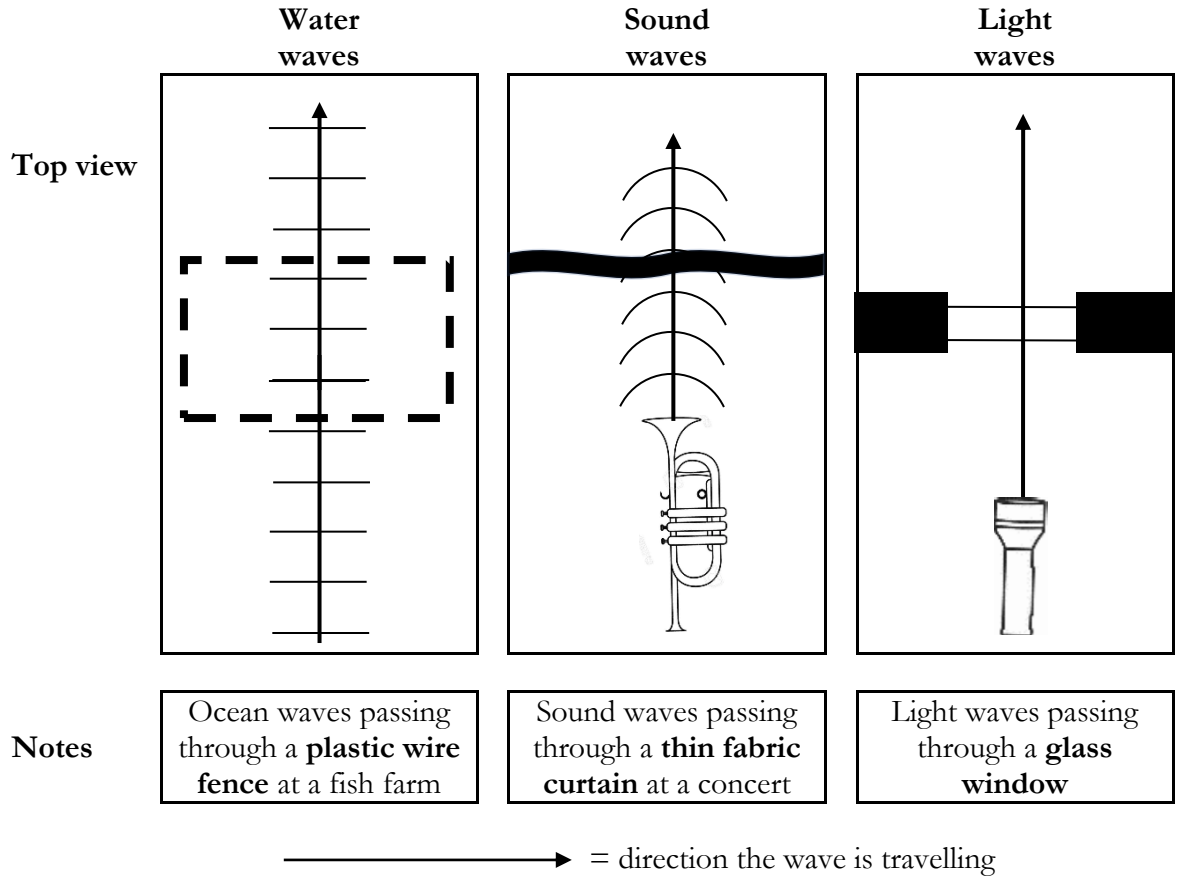
What Happens When Waves Hit Different Kinds of Materials?

Why?

We have explored how water waves, sound waves, and light waves behave when they hit something that is smooth, flat, and reflective. What happens when waves hit something that is not reflective? In this activity we will explore situations where waves do not reflect.

As you work through the following questions, be sure to follow your team role(s).
Use a straightedge or ruler to draw all your lines and arrows.

Model 1 – Waves passing through materials



Use the information in Model 1 to answer questions 1 – 7.
Reach agreement with your team before writing down your consensus answers.

1. Look closely at the information in Model 1. Discuss with your team members. What is happening in each diagram? You do not need to write anything down.

2. How many different types of waves are shown in Model 1?

3. Draw a top view of a water wave as shown in Model 1.

4. Describe what this symbol  represents in Model 1.

5. Identify the **one characteristic** that is the same in all the Model 1 wave diagrams. (Circle) your answer.

a. All the waves enter (go in) one side of a material and exit (go out) the other side.

b. All the waves pass through a material that you can see through.

c. All the waves change direction when they hit the materials shown in Model 1.

Read This!

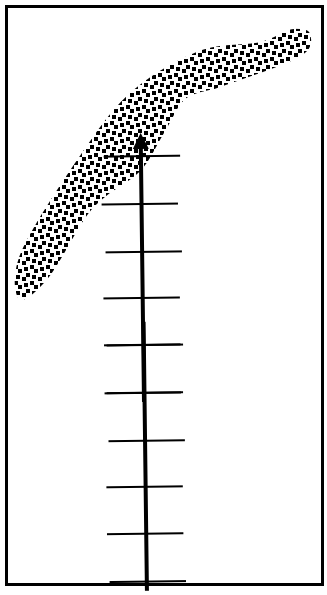
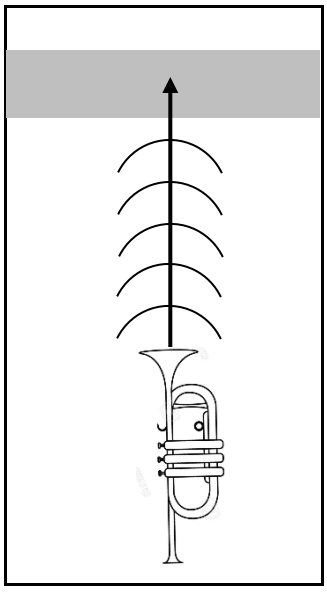
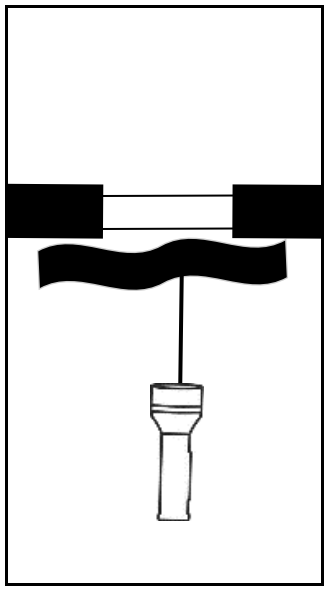
Engineers and physicists use the technical term **transmission** to describe the process of waves traveling through a material or an object. They use the term **transmit** to describe the action. For example, they might say, "When light hits a piece of clear glass, light waves are **transmitted** through the material."

6. Write one sentence that describes **what happens when sound waves hit the surface of a thin fabric curtain**. Use the correct technical term.

7. **Draw an accurate wave diagram** to show how **sound waves** from a fog horn are **transmitted** through thick fog to warn boats of rocks along the shore.

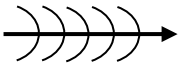
Check your answer with your teacher before you continue.

Model 2 – Waves disappearing as they pass through materials

	Water waves	Sound waves	Light waves
Top view			
Notes	Ocean waves stop when they hit a **huge sandy beach** on a barrier island	Sound waves stop when they hit **acoustical foam** in a practice room	Light waves stop when they hit a **blackout curtain** in front of a window

Use the information in Model 2 to answer questions 8 – 13.
Reach agreement with your team before writing down your consensus answers.

8. What does the pattern  represent in Model 2?

9. What does the symbol  represent in Model 2?

10. Look closely at the diagram of water waves, sound waves, and light waves shown in Model 2. Write one complete sentence that describes **what happens when water waves hit a huge sandy beach on a barrier island.**

Read This!

Engineers and physicists use the technical term **absorption** to describe the process of waves entering a material or object but never exiting that material. They use the term **absorb** to describe the action. For example, they might say, "When light hits a blackout curtain, light waves are **absorbed** by the material."

11. Write one sentence that describes **what happens when sound waves hit the surface of acoustical foam**. Use the correct technical term.

12. **Draw an accurate wave diagram** to show how **light waves** from the sun are **absorbed** by the black fabric of a t-shirt.

13. Compare Model 1 and Model 2. Describe one similarity and one difference between the process of **transmission** and the process of **absorption**. Include specific details from the models.

Similarity:

Difference:

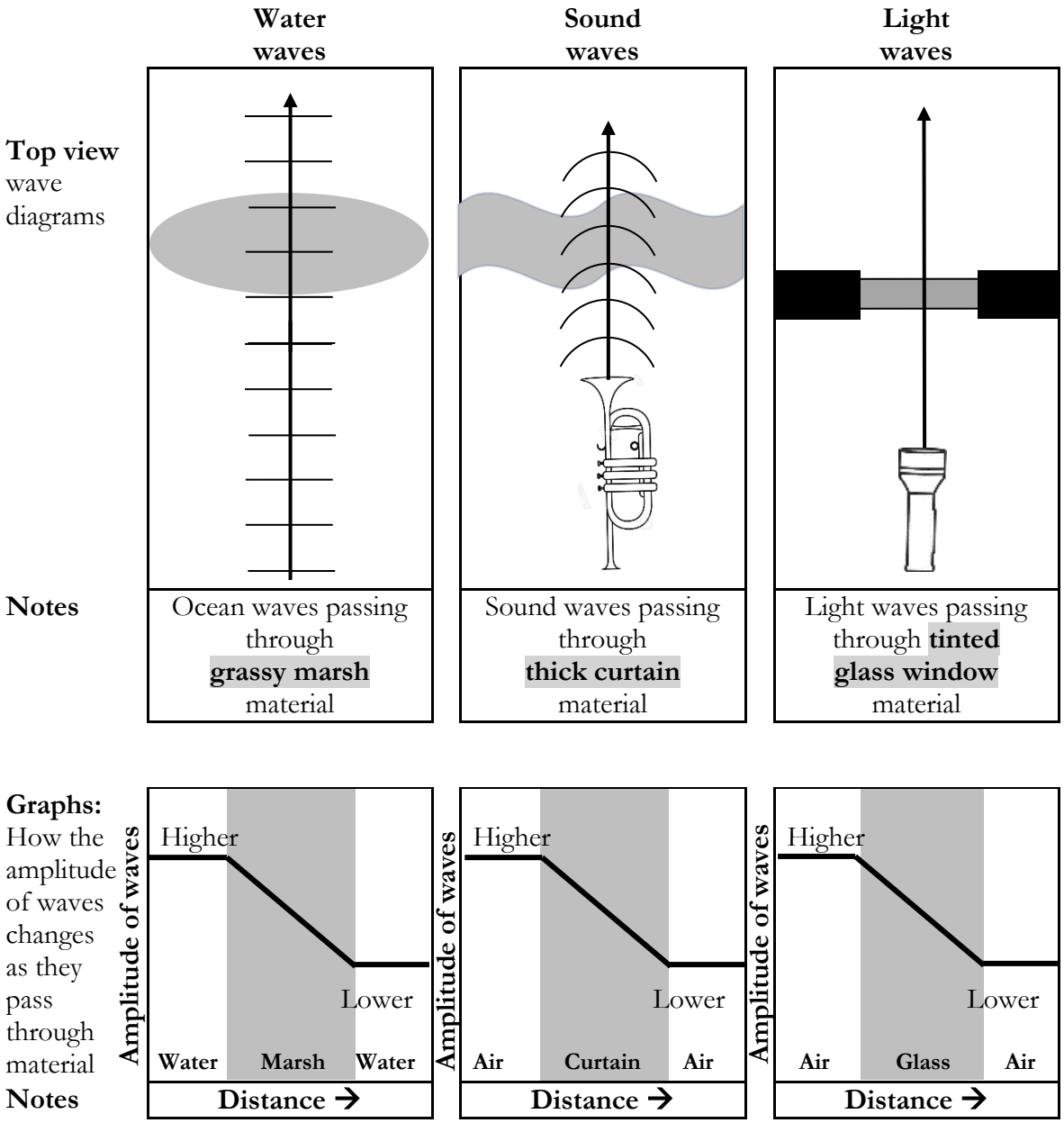
Check your answer with your teacher before you continue.

What I Still Wonder…

14. Write one additional question you have about how water waves, sound waves, or light waves behave.

Extension Questions

Model 3 – Partial transmission and partial absorption



Use the information in Model 3 to answer questions 15 – 22.
Reach agreement with your team before writing down your consensus answers.

15. Look closely at the **top view wave diagram** of **sound waves** in Model 3.

a. What does the **gray area** represent?

b. Just looking at the top view wave diagram, can you tell if the wave amplitude changes as the sound passes through the thick curtain material?

16. Look closely at the **graph** of **sound waves.** Discuss with your team members**.**

a. Describe what happens to the amplitude of the sound waves as time passes.

b. What does the **gray area** on the graph represent? (Circle) the one correct answer.

i. The time during which sound waves are **still inside the trumpet**

ii. The time during which sound waves **travel through open air**

iii. The time during which sound waves **pass through a thick curtain material**

iv. The time during which sound waves **reflect off a wall**

17. Now look at the example of tinted glass in Model 3. Write one complete sentence that describes how the amplitude of a **light wave** changes as it passes through a tinted glass window.

As light passes through tinted glass, the amplitude of the light waves…

18. Look closely at the graphs in Model 3. **What pattern do you detect in all three graphs**?

a. The amplitude does not change as the waves pass through the gray areas.

b. The amplitude is lower before the waves pass thorough the gray area and then higher after the waves pass through the gray area.

c. The amplitude is higher before the waves pass through the gray area and then lower after the waves pass through the gray area.

d. There is no detectable pattern in all three graphs.

Read This!

Engineers and materials scientists use the term **wave-absorbing materials** to describe all of the materials that appear as gray areas in Model 3.

19. **Draw lines** to match each wave-absorbing material to the type of wave it can affect.

Marsh grasses	Light waves
Thick fabric	Water waves
Tinted glass	Sound waves

Read This!

We remember that **waves with larger amplitudes also have higher energy**.

20. Complete the sentence below that summarizes how the energy of a wave changes as the wave passes through a wave-absorbing material.

As a wave passes through a wave-absorbing material, the energy of the wave…

21. Look back at the title for Model 3. Explain why this title makes sense to describe a wave-absorbing material.

22. What happens to **water waves** as they move from **open water** through a **grassy marsh** and then back into **open water**?

Write your claim. Provide evidence from Model 3 and the **Read This!** Boxes above. Explain your reasoning (justification).
Hint: You may find it easier to select and record your evidence before writing your claim.

Include these terms in your answer:
water wave(s) amplitude energy wave-absorbing material

Claim:

Evidence:

Reasoning (justification):

Check your answer with your teacher before you continue.

23. Circle the one true statement.

a. As the absorbance of a material increases, its transmittance also increases.

b. As the absorbance of a material increases, its transmittance does not change.

c. As the absorbance of a material increases, its transmittance decreases.

d. There is no relationship between the absorbance of a material and its transmittance.

24. If **25% of a wave's energy is absorbed** by a non-reflective material, **what percent of the energy is transmitted** by the material? Explain your answer

25. Think about your own experience with sound waves. Imagine you are attending a science camp at a local college. Your team is assigned to design a window covering that will allow students to sleep better in their dorm rooms. The dorm is located beside a fire station. About every 30 minutes vehicles leave the station with their sirens blaring.

Describe two different approaches you might take to solve the design challenge.

Time Estimate
30 - 60 minutes

Learning Outcomes

1. I can draw an accurate model of a wave being transmitted as it passes through a material.

2. I can draw an accurate model of a wave being absorbed as it passes through a material.

(Optional extension questions)
3. I can describe how the amount of energy changes as a wave passes through a wave-absorbing material.

This activity has been designed specifically to support this NGSS* standard:
MS-PS4-2
Develop and use a model to describe that waves are reflected, absorbed, or transmitted through various materials. [Clarification Statement: Emphasis is on both light and mechanical waves. Examples of models could include drawings, simulations, and written descriptions.] [*Assessment Boundary: Assessment is limited to qualitative applications pertaining to light and mechanical waves.*]

Prerequisites
1. Students are able to locate relevant information from complex diagrams.

2. Students can observe closely to distinguish small but important differences in drawings.

3. Students have mastered the concepts in PSActivities 13 - 16.

To prepare before facilitating:
Make copies of pages 1-8 (double sided/stapled) for each student.
It may be helpful to hand out the activity as 3 separate tasks: pages 1- 2 and pages 3-4.
Make copies of pages 5-9 to hand out as enrichment to teams that finish early. These questions include NGSS engineering practices.
It may be helpful to **copy the Models** onto a separate piece of paper to make it easier for the team to view and discuss the same graphic.

Note: Many teachers will find the long Extension Questions section to be applicable to their students. If you choose to use these questions and Model 3, be sure to allow lots of additional time.

Additional Resources

Barrier islands
https://www.sciencenewsforstudents.org/article/natures-coast-guards

Online PhET simulation for students to explore and compare to what they have learned in this activity: Wave Interference
https://phet.colorado.edu/en/simulation/legacy/wave-interference

Assessment Questions

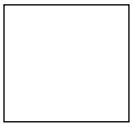
1. Use the correct term to fill in the blanks.

Absorption Reflection Transmission

a. When a wave enters a material, passes through, and exits without changing its amplitude, scientists call the process _____ .

b. a. When a wave enters a material but never exits because its energy stays in the material, scientists call the process _____ .

2. **Draw an accurate wave diagram** to show how **light waves** from the sun are **transmitted** through a clear plastic cube.



3. **Draw an accurate wave diagram** to show how **water waves** are **absorbed** when they strike a muddy shore.