Name:_____

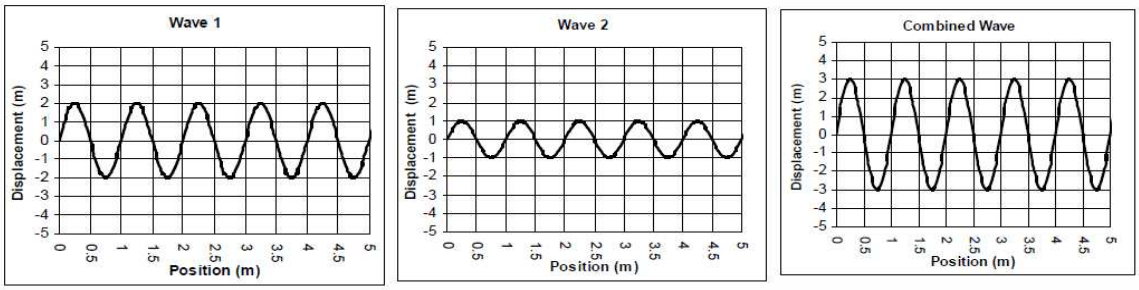
Superposition Principle: Adding Waves

Wave Interference and the Superposition Principle: Combining Waves

Two waves that hit each other will interact, either adding or subtracting amplitude (energy) from each other. If two people send waves along the same side of a slinky, the two pulses will be bigger when they cross (constructive interference). If they are sent on opposite sides (one up, one down), they will be smaller and possibly even cancel each other out (destructive interference).

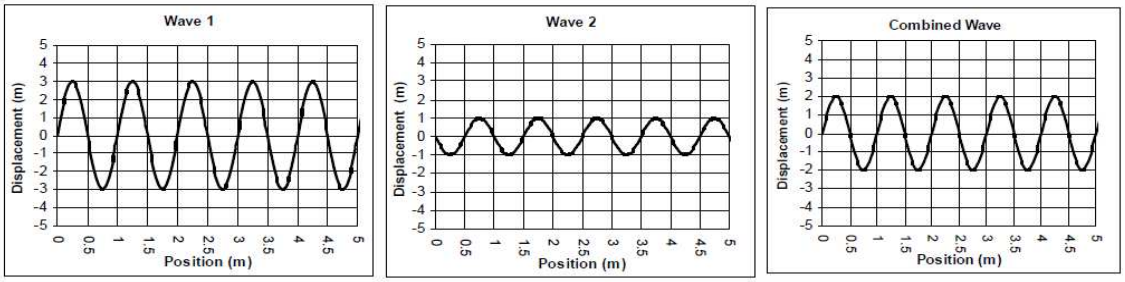
How to Add Waves: The amplitude at any point on the combined wave equals the sum of the individual amplitudes of the two combining waves . Two positive amplitudes make a bigger positive amplitude; two negative amplitudes make a bigger negative amplitude; a positive and a negative amplitude reduce each other. If equal in magnitude a positive and negative amplitude cancel each other out (a medium can't undergo compression and rarefaction [expansion] at the same time, so they equal no motion).

Constructive Interference—Waves In-Phase



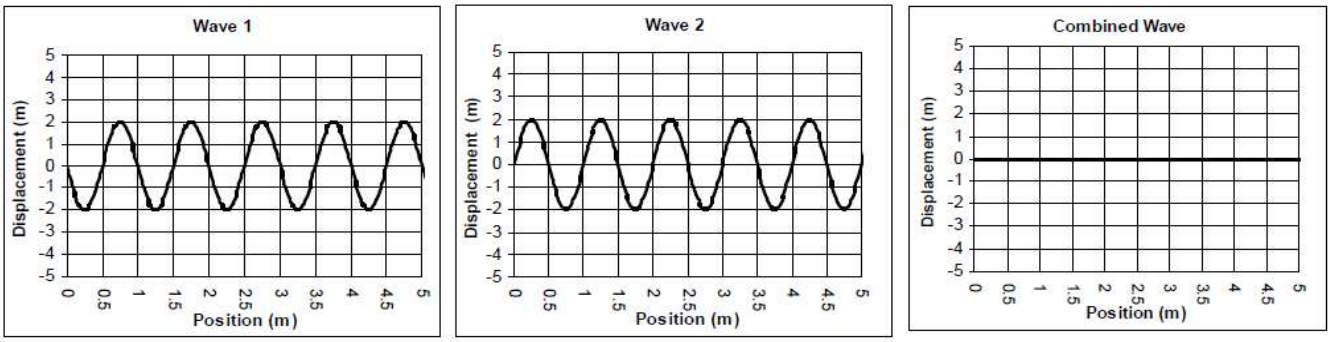
Notice that wave 1 and wave 2 have the same period. Wave 1 has the bigger amplitude. Whenever wave 1 goes up, wave 2 goes up, so their amplitudes add together: 1m + 2m = 3m. Thus, wave 3 has an amplitude of 3 m. This is an easy example, because they have the same period. If they did not, you would have to add the amplitudes at each point.

Destructive Interference—Waves 180° Out-of-Phase



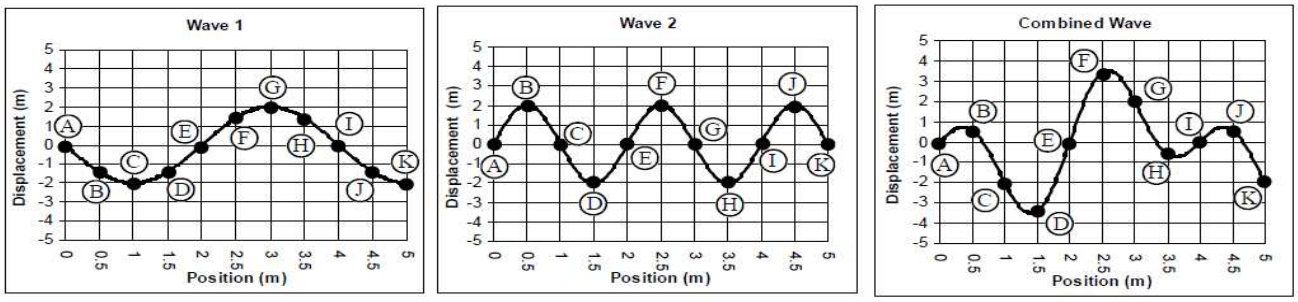
Wave 1 and 2 have the same period, but are 180° out-of-phase. When wave 1 is going up, wave 2 is going down. The two waves destructively interfered with each other, decreasing in amplitude: +3 m – 1 m = 2 m

Complete Destructive Interference—Waves 180° Out-of-Phase; Equal Period and Amplitude



Wave 1 and 2 have the same period, same amplitude and are 180° out-of-phase. Because at every time of Wave 1, Wave 2's amplitude is exactly opposite, the cancel each other out. This is known as Completely Destructive Interference. This is how "Noise Canceling Headphones" work: they send a mirror out-of-phase wave back on the noise, thus canceling (or reducing) the incoming noise.

Complex Interference—Waves of Different Period



Each point on the combined wave is the net amplitude of the individual amplitudes of wave 1 and 2.
(Subscripts: A_1 is wave 1 at A; G_2 is wave 2 at G; J_C is combined wave at J)
Combining the waves at every point:

Amplitude on 1 + Amplitude on 2 = Amplitude on C
$A_1 + A_2 = 0 + 0 = 0$; $A_C = 0$ m
$B_1 + B_2 = -1.5 + 2 = +0.5$; $B_C = +0.5$ m
$C_1 + C_2 = -2 + 0 = -2$; $C_C = -2$ m
$D_1 + D_2 = -1.5 + -2 = -3.5$; $D_C = -3.5$ m
$E_1 + E_2 = 0 + 0 = 0$; $E_C = 0$ m
$F_1 + F_2 = +1.5 + 2 = +3.5$; $B_C = +3.5$ m
$G_1 + G_2 = +2 + 0 = +2$; $G_C = +2$ m
$H_1 + H_2 = +1.5 + -2 = -0.5$; $D_C = -0.5$ m
$I_1 + I_2 = 0 + 0 = 0$; $I_C = 0$ m
$J_1 + J_2 = -1.5 + +2 = +0.5$; $J_C = +0.5$ m
$K_1 + K_2 = -2 + 0 = -2$; $K_C = -2$ m

TRUE or **FALSE**: Identify the following statements as being either true (T) or false (F).

T or F?

_____ 1. When two pulses meet up with each other while moving through the same medium, they have a tendency to bounce off each other and return back to their origin.

_____ 2. Constructive interference occurs when a crest meets up with another crest at a given location along the medium.

_____ 3. Destructive interference occurs when a pulse with an amplitude of +5 units interferes with a pulse with an amplitude of -5 units.

_____ 4. Destructive interference occurs when a trough meets up with another trough at a given location along the medium.

_____ 5. If a pulse with an amplitude of +5 units interferes with a pulse with an amplitude of +3 units, the resulting amplitude of the medium will be +4 units - the average of the two individual amplitudes.

_____ 6. If a pulse with an amplitude of +5 units interferes with a pulse with an amplitude of -3 units, then neither constructive nor destructive interference occurs.

_____ 7. Two sound waves could never interfere in such a manner as to cancel each other out and produce silence.

Two waves are traveling along the same medium. The diagrams below show the waves on the medium at an instant in time. Utilize the principle of superposition in order to construct the shape of the medium at the instant shown in each diagram. To do so, begin by determining the resulting displacement of the medium at each of the marked locations (↑). Approximate the shape of the remainder of the medium by sketching *from dot to dot*.

Diagram A

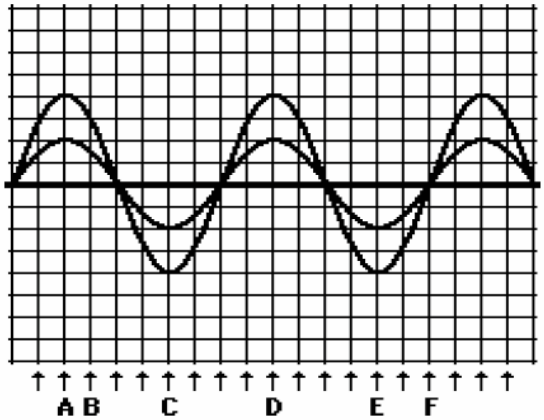
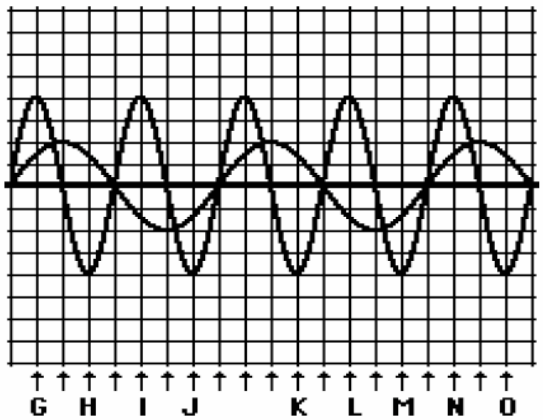


Diagram B



Several of the marked positions (↑) above are labeled with a letter. Categorize each labeled position along the medium as being a position where either constructive or destructive interference occurs.

Constructive Interference	Destructive Interference