WAVES
(TWO WEEKS)(Phyics OnLevel, Honors/ AP)

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SUBJECT/GRADE LEVEL
Subject Area: Waves (Physics/Advanced Physics)

Grade Level: High School

Video

Materials
- Slinkies
- Water Tank or simulations listed below
- Copies of Articles
- Access to internet for websites
- Radio
- Speakers
- X-ray, GPS & satellite pictures
- Phone, infrared camera
- Prism, flashlight, white paper
- A yoga mat, SPF sunscreen, Ultraviolet Lamp

STANDARDS
Next Generation Science Standards
- 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.*

Mathematics Standards | Common Core State Standards
- CCSS.MATH.CONTENT.HSG.MG.A.1
  Use geometric shapes, their measures, and their properties to describe objects (e.g., modeling a tree trunk or a human torso as a cylinder).*
- CCSS.MATH.CONTENT.HSG.MG.A.3
  Apply geometric methods to solve design problems (e.g., designing an object or structure to satisfy physical constraints or minimize cost; working with typographic grid systems based on ratios).*

English Language Arts Standards | Common Core State
- CCSS.ELA-LITERACY.RI.9-10.10
  By the end of grade 9, read and comprehend literary nonfiction in the grades 9-10 text complexity band proficiently, with scaffolding as needed at the high end of the range. By the end of grade 10, read and comprehend literary nonfiction at the high end of the grades 9-10 text complexity band independently and proficiently.

LESSON OBJECTIVE(S)

Students will be able to explore the properties and behavior of waves.

Students will be able to use frequency and wavelength of a wave to determine its usefulness in SAR and determine appropriate frequencies to appropriate uses.

Students will be able to communicate technical information on how technological devices use wave behavior and interactions with matter to transmit and capture information and energy.

CAREER CONNECTION(S)

Mentor Background:

Dr. Benjamin Files: is a researcher at the DEVCOM Army Research Laboratory, studying how to integrate human creativity and adaptability with the power of intelligent systems. His recent work identified successful approaches for improving humans' ability to work with probability distributions to support joint human-machine situational understanding. He is also investigating training approaches to help humans better understand Synthetic Aperture Radar imagery.

Dr. Kimberly Pollard: is a Research Biologist at DEVCOM Army Research Laboratory, where she specializes in research on communication and perception, training, and human-agent interaction. Her current work examines the ways in which information presentation and individual differences come together to affect performance in human-technology domains. Topics include learning in virtual reality, natural language systems, and human adaptation to machine interfaces and novel technologies.

STEM Careers: SAR Researcher, SAR Imagery, Software developer,space engineer, Data Analyst, Radiologist, Astronomer, Geologist, serve in Army, Navy or Airforce.

ENGAGEMENT

Brief Description:

To engage students with waves, we will introduce the secrets that can be found using the appropriate waves. Students love adventure and finding a hidden city is something from the movies.

Procedures:

Students can start with a Do Now of two pictures that look similar but have subtle differences and be asked to find those differences. To the right is an example but any image with differences will do.

After a few minutes, ask students to come up with techniques to make this process easier. Some students might say overlap the images with a light behind it to make the differences easier to see.

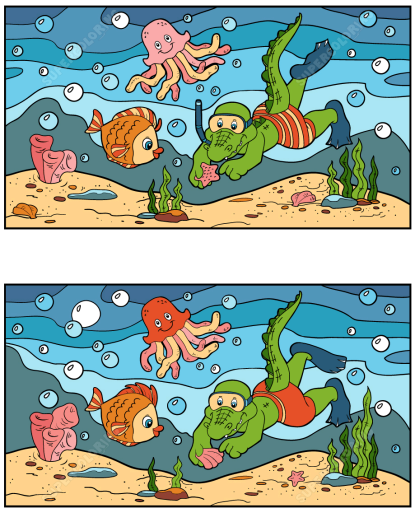


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The teacher can rephrase by saying, so use lightwaves to go through both images so your eyes can compare the two images. Whatever the student says, try to translate it into the language of waves.

Then have students read one or both of these two options about using waves to find a lost city through SAR.

Peering through the Sand
Secrets Beneath the Sand

Discuss how SAR can find small differences and how that might be helpful with class. Discuss the general idea of waves and how we will be learning about them to reach our end goal.
Introduce the end goal of figuring out how to hide US secrets from other countries that are also using this technology.

EXPLORATION

Brief Description: In this activity, students will explore different types of waves across the electromagnetic spectrum and mechanical waves through a series of interactive stations. Each station is designed to demonstrate the properties and real-life applications of various types of waves, which students will explore themselves & make cognitive connections for knowledge building.

Procedure: A.Class is divided into stations: Actually, decorated as EMS (Electromagnetic Spectrum) RMIOUXG 2. RMIOUXG = Radio, Microwaves, Infra-red, Optical, Ultraviolet, X-ray, & Gamma (in a random order so that students can explore and find the connections).

Stations and Their Representations:

1. **OCEAN WAVES / Water Waves:**
    - **Setup:** A big bowl of water.
    - **Concept:** Mechanical Waves (Surface Waves).
    - Instructions at station: Touch and interact with the water to see ripples (waves) form
2. **Sound Waves:**
    - **Setup:** A speaker with salt on it.
    - **Concept:** Mechanical Waves (Sound Waves).
    - Instructions at station: Change volume of speaker to see salt shake
3. **Radio Waves:**
    - **Setup:** Two radios, one tuned to FM and the other to AM.
    - **Concept:** Electromagnetic Waves (Radio Waves).
    - Instructions at station: change frequencies to see how radio waves carry different sounds from far distances
4. **Waves Propagation:**
    - **Setup:** A slinky tied at two points.
    - **Concept:** Mechanical Waves (Propagation of Waves).
    - Instructions at station: move the slinky slowly then faster
5. **Optical / Light / White Light Waves:**
    - **Setup:** A flashlight, a prism, and a piece of paper.
    - **Concept:** Electromagnetic Waves (Optical Waves).
    - Instructions : Pass the light through prism to the paper
6. **Ultraviolet Waves:**
    - **Setup:** A yoga mat and sunscreen SPF.
    - **Concept:** Electromagnetic Waves (Ultraviolet).

    - Instructions: Students apply a bit of sunscreen and see that their skin looks different under UV light lamps.
7. **Infrared Waves:**
    - **Setup:** A phone with an infrared camera attached.
    - **Concept:** Electromagnetic Waves (Infrared Waves).
    - Instructions: Students will turn on the camera and try to click pictures of each other.
8. **Microwaves / Satellite:**
    - **Setup:** A GPS image of the school and a satellite picture (SAR: Synthetic Aperture Radar Image).
    - **Concept:** Electromagnetic Waves (Microwaves).
    - Instructions: Look at both the pictures carefully.

9. **X-Ray Pictures:**
    - **Setup:** X-ray images of the human body.
    - **Concept:** Electromagnetic Waves (X-Rays).
    - Instructions: Analyze the image and compare it with other pictures you've encountered. Identify similarities and differences between this picture and others.

Procedure:

1. Divide the class into pairs or groups of three.
2. Assign each group to start at a different station.
3. Each group will rotate through all the stations, recording their observations and findings.
4. After completing all stations, groups will present their findings to the class.
5. The teacher will highlight important points during the presentations.

Wrap-Up Activity:

To consolidate learning, the class will watch the recall/recap video on Electromagnetic Spectrum.

Discussion Points:

- As the video plays, pause to ask questions about which station corresponds to which type of wave.
- Encourage students to make connections between the stations and the concepts presented in the video.

Next Steps:

1. **Research and Presentation:**
    - Groups will pick a card from a bowl, each with the name of a specific type of wave (Mechanical waves, sound waves, light waves, electromagnetic spectrum & microwaves as SAR).
    - Each group will explore their assigned wave/ card through the provided video resources and document their findings in a Google Document link with the source itself. Each student should have an account linked to the teacher and complete the assignments at the bottom of each link.
2. **Video Resources with google documents linked to be completed by students(group) to validate constructive learning :**
    - The Electromagnetic Spectrum
    - Mechanical Waves
    - Sound Waves

- Light Waves
- Microwaves as SAR

3. **Extra Credit Opportunity:**
   - Students can watch the Disney show *Drain the Ocean* and evaluate if Synthetic Aperture Radar (SAR) is used or could be used.

EXPLANATION

Brief Description:
In this phase, each group will prepare and present a detailed exploration of the wave type they researched. The focus will be on the properties of the wave, its unique features, and real-life applications. This will help consolidate their understanding of the electromagnetic spectrum and mechanical waves.

Procedure:

1. Group Work:
   - Each group (of 3 students) will use their research findings to prepare a presentation on their assigned wave type.
   - The presentation should cover:
     - Basic Properties of the wave
     - Real-Life Applications
     - Examples and Visuals
2. Class Presentations:
   - Groups will present their findings to the class.
   - Each presentation should be followed by a Q&A session where students can ask questions and discuss the content.
3. Completion of the Topic:
   - After all presentations, the class will have a comprehensive overview of the different types of waves, their properties, and applications.
4. Discussion and Reflection:
   - Lead a class discussion to reflect on the different waves studied and their real-world significance.
   - Summarize the key concepts learned and discuss how they fit into the broader topic of waves.
   - Additional resources:
   - Possible Resources for Students
   - Boston University Physics: A Longitudinal Wave
   - This interactivity allows students to change the amplitude and frequency of a sound wave and explore the molecular movement in the wave.
   - Netfirms: Transverse Travelling Wave
   - This interactivity allows students to manipulate a transverse wave and observe the movement of one point on the wave including velocity and acceleration.
   - Netfirms: Generating Stationary Waves on String
   - This interactivity allows students to manipulate and measure waves on a string.
   - Falsted: Ripple Tank Simulation

- This interactivity allows students to manipulate a simulated ripple tank by changing variables about the waves as well as the characteristics of the tank itself.
- Netfirms: Simulations
- This page includes links to a variety of Physics simulations including a number of simulations related to waves.
- Flipping Physics: Introduction to Waves
- Footage of different mechanical waves. Wave pulses, transverse waves, longitudinal waves, and wave properties are explained.

Rubric for Group Presentations : Rubric

This structure ensures a comprehensive and engaging learning experience for students, covering both exploration and explanation of waves in the electromagnetic spectrum and mechanical waves.

ELABORATE

Brief Description: Students will present their findings based on their assigned wave type. Presentations by each group to the whole class.

Procedures:
Presentations followed up with the activity:
Wave Interference Lab

EVALUATION

Brief Description: Hands on/H.O.T.S. activity

Students are given the task of figuring out how to hide the secrets of our military bases (square miles) from foreign governments using what they know about waves and create a proposal to protect US secrets.

Procedures:
Students will be introduced to the prompt and given a graphic organizer with all of the types of waves discussed. Each group is responsible for writing down the abilities and limitations of each of the waves and their appropriate uses. This can also be done as the lessons on waves are completed. After a day to research and fill in this organizer, students will start to come up with a solution of their own. Their job is to create a proposal for this problem that includes an estimated budget, why this protection is important, and why they deem it acceptable to not protect against any wave types not discussed in their proposal. Students will then present this information to a group of “generals” who will evaluate the proposal and assess the proposals effectiveness and practicality.

Grading rubric Rubric

REFERENCES

- https://www.earthdata.nasa.gov/learn/backgrounders/what-is-sar
- https://www.youtube.com/watch?v=zMsCyEAOrh0
- Savvas Realize
- GenerationGenius, Credits, Crisp: singapore research, Germany research, NASA, Sentinel, Google earth engine, youtube videos.