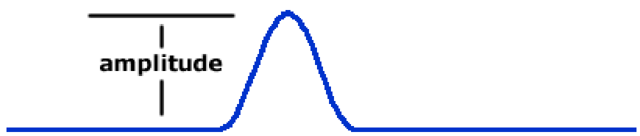
Wave Behavior—Reflection, Refraction, and Diffraction **Name: ____KEY_____**

Instructions: This packet is in the place of notes for this unit. Some of the information you will need to look up in your textbook (page references given for some of these). Most of the information will be gathered while performing exercises with the ripple tank (in your small group) or while observing behaviors shown with the transverse wave demonstrator (as a class).

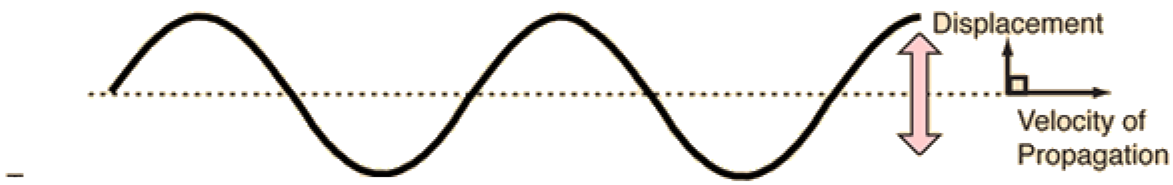
Keep this packet with your notes. Answer every question as completely and thoroughly (and correctly) as possible. You **will** be getting a lab score for your lab-based work (marked with ❖), and an assignment score for the non-lab portion (marked with ➢) and for an overall completion and quality of the packet.

Section 1: Reflection of Waves (on a rope or similar) *(review—answer these based on demos we've already done)*

➢ Sketch a "snapshot" of a transverse wave pulse:



➢ Sketch a "snapshot" of a transverse continuous wave (travelling wave):

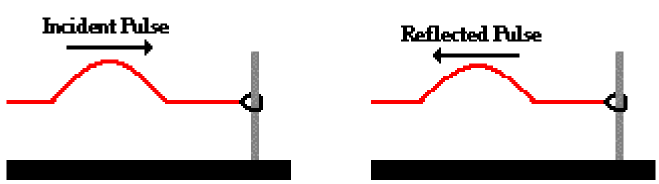


When a wave pulse (or continuous wave) reaches a boundary, or a transition, between two different media, there is a portion of the wave's that will continue forward and be transmitted into the new medium. There is also a portion of the wave's energy that will return back into the original medium (it is **reflected**).

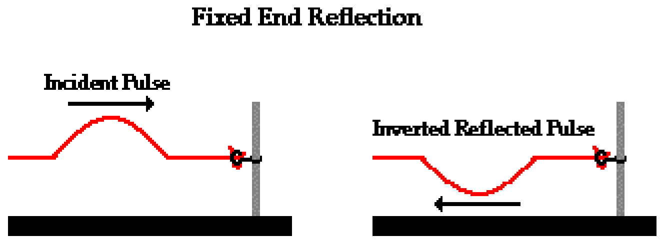
Demo #1: Reflection of one-dimensional waves

❖ A transverse wave pulse traveled down the length of the wave demonstrator and reached a ***free end***. Describe (in words) what happened to the appearance of the wave after reaching the free-end boundary. Sketch a "snapshot" of the wave pulse AFTER it has reflected.

Free End Reflection



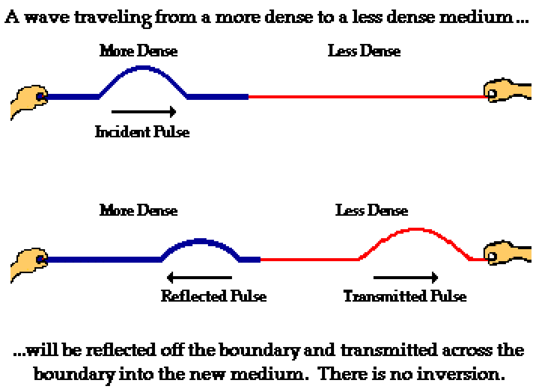
❖ A transverse wave pulse traveled down the length of the wave demonstrator and reached a ***fixed end***. Describe (in words) what happened to the appearance of the wave after reaching the fixed-end boundary. Sketch a "snapshot" of the wave pulse AFTER it has reflected.



Demo #2: Transmission and Reflection of waves *(again, review—answer based on previous notes/discussions)*

When a transverse wave travels through a medium and encounters a transition boundary into a new medium, part of the wave will be reflected, and part of the wave will be transmitted.

- ❖ Sketch a "snapshot" of the wave demonstrator's appearance after a wave pulse reaches a boundary between the original medium and a medium in which it will move <u>faster</u>.

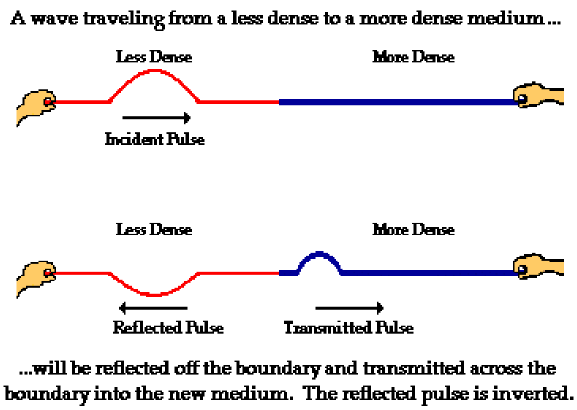


- ❖ Based on your observation, is this boundary similar to a fixed-end, or a free-end?
  Free End

- ❖ <u>Describe what happens (and why) to the amplitude</u> of the wave in the original medium when it reaches a transition boundary into a medium in which it will be moving <u>faster</u>.

  The amplitude of the wave pulse reflected back into the original medium will be lower. Some of its energy has been transmitted into the second medium. The reflected amplitude will be upright, as the boundary acts like a free-end.

❖ Sketch a “snapshot” of the wave demonstrator’s appearance after a wave pulse reaches a boundary between the original medium and a medium in which it will move slower.

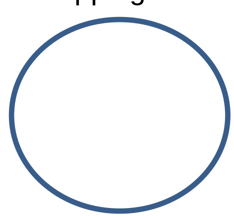


❖ Based on your observation, is this boundary similar to a fixed-end, or a free-end?
Fixed end

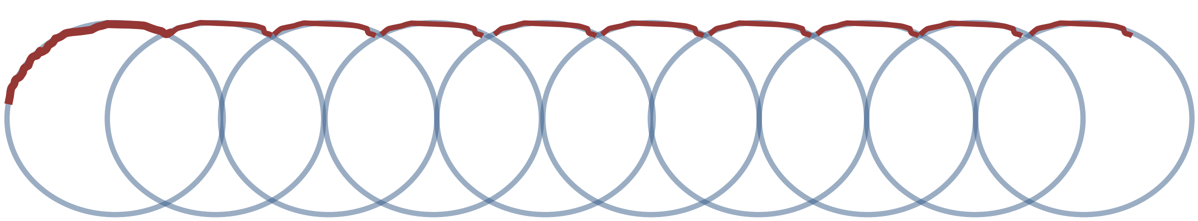
Section 2: 2-dimensional waves (as observed in a ripple tank)

A **ray** is drawn as an arrow to indicate the direction in which the energy is propagating through the medium.

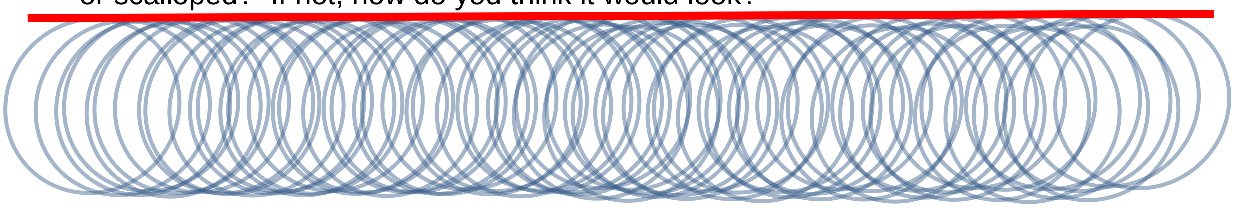
➢ Using the pipette at your lab station, drop **1 drop** of water into the center of the ripple tank. This creates a wave such as that created by a point source. Sketch what the wave looks like shortly after dropping the water droplet:



➢ Imagine that you had 10 drops of water drop simultaneously in a straight line. Sketch your prediction for what the water in the ripple tank would look like shortly after all 10 drops dropped:



- Imagine that you had 100 drops of water drop simultaneously in a straight line (and very close together). Do you think the wave moving through the water would still look circular or scalloped? If not, how do you think it would look?



The more point sources there are in a line, the straighter the wavefront will appear.

What you just observed and imagined is called a **wavefront**, which is, essentially, the actual two-dimensional wave itself. The wavefront will always be perpendicular to the direction in which the energy is propagating in the medium. A Plane Wavefront is a straight line wave, and a cylindrical wavefront is circular, like the wave you just drew in the first question in this section.

A plane wavefront can be assumed to be many point sources all in a row, creating circular wavefronts simultaneously. As they move forward through the medium, they overlap so much that they appear to be a straight-line wave—**What is the name of this principle?**

___**Huygen's Principle**_______________________________________.

{for more information on **wave fronts and rays,** please read 134-137}

- **Complete Experiment 1: Reflection *(Follow instructions in lab procedure packet)***
  - **Angle of Incidence** is the angle that is measured between the incoming ray and a normal line drawn to the surface at the point where the ray hits the surface.
  - **Angle of Reflection** is the angle that is measured between the outgoing (reflected) ray and a normal line drawn to the surface at the point where the ray leaves the surface.
  - Complete experiment 1 as written in the packet at your lab station. However, instead of just 2 angles, please complete at least 5 different angles. Each person in the group must complete at least one angle's tracing and measurements, and then share your data. Record your group's data here:
    - **Part 1: Reflection off a Straight Barrier**

Trial Number	Angle of Incidence (°) (± 0.5°)	Angle of Reflection (°) (± 0.5°)
1		
2		
3		
4		
5		

1. Describe any pattern that you notice throughout your group's data.

The angle of incidence should appear to be nearly equal to the angle of reflection.

The <u>Law of Reflection</u> states that the angle of incidence is exactly equal to the angle of reflection—this is true for mechanical waves and for light (EM waves)

<u>Section 2: Refraction of plane wavefronts</u>

<u>Refraction</u> occurs when a wavefront changes its direction of propagation as a result of entering a new medium and changing wavespeed. This will only occur if the wave fronts hit the transition boundary between media at an angle rather than straight on. (i.e. if the ray is perpendicular to the boundary line, no refraction of the wavefront will occur)

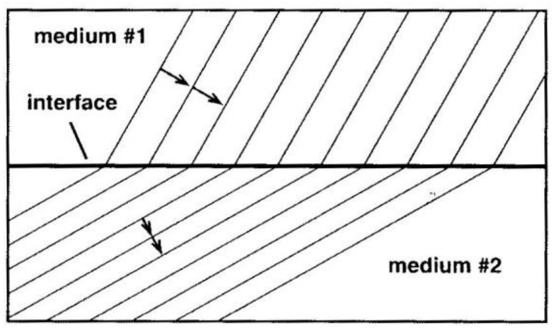


Figure 2.1: Refraction

- In the diagram to the left, in which medium is the wave traveling <u>slower</u>? How do you know?

Medium #1. The wavelengths are shorter, and it appears to be lagging behind the part of the wavefront that is in medium #1.

Complete Experiment 2: Refraction—*(follow instructions in lab procedure packet)*

- **Part 1: Refraction Using a Straight Barrier**
  - Neatly sketch the behavior of the waves that you observed by completing the tracing and drawing of rays stated in the procedure.
  - As the wavefronts move over the top of the refractor, what happens to their wavelength?

    Decreased wavelengths in the water over the refractor.

  - As the wavefronts move off the angled edge of the refractor, what happens to their direction?

    As they move off the refractor and speed up in the deeper water, the wavefronts appear to change direction so that it moves towards the pointed part of the refractor

- In which medium, deeper water or shallow water, was the wave traveling the fastest? How can you tell?

  Deeper water = faster wave; wavelengths are longer in the deeper water.

- On your group's drawing, you should have an **angle of incidence** (in the deeper water) and an **angle of refraction** (in the shallower water). Which of these two angles is smaller? (remember, each angle is measured to a normal line drawn to the boundary) What does this tell you about the relationship between the change in direction of the wavefront and its speed, compared to the speed at which it traveled in the original (incident) medium?

The angle of refraction, drawn in the shallower water, would be a smaller angle between the ray and the normal. The angle in the deeper water will be the larger angle measured. As a wave speeds up, its direction changes so that it is moving at an angle further from the normal line. As the wave slows down, its direction shifts closer to the normal line.

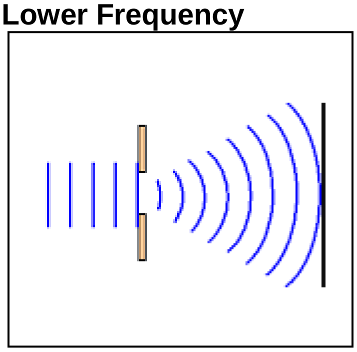
Section 3: Diffraction and Interference—*(follow instructions in the lab procedure packet)*

➢ Based on the **Theory** presented in Experiment 3: Diffraction, what is the definition/description of **Diffraction**:

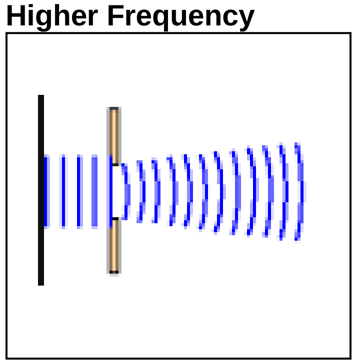
Diffraction is the behavior waves display when they pass through/around a barrier and change direction. The waves bend around the edge of a barrier—it is a circular wavefront that fills the space behind the barrier.

❖ **Complete Experiment 3: Diffraction**
❖ **Part 1: Longer Barriers—single opening**
   - Rather than tracing the wave patterns, just sketch them in the boxes below:

Lower Frequency



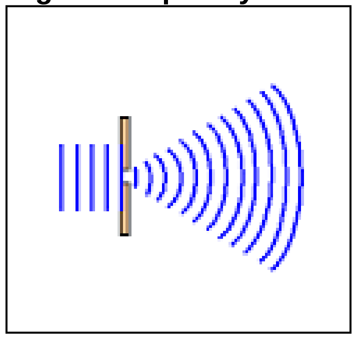
Higher Frequency



Slit width = __wider__

Lower Frequency

Higher Frequency

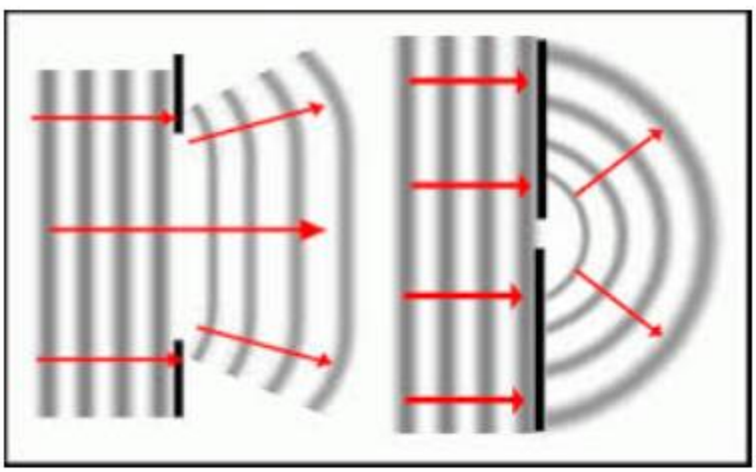


Slit width = __narrower___

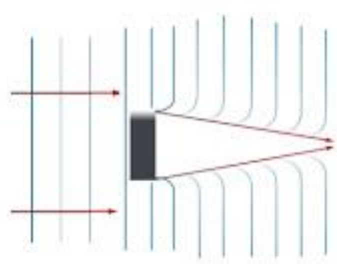
1. Describe, in your own words, how the frequency of the waves affected the diffraction patterns seen in the ripple tank.

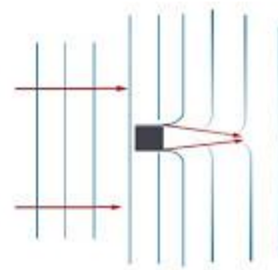
As the frequency increases, the wavelength decreases. Typically the smaller the wavelength, the more diffraction (the more apparent diffraction pattern) we will see.

2. Describe, in your own words, how the width of the slit opening affected the diffraction patterns observed in the ripple tank.
   If the size of the opening is larger than the wavelength, there will be little diffraction—the wave will appear to go through the opening mostly unbent. If the opening is the same size, or smaller than, the wavelength, there will be more noticeable diffraction of the wave as it passes through the boundary.



- **Part 2: Small Solid Barrier**
  - Sketch the diffraction pattern observed:

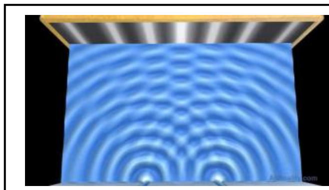




3. What happens to the diffraction pattern as the frequency is increased?

Higher frequency results in less diffraction around the barrier. There should be a longer "shadow" where the water is not disturbed (much).

- **Experiment 4: Interference—follow the steps in the procedure packet**
- Sketch the interference pattern observed as the plane wave passes through 2 slits formed by placing the larger of the two small barriers in between the long barriers:



There should be areas of total destructive interference that are visible. They look like rays coming from near the slit and directed away. These are called nodal lines, as they are areas of the most destructive interference. In between these nodal lines are areas of the most constructive interference. The amplitude of the waves add together to give a larger amplitude than if just a single point source wave was present.

- Change the frequency without altering the placement of the barriers. Describe how the frequency and the interference pattern observed seem to be related:

  As the frequency increases, the wave will not diffract as much, but because the wavelength is smaller there are more places that interference will occur. As a result, the increased frequency has a higher number of nodal lines.

- Change the center barrier to the mini barrier, making the slits closer together, but keep the size of the slits the same as they previously were. Describe how the interference pattern changed. Does changing frequency still affect it the same way as before?

  As the slits get closer together, less interference will occur. The waves coming through the slits will act more and more similarly to a single slit the closer the slit openings are to each other.