Wave Movement
2021 NHERI HWRL REU

Audience

Middle school (6-8th grade)

Takeaway

Students will understand the motion of water underneath a wave. Common sense would lead students to believe that the water moves with the waves from one side of the flume to the end of the flume. In reality, the water moves in a circle under the waves. The idea here is to get students interested in learning more about waves, research design, being curious enough to ask more questions.

Introduction and Motivation

When you first start learning and understanding wave movement, things that you would expect to be the case, often are not. When you think of someone surfing, you often think of the wave pushing the surfer. Imagine how that wave moves, you're probably imagining the wave moving across the ocean. Well today, we are going to show you that those waves are not even moving at all.

Learning Activities

- Tour of the O.H. Hinsdale Wave Research Laboratory large wave flume and wave basin
- Explain how each work
- Explain where the water comes from and what moves the water to make waves
- Fill bottom of the flume with a few feet of water
- Ask students the following questions about waves:
    - How does water move at the beach?
    - Why do you think the water moves in that direction?
    - Are the waves and the water the same thing? How might they be different?
    - Does the water move the same way that the waves do? How can we find out?
- Model designing an experiment
- Make boats to place on top of the water (*If the water and the waves move the same way, then the boats will get “picked-up” by the waves and move with them towards the beach.)
    - Create foam/popsicle/ paper boats to float on the water
    - (*Staff) Place boats in flume equal distance from the wave-generator and the beach
    - Model creating a hypothesis and survey students by show of hands, “Will boats move forward, backward or stay in place?”

- (*Staff) Test hypothesis by generating waves about half of depth and a corresponding period to create a linear, regular wave in “deep water” simulation (depth: 0.5m, wave height: 30cm, period: 2.5 sec)
    - Run waves for multiple wave cycles underneath the boats
    - Observe the movement of the boats (* Boats will either stay in place or move at a fractional speed of the waves)
- Model drawing conclusions by asking the following questions again:
    - How does water move at the beach?
    - Why do you think the water moves in that direction?
    - Are the waves and the water the same thing? How might they be different?
    - Does the water move the same way that the waves do?
    - Were you surprised by what happened to the boats?
- Help solidify the structure of the wave for students by showing a wave in the small-scale flume so that students can see the water from the cross-direction.
    - Place a small amount of food coloring at a middle location in the flume and generate a waves (*Food coloring will move in an orbital motion under the wave until dissipated)
    - Explain particle motion in a circular direction
    - Scaffold connection by asking, “How does particle motion and the structure of the wave explain why boats in the “real world” need sails and motors?” (* Waves do not cause lateral directional movement)

Objectives

Students will

- Generate a hypothesis about what they expect to happen with waves and boat
- Test hypothesis by creating a boat to float on the waves
- Observe the boat and notice it does not move much from its initial position
- Draw conclusions as to why the boat does not move forward
- Observe cross-section of wave with dye to identify how waves move
- Understand basic wave propagation

Background and Vocabulary

- Particle
- Wave
- Orbital or circular
- Force
- Newton’s first law of motion

Assessment

Provide students a prompt to answer in writing or verbally, “Does anyone know what surfers do while they are out in the ocean, but want to avoid a large incoming wave? They take the nose of their board, and dive under the water. Why do we think they do this? Would the surfer move at all?”

(*Relating back to the surfer, the answer is no. The surfer would not move from their position. This is a fun experiment you can go and try yourself. Maybe the next time you go swim in the ocean or even if you make it to the water park and it has a wave pool. As you see a wave approaching, dive under the water, and notice how you move. Notice if you feel any forces on the water pushing you in any direction.)

Conclusion

Understanding wave propagation and research design is complex. Introducing students to both in a fun hands-on, scaffolded manner, helps them to build schema to move onto more complex concepts and designs as well as sparks interest in science and research.