Wave Behavior

Grades
9-12

Overview:

Students view models and animations of wave behavior then search for examples of those types of behavior in tsunami animations.

Targeted Alaska Grade Level Expectations:

Science

[9] SA1.1 The student demonstrates an understanding of the processes of science by asking questions, predicting, observing, describing, measuring, classifying, making generalizations, inferring, and communicating.

[10-11] SA1.1 The student demonstrates an understanding of the processes of science by asking questions, predicting, observing, describing, measuring, classifying, making generalizations, analyzing data, developing models, inferring, and communicating.

[9] SB4.3 The student demonstrates an understanding of motions, forces, their characteristics, relationships, and effects by describing the interactions of waves (i.e., reflection, refraction, wave addition).

Math

[9] F&R-3 The student demonstrates conceptual understanding of functions, patterns, or sequences including those represented in real-world situations by describing in words how a change in one variable in a formula affects the remaining variables (e.g., how changing the radius affects the volume of a cylinder) (M4.3.2)

[9] G-3 The student demonstrates conceptual understanding of similarity, congruence, symmetry, or transformation of shapes by drawing or describing the results of applying transformations (translations, rotations, reflections, or dilations) to figures on a coordinate plane (L) (M5.4.4)

[9] PS-5 The student demonstrates the ability to apply mathematical skills and processes across the content strands by using real-world contexts such as science, humanities, peers, community, careers, and national issues (M10.4.1 & M10.4.2)

Objectives:

The student will:

- observe models of wave reflection, refraction, diffraction and wave addition;
- apply knowledge of wave behaviors while searching for examples in tsunami animations; and
- identify and explain wave behaviors and how changes in wave behavior affect wave characteristics.

Materials:

- Overhead projector
- Clear container
- Water
- Dish soap
- Clay
- Small sheet of plexiglass that covers a portion of the bottom of the tank
- STUDENT WORKSHEET: “Wave Behavior”
- VISUAL AID: “Wave Behavior”
- MULTIMEDIA FILE: “Diffraction” at the ATEP Website: www.aktsunami.org/multimedia
- MULTIMEDIA FILE: “Wave Interference” at the ATEP Website: www.aktsunami.org/multimedia
- MULTIMEDIA FILE: “1964 Seward Model” at the ATEP Website: www.aktsunami.org/multimedia
- MULTIMEDIA FILE: “Kuril Islands” at the ATEP Website: www.aktsunami.org/multimedia

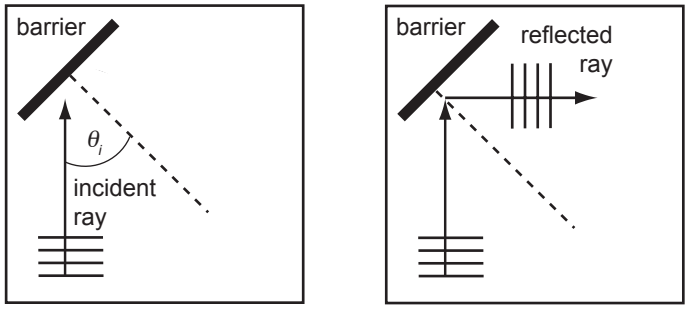
Whole Picture:

Part of tsunami modeling involves understanding how waves will behave in different situations and how the land will influence wave behavior. Waves change behavior when they reach the end of a medium, travel across different media, or interact with other waves. Four types of wave behavior include reflection, refraction, and diffraction and superposition. Animations and modeling in a ripple tank demonstrate these behaviors.

Reflection

As waves approach a long, straight barrier they bounce off and head in a different direction. The diagram below shows a series of long waves approaching a barrier. The first picture shows a series of waves approaching a barrier. The arrow, or ray, indicates the direction of wave energy. As this ray approaches the barrier, it is called the angle of incidence (θ_i). When the wave energy strikes the barrier, it reflects, or bounces off in such a way that the angle of reflection (θ_r) and angle of incidence (θ_i) are the same. The law of reflection states that the angle of incidence (θ_i) equals the angle of reflection (θ_r).

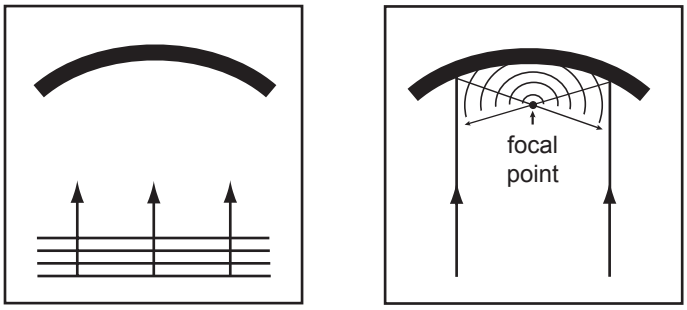
The Law of Reflection



Before Reflection After Reflection

If the barrier is in the shape of a parabola, then the waves will reflect and converge at a single point called a focal point.

Reflection off of Curved Surfaces



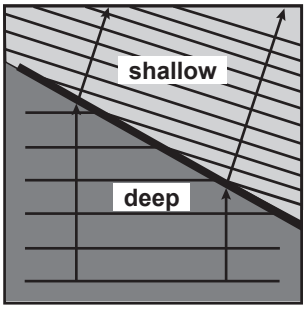
Before Reflection After Reflection

The reflection off the shape of the coast will influence the reflection of incoming waves. Waves heading into a bay will behave more like waves entering a parabola, whereas waves approaching a straighter coastline will behave as waves approaching a straight barrier.

Refraction

As waves move across different media, their behavior changes. As waves refract, the direction of wave energy changes as well as the wavelength and speed. When waves with a wavelength much greater than the water depth transition from deep water to shallow water, wave speed and wavelength decrease.

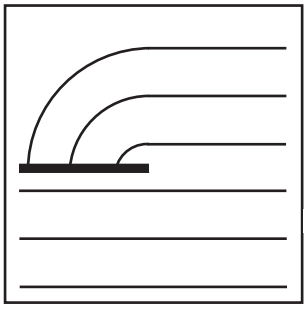
Refraction of Waves



Diffraction

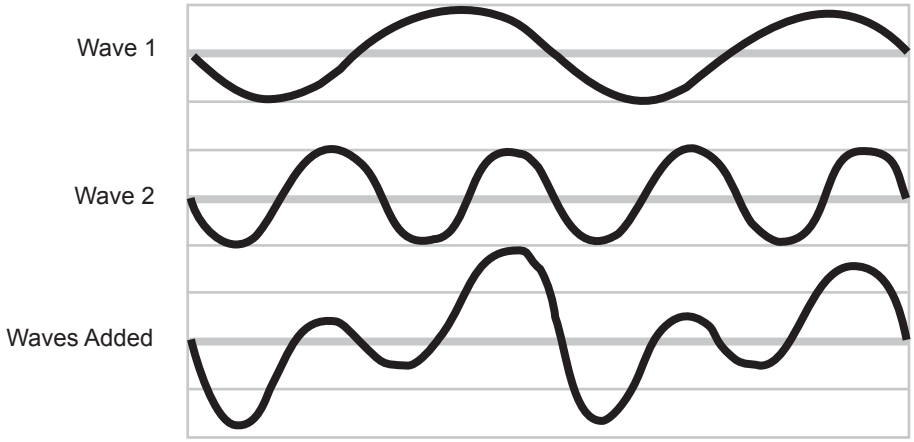
As waves travel around a barrier or go through openings, they change direction by bending. This is called diffraction. Diffraction is most obvious when the wavelength is greater than the obstacle. As wavelength increases, the degree of diffraction increases.

Diffraction of Waves



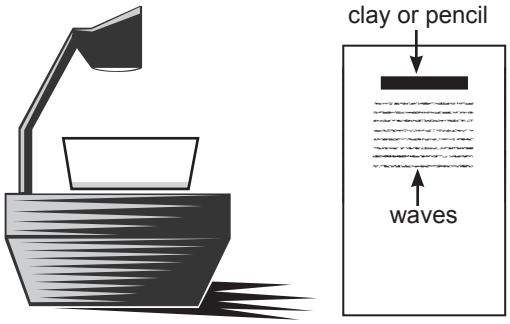
Wave Interference

This is the addition, or superposition, of waves. When two waves interact a new waveforms with different properties. Amplitudes add together and create new patterns.



Activity Preparation:

Set up a ripple tank by placing a clear container on an overhead projector. Place a small amount of dish soap on a finger and run a thin film of soap around the inside of the container about 1-2 centimeters up from the bottom. This soap will help decrease the amount of wave reflection off the walls of the container. Slowly fill the container with 1-2 centimeters of water. To generate waves, use an elongated item such as an elongated piece of clay or pencil, to make waves that are straight.



Activity Procedure:

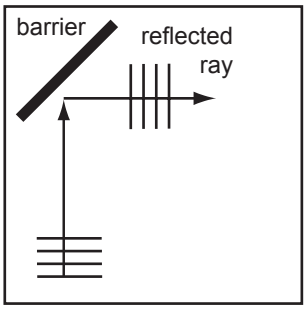
1. Explain that part of tsunami modeling involves understanding how waves will behave in different situations and how the land will influence wave behavior. Wave behavior can be classified into several categories.
2. Display VISUAL AID: “Wave Behavior.” Share the information on reflections from the Whole Picture section. Using the ripple tank, model wave reflection against a straight barrier by placing a straight elongated barrier (1cm diameter x 12 cm piece of clay) in the tank at an angle. Generate straight waves using an elongated item as described in Activity Preparation. Repeat the process of reflection but form the clay into a parabola to model the effect of reflection on a parabola.
3. Use the visual aid and information from Whole Picture to explain refraction. Model by changing the depth of a portion of the tank by placing a piece of plexiglass or other transparent material in part of the tank. It must be large enough to view a change in wave behavior. Generate elongated waves in the deep end of the tank.
4. Display MULTIMEDIA FILE: “Diffraction” and use the information from Whole Picture to explain diffraction. Emphasize that the amount of diffraction increases as wavelength increases. Ask students to consider if there are any barriers in the local area or region that they know of that may cause wave diffraction in the event of a tsunami. Some examples may be piers and spits.
5. Display MULTIMEDIA FILE: “Wave Interference” [make similar to http://www.questacon.edu.au/activities/wave_addition.html] and use the information from Whole Picture to explain wave interference.
6. Display MULTIMEDIA FILES: “1964 Seward Model” and “Kuril Islands.” View each multimedia file several times to search for examples of the different types of wave behavior.
7. Distribute STUDENT WORKSHEET: “Wave Behavior” for student completion.

Extension Ideas:

- Task your students with the challenge of acting out wave behavior in groups and ask them to perform for the class. Observers can identify which type of behavior they are acting out.
- Using a long rope, generate waves from both ends to explore wave interference.
- Look at a local map to determine local barriers and how those barriers may influence wave propagation. Compare the local situation with another area.

Answers:

1. See diagram at right.



2. D
3. E
4. B
5. G
6. F
7. A
8. C
9. Increases
10. Increase
11. Answers will vary but should display that the reflection off the shape of the coast will influence the reflection of incoming waves. Waves heading into a bay will behave more like waves entering a parabola, whereas waves approaching a straighter coastline will behave as waves approaching a straight barrier.

Lesson Information Sources:

VanCleave, J. P. (2006). *Janice VanCleave's energy for every kid*. Hoboken, N.J.: J. Wiley & Sons.

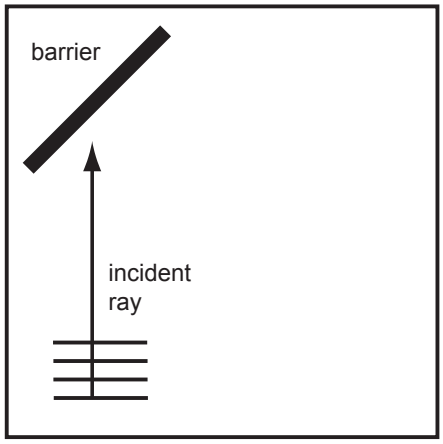
Name:_____

Grades 9-12

Digital Mapping Technology Scavenger Hunt

Student Worksheet

1. Draw the angle of reflection.



Directions (2-8): Match items from the left column to the best wave behavior in the box on the right.

2. ____ Amplitudes of different waves combine to form a new wave pattern.
3. ____ The angle at which a wave approaches a barrier.
4. ____ A wave transfers from one medium to another.
5. ____ Waves reflect off a parabola to converge at this single point.
6. ____ The angle at which a wave bounces off a barrier.
7. ____ Waves bouncing off a barrier.
8. ____ Waves bending around barriers.

A. Reflection
B. Refraction
C. Diffraction
D. Wave Interference
E. θ_i
F. θ_r
G. Focus

Directions (9-10): Circle the correct answer to complete each sentence.

9. As wavelength increases, the degree of diffraction _____.

   increases decreases

10. As waves transition from deep water to shallow water, wave speed and wavelength _____.

    increase decrease

11. Describe how the shape of the coast may influence an incoming wave.

_____

_____

_____

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