS-PS3	Energy
SCI.9-12.HS-PS3-1	Create a computational model to calculate the change in the energy of one component in a system when the change in energy of the other component(s) and energy flows in and out of the system are known.
SCI.9-12.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.
SCI.9-12.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.9-12.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.9-12.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.

Science and Engineering Practices

- Analyzing and Interpreting Data
- Asking Questions and Defining Problems
- Constructing Explanations and Designing Solutions
- Developing and Using Models
- Engaging in Argument from Evidence
- Obtaining, Evaluating, and Communicating Information
- Planning and Carrying Out Information
- Using Mathematics and Computational Thinking

Cross Cutting Concepts

- Cause and Effect
- Energy and Matter
- Influence of Engineering, Technology, and Science on Society and the Natural World
- Interdependence of Science, Engineering, and Technology
- Patterns
- Scale, Proportion, and Quantity
- Stability and Change
- Structure and Functions
- Systems and System Models

Disciplinary Core Ideas

PS4 A: Wave Properties

PS4 B: Electromagnetic Radiation

Physical Sciences

- PS1A: Structure and Properties of Matter
- PS1B: Chemical Reactions
- PS1C: Nuclear Processes
- PS2A: Forces and Motion
- PS2B: Types of Interaction
- PS3A: Definitions of Energy

- PS3B: Conservation of Energy and Energy Transfer
- PS3C: Relationship Between Energy and Forces
- PS3D: Energy in Chemical Processes and Everyday Life
- PS4A: Wave Properties
- PS4B: Electromagnetic Radiation
- PS4C: Information Technologies and Instrumentation

Earth and Space Sciences

- ESS1A: The Universe and its Stars
- ESS1B: Earth and the Solar System
- ESS1C: The History of Planet Earth
- ESS2A: Earth Materials and Systems
- ESS2B: Plate Tectonics and Large-Scale Systems
- ESS2C: The Role of Water in Earth's Surface Processes
- ESS2D: Weather and Climate
- ESS2E: Biogeology
- ESS3A: Natural Resources
- ESS3B: Natural Hazards
- ESS3C: Human Impacts on Earth Systems
- ESS3D: Global Climate Change

Engineering. Technology. and Applications of Science

- ETS1A: Defining and Delimiting an Engineering Problem
- ETS1B: Developing Possible Solutioins
- ETS1C: Optimizing the Design Solution

Essential Questions

- How are waves used to transfer energy, information and to extend human senses?
- What characterizes an object's motion as simple harmonic?
- What is common to all waves?
- How do transverse and longitudinal waves differ?
- Why do sound waves need a medium through which to travel?
- What is one advantage of transferring energy by electromagnetic waves?
- Can more than two waves interfere in a given medium?
- Why does a clear stream always appear to be shallower than it actually is?
- Why does a diamond show flashes of color when observed under ordinary white light?
- Under what conditions is the interference of light most noticeable?

- Why do sound waves diffract more readily than light waves?
- What type of interference pattern does a diffraction grating produce?
- How does a standing wave form?

Enduring Understanding

A study of oscillations underpins many areas of physics with simple harmonic motion, a fundamental oscillation that appears in various natural phenomena. There are many forms of waves available to be studied. A common characteristic of all traveling waves is that they carry energy, but generally the medium through which they travel will not be permanently disturbed. All waves can be described by the same sets of mathematical ideas. Detailed knowledge of one area leads to the possibility of prediction in another. Waves interact with media and each other in a number of ways that can be unexpected and useful. When traveling waves meet they can superpose to form standing waves in which energy may not be transferred.

Students will know…

- Simple harmonic oscillations
- Time period, frequency, amplitude, displacement and phase difference
- Conditions for simple harmonic motion
- Traveling waves
- Wavelength, frequency, period and wave speed
- Transverse and longitudinal waves
- The nature of electromagnetic waves
- The nature of sound waves
- Wavefronts and rays
- Amplitude and intensity
- Superposition
- Polarization
- Reflection and refraction
- Snell’s law, critical angle and total internal reflection
- Diffraction through a single-slit and around objects
- Interference patterns
- Double-slit interference
- Path difference
- The nature of standing waves
- Boundary conditions
- Nodes and antinodes

Possible Misconceptions

- There must be a medium for a wave to travel through.
- Waves do not have energy.
- All waves travel the same way.
- Matter moves along with waves as the waves move through the medium.

Students will be able to...

- Qualitatively describe the energy changes taking place during one cycle of an oscillation.
- Sketch and interpret graphs of simple harmonic motion examples.
- Explain the motion of particles of a medium when a wave passes through it for both transverse and longitudinal cases.
- Sketch and interpret displacement–distance graphs and displacement–time graphs for transverse and longitudinal waves.
- Solve problems involving wave speed, frequency and wavelength.
- Investigate the speed of sound experimentally.
- Sketch and interpret diagrams involving wavefronts and rays.
- Solve problems involving amplitude, intensity and the inverse square law.
- Sketch and interpret the superposition of pulses and waves.
- Describe methods of polarization.
- Sketch and interpret diagrams illustrating polarized, reflected and transmitted beams.
- Solve problems involving Malus's law.
- Sketch and interpret incident, reflected and transmitted waves at boundaries between media.
- Solve problems involving reflection at a plane interface.
- Solve problems involving Snell's law, critical angle and total internal reflection.
- Determine refractive index experimentally.
- Qualitatively describe the diffraction pattern formed when plane waves are incident normally on a single-slit.
- Quantitatively describe double-slit interference intensity patterns.
- Describe the nature and formation of standing waves in terms of superposition.
- Distinguish between standing and traveling waves.
- Observe, sketch and interpret standing wave patterns in strings and pipes.
- Solve problems involving the frequency of a harmonic, length of the standing wave and the speed of the wave.

STAGE 2- EVIDENCE OF LEARNING

Formative Assessment

- 3- Minute Pause

- A-B-C Summaries
- Analogy Prompt
- Choral Response
- Debriefing
- Exit Card / Ticket
- Hand Signals
- Idea Spinner
- Index Card Summaries
- Inside-Outside Circle Discussion (Fishbowl)
- Journal Entry
- Misconception Check
- Observation
- One Minute Essay
- One Word Summary
- Portfolio Check
- Questions & Answers
- Quiz
- Self-Assessment
- Student Conference
- Think-Pair-Share
- Web or Concept Map

Authentic Assessments

Sketching & interpreting: Graphs of SHM, displacement –distance & displacement–time graphs for transverse & longitudinal waves, Superposition of pulse & waves, Standing waves patterns in strings & pipes, Wavefronts and rays; Incident, reflected & transmitted waves at boundaries between media, Intensity graphs of double slit interference

Worksheet on: acceleration, velocity and displacement and energy transfer during simple harmonic motion, Wave speed, frequency and wavelength, Amplitude, intensity and the inverse square Frequency of a harmonic, length of standing wave & the speed of the wave; Reflection at a plane surface, Snell's law, Critical angle and total internal reflection**.**

Lab Activity - Investigating the speed of sound, g using simple pendulum , Wave tank , Investigating Resonance ; Investigating Young's double slit; Determining refractive index, Measuring either light wavelength or slit width using single slit diffraction.

Quizzes and tests

Benchmark Assessments

Unit Test

STAGE 3- LEARNING PLAN

Instructional Map

- Students will be given the details of the learning outcome of the unit in the beginning of the unit. Every day at the beginning of the class, expected questions/goal will be written on the board.
- Steps to be followed, writing all meaning of important vocabularies on board, using ICT and/or address information literacy, you tube videos , ppt, use of graph plotting software, Simulations using java applets.
- Distinguish between frequency and period and explain how they are related.
- Identify the condition required for simple harmonic motion to occur in an oscillating system.
- Calculate the period of a mass-spring system in simple harmonic motion.
- Graphs describing simple harmonic motion should include displacement–time, velocity–time, acceleration–time and acceleration–displacement.
- Students are expected to understand the significance of the negative sign in the relationship: $F = -kx$.
- Calculate the period of a pendulum based on its length and the acceleration due to gravity.
- Define resonance and explain its practical implications.
- Compare and contrast the motion of a wave with the motion of the particles making up the wave.
- Recognize that the speed of a wave depends on the medium through which it travels.
- Students will discover the properties of standing waves and make predictions about harmonics.
- Describe how overlapping waves interfere constructively and destructively.
- Explain how standing waves are formed.
- Describe the structure of an electromagnetic wave.
- Calculate the wavelength of an electromagnetic wave with a known frequency.
- Students should be aware of the order of magnitude of the wavelengths of radio, microwave, infrared, visible, ultraviolet, X-ray and gamma rays.
- Students will be expected to calculate the resultant of two waves or pulses both graphically and algebraically.
- Define polarization and identify the polarization direction of a linearly polarized electromagnetic wave.
- Describe the effect a polarizer has on an unpolarized beam of light.
- Methods of polarization will be restricted to the use of polarizing filters and reflection from a non-metallic plane surface.
- Compare the speed of light in a material to the speed of light in a vacuum.
- List the conditions that are required in order for refraction to occur.
- Recognize that the index of refraction of a material depends on the color of the light being refracted.
- Quantitative descriptions of refractive index are limited to light rays passing between two or more

transparent media. If more than two media, only parallel interfaces will be considered.
- Calculate the path-length differences that lead to constructive and destructive interference.
- Explain why waves spread out after passing through a small opening.
- Define diffraction and explain why sound waves diffract more than light waves.
- Use water waves to demonstrate diffraction.
- Have students research how the pupil of the human eye responds to different levels of light. Students should use diffraction to explain their findings.
- Describe the interference pattern produced by a diffraction grating.
- Students will not be expected to derive the double-slit equation.
- Students should have the opportunity to observe diffraction and interference patterns arising from more than one type of wave.
- Identify the locations of nodes and antinodes in a standing sound wave in a pipe that is open at one end.
- Identify the locations of nodes and antinodes in a standing sound wave in a pipe that is open at both ends.
- Students will be expected to consider the formation of standing waves from the superposition of no more than two waves.
- Boundary conditions for strings are: two fixed boundaries; fixed and free boundary; two free boundaries.
- Boundary conditions for pipes are: two closed boundaries; closed and open boundary; two open boundaries.
- For standing waves in air, explanations will not be required in terms of pressure nodes and pressure antinodes.
- The lowest frequency mode of a standing wave is known as the first harmonic.
- The terms *fundamental* and *overtone* will not be used in examination questions.

Lab work

- mass on a spring;
- simple pendulum;
- speed of waves in different media;
- superposition of waves;
- representation of wave types using physical models (eg slinky demonstrations)
- determination of refractive index and application of Snell's law;
- determining conditions under which total internal reflection may occur;
- examination of diffraction patterns through apertures and around obstacles;
- investigation of the double-slit experiment;
- observation of standing wave patterns in physical objects (eg slinky springs);
- prediction of harmonic locations in an air tube in water; determining the frequency of tuning forks;
- observing or measuring vibrating violin/guitar strings;
- measuring the vibrations of a tuning fork;

Modification/Differentiation of Instruction

Differentiation Strategies for Special Education Students

- Remove unnecessary material, words, etc., that can distract from the content
- Use of off-grade level materials
- Provide appropriate scaffolding
- Limit the number of steps required for completion
- Time allowed
- Level of independence required
- Tiered centers, assignments, lessons, or products
- Provide appropriate leveled reading materials
- Deliver the content in "chunks"
- Varied texts and supplementary materials
- Use technology, if available and appropriate
- Varied homework and products
- Varied questioning strategies
- Provide background knowledge
- Define key vocabulary, multiple-meaning words, and figurative language.
- Use audio and visual supports, if available and appropriate
- Provide multiple learning opportunities to reinforce key concepts and vocabulary
- Meet with small groups to reteach idea/skill
- Provide cross-content application of concepts
- Ability to work at their own pace
- Present ideas using auditory, visual, kinesthetic, & tactile means
- Provide graphic organizers and/or highlighted materials
- Strategy and flexible groups based on formative assessment
- Differentiated checklists and rubrics, if available and appropriate

Differentiation Strategies for Gifted and Talented Students

- Increase the level of complexity
- Decrease scaffolding
- Variety of finished products
- Allow for greater independence
- Learning stations, interest groups
- Varied texts and supplementary materials
- Use of technology
- Flexibility in assignments
- Varied questioning strategies
- Encourage research
- Strategy and flexible groups based on formative assessment or student choice
- Acceleration within a unit of study
- Exposure to more advanced or complex concepts, abstractions, and materials
- Encourage students to move through content areas at their own pace

- After mastery of a unit, provide students with more advanced learning activities, not more of the same activity
- Present information using a thematic, broad-based, and integrative content, rather than just single-subject areas

Differentiated Strategies for ELL Students

- Remove unnecessary materials, words, etc., that can distract from the content
- Provide appropriate scaffolding
- Limit the number of steps required for completion
- Gradually increase the level of independence required
- Tiered centers, assignments, lessons, or products
- Provide appropriate leveled reading materials
- Deliver the content in “chunks”
- Varied texts and supplementary materials, including visuals
- Use technology, if available and appropriate
- Differentiate homework and products
- Varied questioning strategies
- Provide background knowledge
- Define key vocabulary, multiple-meaning words, and figurative language.
- Use audio and visual supports, if available and appropriate
- Provide multiple learning opportunities to reinforce key concepts and vocabulary
- Meet with small groups to reteach idea/skill
- Provide cross-content application of concepts
- Allow students to work at their own pace
- Presenting ideas through auditory, visual, kinesthetic, & tactile means
- Role play
- Provide graphic organizers, highlighted materials
- Strategy and flexible groups based on formative assessment

Differentiation Strategies for At Risk Students

- Remove unnecessary materials, words, etc., that can distract from the content
- Provide appropriate scaffolding
- Limit the number of steps required for completion
- Gradually increase the level of independence required
- Tiered centers, assignments, lessons, or products
- Provide appropriate leveled reading materials
- Deliver the content in “chunks”
- Varied texts and supplementary materials
- Use technology, if available and appropriate

- Differentiate homework and products
- Varied questioning strategies
- Provide background knowledge
- Define key vocabulary, multiple-meaning words, and figurative language
- Use audio and visual supports, if available and appropriate
- Provide multiple learning opportunities to reinforce key concepts and vocabulary
- Meet with small groups to reteach idea/skill
- Provide cross-content application of concepts
- Presenting ideas through auditory, visual, kinesthetic, & tactile means
- Provide graphic organizers and/or highlighted materials
- Strategy and flexible groups based on formative assessment

504 Plans

Students can qualify for 504 plans if they have physical or mental impairments that affect or limit any of their abilities to:

- walk, breathe, eat, or sleep
- communicate, see, hear, or speak
- read, concentrate, think, or learn
- stand, bend, lift, or work

Examples of accommodations in 504 plans include:

- preferential seating
- extended time on tests and assignments
- reduced homework or classwork
- verbal, visual, or technology aids
- modified textbooks or audio-video materials
- behavior management support
- adjusted class schedules or grading
- verbal testing
- excused lateness, absence, or missed classwork
- pre-approved nurse's office visits and accompaniment to visits
- occupational or physical therapy

Peer Tutoring

Repeated Drill and Practice

Cooperative Grouping

Teacher notes

Use of additional reference materials

Modification Strategies

- Cooperative Grouping
- Extended Time
- Frequent Breaks
- Highlighted Text
- Interactive Notebook
- Modified Test
- Oral Directions
- Peer Tutoring
- Preferential Seating
- Re-direct
- Repeated Drill and Practice
- Shortened Assisgnment
- Teacher Notes
- Tutorials
- Use of Additional Reference Materials
- Use of Audio Resources

Differentiation Strategies

High Preparation

- Alternative Assessments
- Choice Boards
- Games and Tournaments
- Group Investigations
- Guided Reading
- Independent Research / Project
- Interest Groups
- Learning Contracts
- Leveled Rubrics
- Literature Circles
- Multiple Intelligence Options

- Multiple Texts
- Personal Agendas
- Project Based Learning (PBL)
- Stations / Centers
- Think-Tac-Toe
- Tiered Activities / Assignments
- Varying Graphic Organizers

Low Preparation

- Choice of Book / Activity
- Cubing Activities
- Exploration by Interest (using interest inventories)
- Flexible Grouping
- Goal Setting With Student
- Homework Options
- Jigsaw
- Mini Workshops to Re-teach or Extend Skills
- Open-ended Activities
- Think-Pair-Share by Readiness, Interest, or Learning Style
- Use of Collaboration
- Use of Reading Buddies
- Varied Journal Prompts
- Varied Product Choice
- Varied Supplemental Materials
- Work Alone / Together

Horizontal Intergration- Interdisciplinary Connections

See Appendix

Vertical Integration- Discipline Mapping

Physics IB SL course is offered during the Junior and Senior years of High School. At this point in their studies, students will have been exposed to the Performance Expectations of the NGSS in Middle school. This course will allow the student to further expand and develop a deeper understanding of the physics concepts taught in earlier years.

Tenth grade Chemistry

Eighth Grade - Chemical Interactions

Seventh Grade - Electromagnetic Force and Gravity and Kinetic Energy

Sixth Grade - Waves

Additional Materials

Internet resources:

Khan Academy

Physicsclassroom.com

Youtube videos

Phet.colorado.edu

http://phet.colorado.edu/en/simulation/wave-on-a-string

http://phet.colorado.edu/en/simulation/bending-light

http://phet.colorado.edu/en/simulation/wave-intereference

http://phet.colorado.edu/en/simulation/resonance

http://phet.colorado.edu/en/simulation/wave-interference

http://www.animations.physics.unsw.edu.au/waves-sound/Doppler/