

# PhyzGuide: Superposition

Normally, a wave pulse can travel happily through its medium, dissipating energy until it dies out. However, there are times when one pulse encounters another pulse in the medium, and that's when things get interesting! A collision of pulses or series of pulses (waves) is called **interference**. When the pulses meet, each one exerts a force on the medium resulting in a displacement of the medium equal to the algebraic sum of each pulse's individual displacement of the medium. In other words, *the pulses add!* This "wave addition" is called the **principle of superposition**.

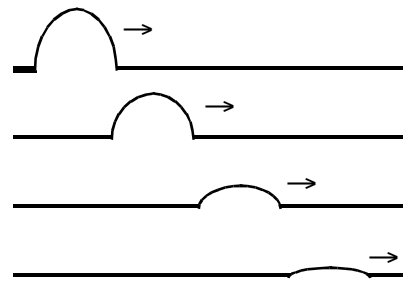
To understand the principle of superposition, let's examine the simplest cases of interference we can think of.

Consider the sequence depicted to the right. A pulse with an amplitude of +1 traveling to the right and a pulse with an amplitude of +1 traveling to the left "collide." The result is a momentary displacement of +2 in the medium. This is called **constructive interference**. The pulses then continue on their way with their original amplitudes.

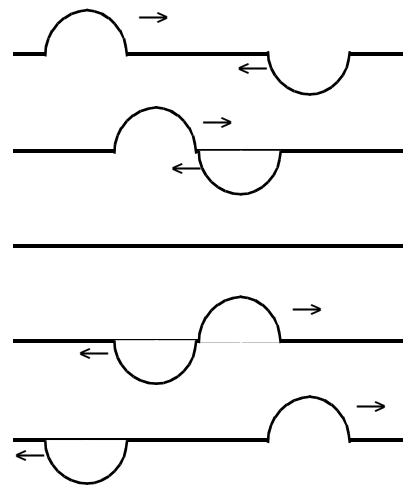
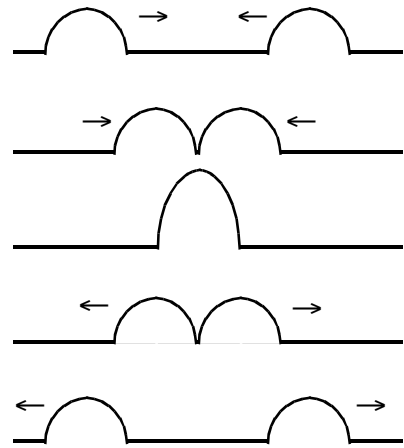
Now consider the next sequence shown to the right. A pulse with amplitude +1 and a pulse with an amplitude of -1 "collide." The result is a momentary displacement of zero in the medium. This is called **destructive interference**. The pulses then continue on their way with their original amplitudes.

Superposition occurs *whenever* waves interfere. Complicated waveforms are the result of many overtones superposed on a fundamental waveform.

The principle of superposition is *not* a basic Rule of the Universe. It is simply a *consequence* of Newton's laws/conservation of energy.

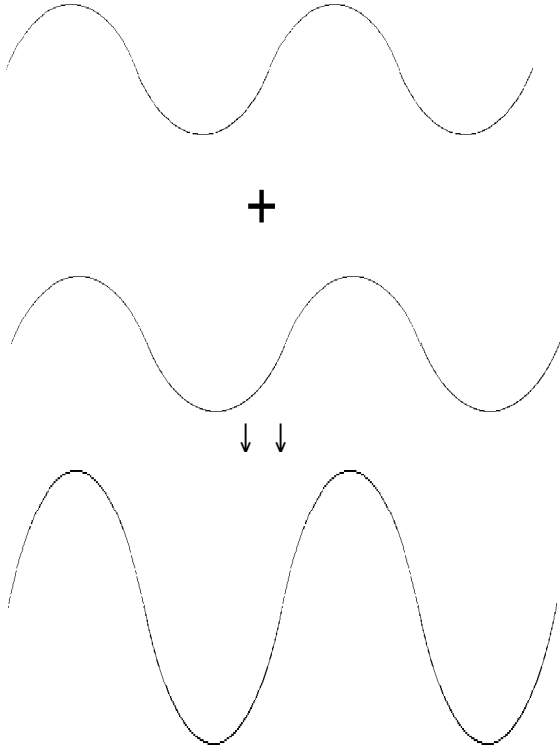


A wave pulse loses energy as it propagates. The energy dissipated from the pulse becomes internal energy in the medium.

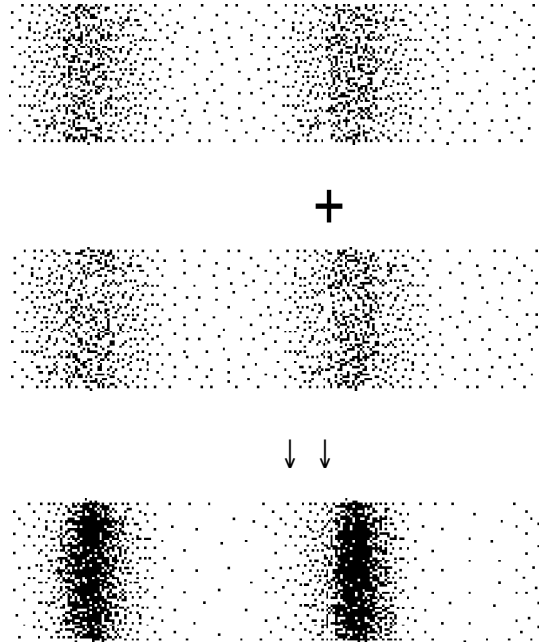


# CONSTRUCTIVE INTERFERENCE

## TRANSVERSE

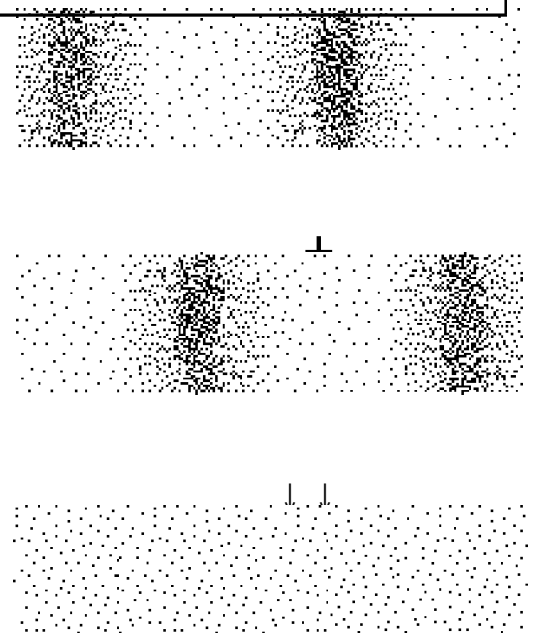
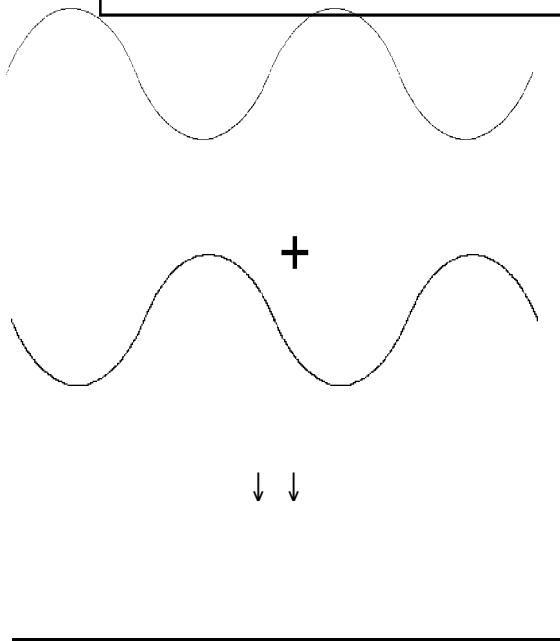


## LONGITUDINAL



**CONSTRUCTIVE INTERFERENCE:** waves that are "in phase" with each other add to form a wave with an increased amplitude. "In phase" means that the crest or compression of one wave coincides with the crest or compression of the other wave.

# DESTRUCTIVE INTERFERENCE



**DESTRUCTIVE INTERFERENCE:** waves that are "out of phase" with each other cancel to form a wave with a decreased (or no) amplitude. "Out of phase" means that the crest or compression of one wave coincides with the trough or rarefaction of the other wave.