Reflection and Superposition

Unit: Mechanical Waves

MA Curriculum Frameworks (2016): HS-PS4-1

AP® Physics 2 Learning Objectives: 6.C.1.1, 6.C.1.2

Mastery Objective(s): (Students will be able to…)

- Explain the behavior of waves when they pass each other in the same medium and when they reflect off something.

Success Criteria:

- Descriptions & explanations account for observed behavior.

Language Objectives:

- Explain what happens when two waves pass through each other.

Tier 2 Vocabulary: reflection

Labs, Activities & Demonstrations:

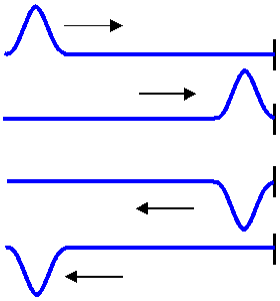
- waves on a string or spring anchored at one end
- large Slinky with longitudinal and transverse waves passing each other

Notes:

Reflection of Waves

reflection: when a wave hits a fixed (stationary) point and "bounces" back.

Notice that when the end of the rope is fixed, the reflected wave is inverted. (If the end of the rope were free, the wave would not invert.)

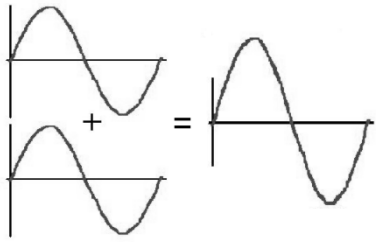


Use this space for summary and/or additional notes:

Superposition of Waves

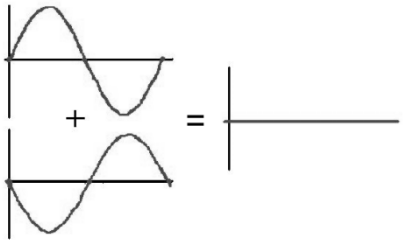
When waves are superimposed (occupy the same space), their amplitudes add.

constructive interference: when waves add in a way that the amplitude of the resulting wave is larger than the amplitudes of the component waves.



Because the wavelengths are the same and the maximum, minimum, and zero points all coïncide (line up), the two component waves are said to be "in phase" with each other.

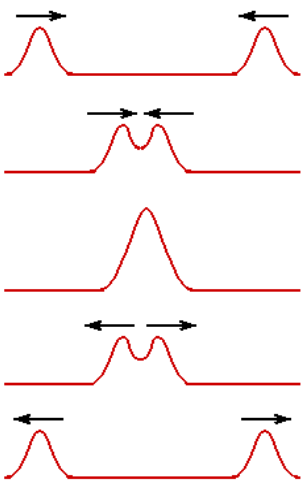
destructive interference: when waves add in a way that the amplitude of the resulting wave is smaller than the amplitudes of the component waves. (Sometimes we say that the waves "cancel" each other.)



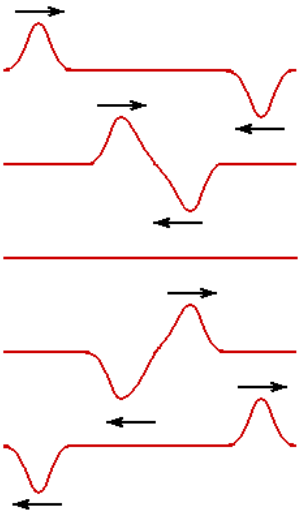
Because the wavelengths are the same but the maximum, minimum, and zero points do not coïncide, the waves are said to be "out of phase" with each other.

Note that waves can travel in two opposing directions at the same time. When this happens, the waves pass through each other, exhibiting constructive and/or destructive interference as they pass:

Constructive Interference



Destructive Interference



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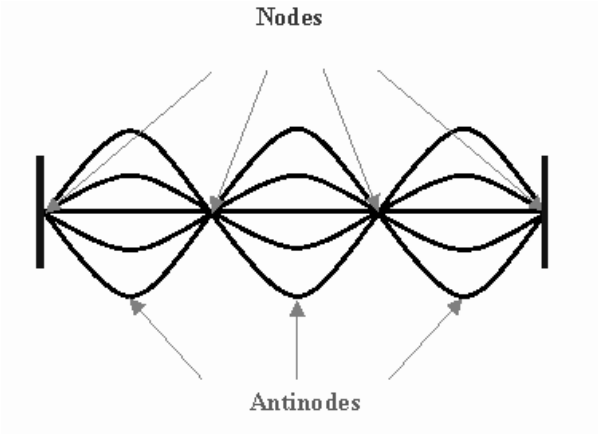
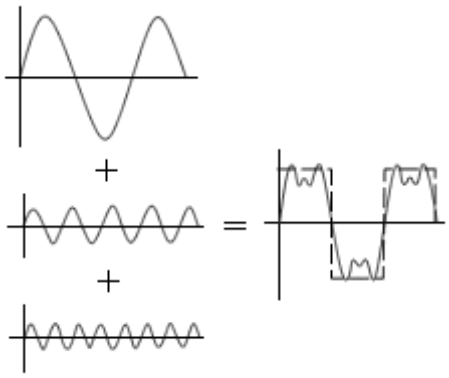
Standing Waves

standing wave: when half of the wavelength is an exact fraction of the length of a medium that is vibrating, the wave reflects back and the reflected wave interferes constructively with itself. This causes the wave to appear stationary.

Points along the wave that are not moving are called “nodes”. Points of maximum displacement are called “antinodes”.



When we add waves with different wavelengths and amplitudes, the result can be complex:

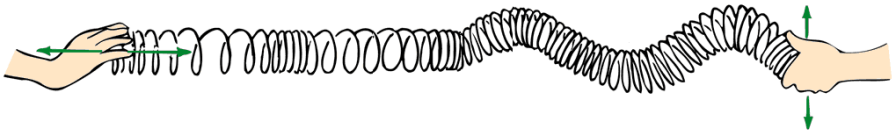


This is how radio waves encode a signal on top of a “carrier” wave. Your radio’s antenna receives (“picks up”) radio waves within a certain range of frequencies. Imagine that the bottom wave (the one with the shortest wavelength and highest frequency) is the “carrier” wave. If you tune your radio to its frequency, the radio will filter out other waves that don’t include the carrier frequency. Then your radio subtracts the carrier wave, and everything that is left is sent to the speakers.

Use this space for summary and/or additional notes:

Homework Problem

1. **(M)** A Slinky is held at both ends. The person on the left creates a longitudinal wave, while at same time the person on the right creates a transverse wave with the same frequency. Both people stop moving their ends of the Slinky just as the waves are about to meet.



   a. Draw a picture of what the Slinky will look like when the waves completely overlap.

   b. Draw a picture of what the Slinky will look like just after the waves no longer overlap.

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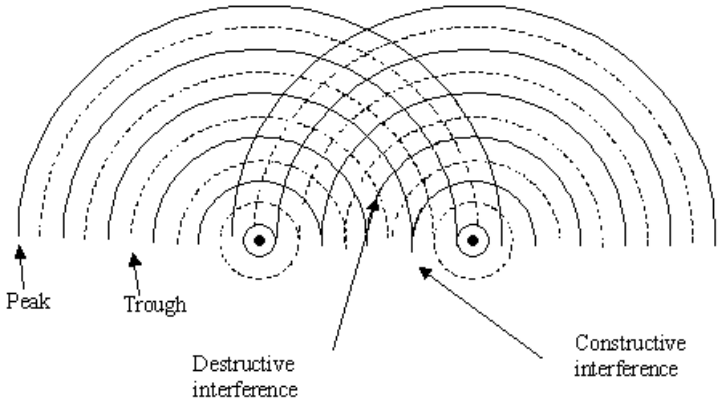
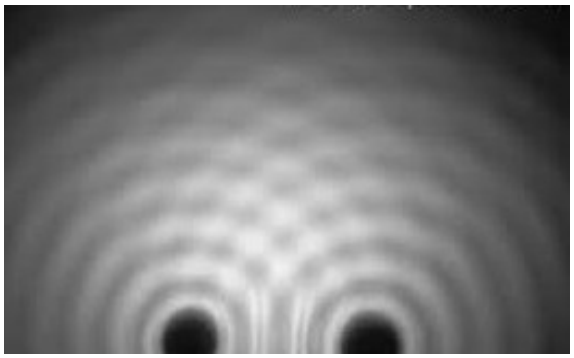
Two-Dimensional Interference Patterns

When two progressive waves propagate into each other's space, the waves produce interference patterns. This diagram shows how interference patterns form:



The resulting interference pattern looks like the following picture:

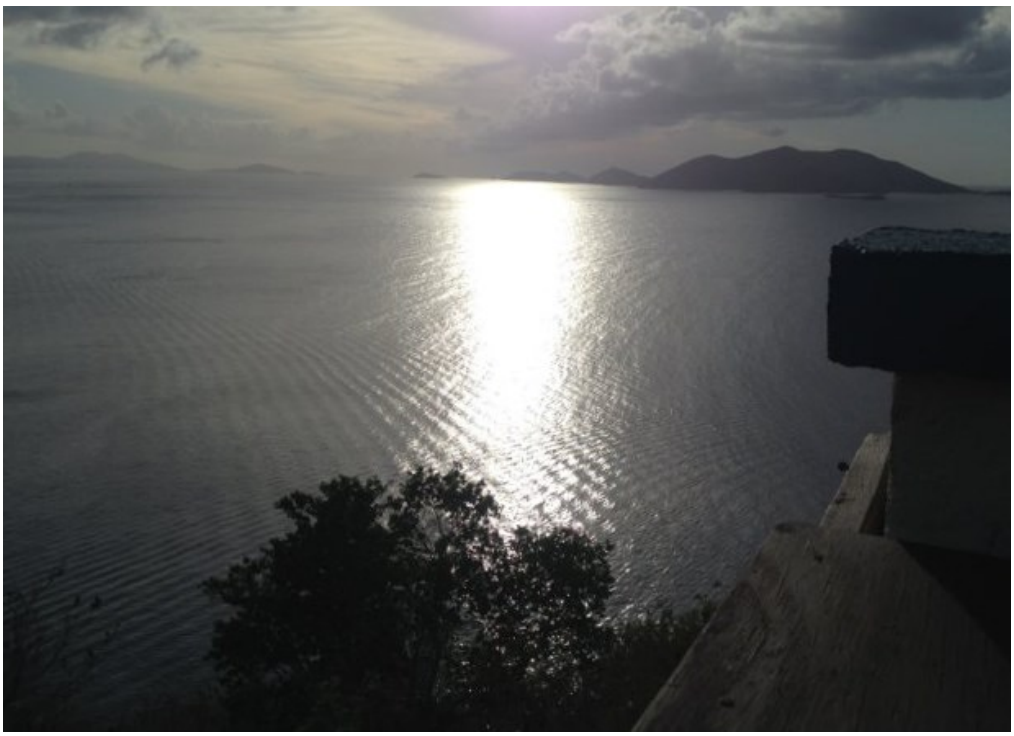


In this picture, the bright regions are wave peaks, and the dark regions are troughs. The brightest intersections are regions where the peaks interfere constructively, and the darkest intersections are regions where the troughs interfere constructively.

Use this space for summary and/or additional notes:

The following picture* shows an interference pattern created by ocean waves, one of which has been reflected off a point on the shore. The wave at the left side of the picture is traveling toward the right, and the reflected wave at the bottom right of the picture is traveling toward the top of the picture.

Because the sun is low in the sky (the picture was taken just before sunset), the light is reflected off the water, and the crests of the waves produce shadows behind them.



* Taken from Tortola in the British Virgin Islands, looking west toward Jost Van Dyke.

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