CLEAN ENERGY BRIGHT FUTURES
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LESSON PLAN

Wave Attenuator

Lesson 3: Testing a Tidal Wave Attenuator

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DESCRIPTION
Students will test the efficiency of the tidal wave attenuator models that they previously built. They will determine variables on their models they can manipulate, such as wire gauge and magnet strength, and measure the effects of manipulating this variable on the success of their design. They will report their findings in a presentation to the class.

GRADE LEVEL(S)
6, 7, 8

SUBJECT AREA(S)
Electromagnetic Induction, Renewable Energy, Wave Fundamentals, Electricity Generation

ACTIVITY LENGTH
6-8 class periods (~50 minute class periods)

LEARNING GOAL(S)

1. Students will investigate variables that may affect the output of an energy conversion device (wave attenuator).
2. Students will interpret data to identify which variables increase electrical output for these model wave attenuators.
3. Students will communicate results from scientific inquiry to identify factors that are important to optimizing the design of a wave attenuator.

STANDARDS REMINDERS

- This portion of the unit should be extremely student-driven.

- Students will design the experiments, track and analyze data. This is a chance for questioning strategies and encouraging students to make their thinking clear so that other students can question illogical or non-data-driven ideas

EXPECTED CONTENT UNDERSTANDING

STUDENT UNDERSTANDING

Students participating in this lesson should be familiar with the following:

- Basics of wave energy
- Knowledge of how tides work
- Understanding of electromagnetic induction
- Understanding of the Engineering Design Process
- Working knowledge of how a wave attenuator works

EDUCATOR UNDERSTANDING

Educators leading this lesson should be familiar with the following:

- Understanding of Electromagnetic induction
- Understanding of Engineering Process
- Understanding of wave and tidal energy
    - Wave Energy- Ocean Energy Council (http://www.oceanenergycouncil.com/ocean-energy/wave-energy/.)
    - Tidal Energy- Ocean Energy Council (http://www.oceanenergycouncil.com/ocean-energy/tidal-energy/)
- The Environment – Ducksters Wave and Tidal Energy (http://www.ducksters.com/science/environment/wave_and_tidal_energy.php)
- Understanding of wave attenuators
    - Wave Power in the UK (2014, https://prezi.com/nw7rxba7vb-c/wave-power-in-the-uk/)
- How to use a galvanometer

REQUIRED MATERIALS

HANDOUTS/PAPER MATERIALS

- Student Science Journals

CLASSROOM SUPPLIES

- 100-quart tote
- Water to fill tote approx. 5 inches deep
- A 2-liter soda bottle (to move up and down in the wave tank to create waves)
- 1 Galvanometer OR Vernier LabQuest 2 with Vernier Instrumentation Amplifier
- Needlenose pliers or other wire cutter

- Scissors (to cut duct tape)
- Hot glue gun
- Sandpaper (to de-insulate wire)
- Metronome (to keep wave lengths consistent)
- Laptops or computers for students

ACTIVITY SUPPLIES (GROUPS OF 3-4 STUDENTS)

Note: Each group of 3-4 students will select an independent variable that they will change and therefore will need more supplies for that variable.

DAY 1:

- Previously built wave attenuator models

DAYS 2-4: BUILDING DAYS

- 90 centimeters (~3 ft) magnet wire
- Rare earth magnet
- 3 ½ x 7 x 1 ¼ inch foam
- 7/8 x ¾ inch acrylic tube—this will be a fitting so acrylic tube with wire can be exchanged throughout the experiment
- ¾ x 3-inch acrylic tube—this will be used for wire
- ¼ 20 4-inch bolt
- ¼ 20 nuts
- 1 ½ inch L bracket
- 90 cm (~3 feet) of duct tape
- Roll of scotch tape

Figure 1. Picture of group materials for Day 3

LESSON PROGRESSION

PLANNING AND PREP

This lesson is designed to span 5 days, building upon previous 3-day lesson in which students built a model wave attenuator, to explore engineering from a rigorous scientific perspective in which students attempt to hold all but one variable constant in their tests.

It is important that students use the engineering design and inquiry process throughout the unit. Models between groups do not have to be identical but it is important that students are very cautious to only alter and test one variable. I found it beneficial to have regular check-ins with each group.

Give students lots of time to practice creating waves in the wave tank with the 2-liter bottle and metronome (to be used starting Day 3). Even though this is a simple way to create waves, it is an important variable that needs to remain constant throughout the testing.

Day 1: Wave attenuators and variables. Students will need their science journals and teacher will need some method of capturing ideas from the class for different variables that could be modified in the wave attenuator design.

Day 2: First Building Day. Prepare a demo station (water tank, model attenuator, wave-maker) and a galvanometer or a Vernier LabQuest 2 with Instrumentation Amplifier. Students need access to the materials so that they can begin manipulating variables. Some teacher prep may be required for the materials, but this can also come in the form of students "ordering" specific materials for their tests, which may give the teacher time to cut specific materials for student groups during class.

Day 3: Second Building Day. Set up hot glue station, if it wasn't set up on Day 2. Students should not need the water tub today, so a teacher may or may not choose to set it up.

Day 4: Third Building Day. No new prep needed, but teacher should set up the water tub testing station if it is not already set up.

Day 5: Group Presentations. Set up classroom for group presentations and any additional items for presentations (e.g. projector if students are directed or allowed to use slideshow presentations).

Days 6-8: Building and Testing Final Wave Attenuator. Students will need access to building materials to make modifications to their wave attenuators using data from their or other groups with the goal of improving their models.

LESSON SEQUENCE

DAY 1: WAVE ATTENUATORS AND VARIABLES

1. (15 min) Warm-up: In Science Journals have students reflect on the previous lesson. How well did their wave attenuators work? What could they change to make it more efficient?
2. (10 min) Review the difference between dependent and independent variables. Have a discussion with students why it is important to only change one variable in an experiment. Discuss how they have created a control and how they will be using this control in their experiment. *Note: if students are less familiar with independent and dependent variables, the discussion does not need to include this terminology until the importance of changing one variable at a time is established. This is a time to explicitly call on students to talk about patterns and cause and effect.*

3. (20 min) Have students help brainstorm a list of variables that could be changed on the wave attenuator. As the class is building the list, have students take notes in their science notebook and continue to reinforce the importance of changing only one variable. Also take this opportunity to start talking about why or how each variable may be changed (possible variables could be wire gauge, magnet strength, number of wire coils, wave frequency).
    a. Use previous scaffolding experiments with electromagnetism to determine the key components of this type of system. Students should be directed to discuss and identify the dependent variable, which they should decide is the electrical output as measured by the galvanometer or the Vernier sensor.
    b. The class can decide as a whole or in groups how to measure the dependent variable or the teacher can dictate this. If using a galvanometer, the easiest way to measure output is to have someone track the highest value that the needle hits, but the class might be able to come up with some different or more scientifically valuable methods for this process.
4. (5 min) Have students work with their group to decide which variable they are going to be changing in their experiment, how they are going to change this variable (students should have at least three forms of this variable to test including the control, if it is being used) and to come up with their hypothesis. Hypotheses structure can vary depending on classroom. The most straightforward way to frame these in the context of this lesson is through variable placement: "If the (independent variable) is (describe change) then the (dependent variable) will (describe change). This also allows for a clean transition into Claim, Evidence, Reasoning structures to be used as an assessment.

DAY 2: FIRST BUILDING DAY

1. (15 min) Warm up: Have each group share out the variable they are going to change, how they are going to change it and their hypothesis. Give additional brainstorming time if needed.
2. (10 min) Go over how to read a **galvanometer** or the Vernier instrumentation amplifier and have students practice reading these to ensure accuracy during the experiment/testing phase. Note: using Vernier equipment such as the instrumentation amplifier will allow for a much more detailed and accurate log of data for your students to analyze.
3. (5 min) Review group roles and procedures. Discuss safety procedures with magnets and hot glue. (Teacher may want to model the use of the hot glue gun to the gluing of the brackets. All other material should be able to be taped with the tape provided). Student must include all materials in their model.

4. (20 min) Give students time to build their wave attenuator and elements needed for their variable testing.

DAY 3: SECOND BUILDING DAY

1. (10 min) Group check in. Check in with groups to see how building day 1 went.
2. (10 min) Review group roles and procedures. Discuss safety procedures with magnets and hot glue. Also discuss protocols for data collection, such as data tables.
3. (30 min) Students should finish building wave attenuator and elements needed for their variable testing.

DAY 4: THIRD BUILDING DAY

1. (10 min) Warm-up: Have student reflect on yesterday's workday and what they need to accomplish in order to finish the testing/experiment phase today.
2. (40 min) Give students time to work on test their wave attenuator.

DAY 5: GROUP PRESENTATIONS

Note: These presentations are designed relatively informally with 20 minutes of student prep. For classroom unfamiliar with or not used to class presentations, it may be useful to provide a more formal structure for presentations and increase this prep time.

1. (5 min) Warm-up: Discuss group norms for presenting and viewing presentations, especially around receiving and giving feedback.
2. (20 min) In their group and decide what they are going to share with each group or the class. Students may want to share about what they learned, discovered, struggled with, why they think something worked or did not work. Students may want to write information on a large whiteboard or poster board so other groups can easily see it.
3. (25 min) Have students either share in a round robin style or present in front of the whole class. Students should be giving presenting groups feedback on how they could improve their wave attenuator based on data or observations as well as background knowledge from the class, remembering that only one variable should be altered or change.

DAYS 6-8: BUILDING AND TESTING FINAL WAVE ATTENUATOR

1. Finish group presentations, if needed
2. Give students time to make modifications to their wave attenuator models to see if their modifications improved their models, as measured by the dependent variable. Students may choose to make modifications based on other groups' findings to improve their wave attenuator, but they should still be encouraged to only change one variable at a time and test results of that change before making any other changes.

3. Students will work on write-ups for the lesson, including creating data tables, graphs, and conclusions.

ASSESSMENT AND EXTENSIONS

FORMATIVE ASSESSMENT

Students will be assessed throughout the lesson as they complete and receive feedback on the work they completed.

SUMMATIVE ASSESSMENT

Final assessment will be grading student write-ups that they complete on days 6, 7, and 8 based on the Wave Attenuator Rubric (see "Wave Attenuator Rubric" worksheet). The first 4 categories in the rubric can also be used as guidelines for grading the group presentations.

LESSON EXTENSIONS

- Student could write a letter to a local organization such as NNMREC (http://nnmrec.oregonstate.edu/) either promoting or discouraging the use of wave attenuators.
- Students could create a brochure comparing wave attenuators to another renewable resource such as wind or solar energy.
- Students could create a video promoting or discouraging the use of wave attenuators.
- Students could write an argumentative paper supporting or not supporting the use of wave attenuators on the Oregon Coast.