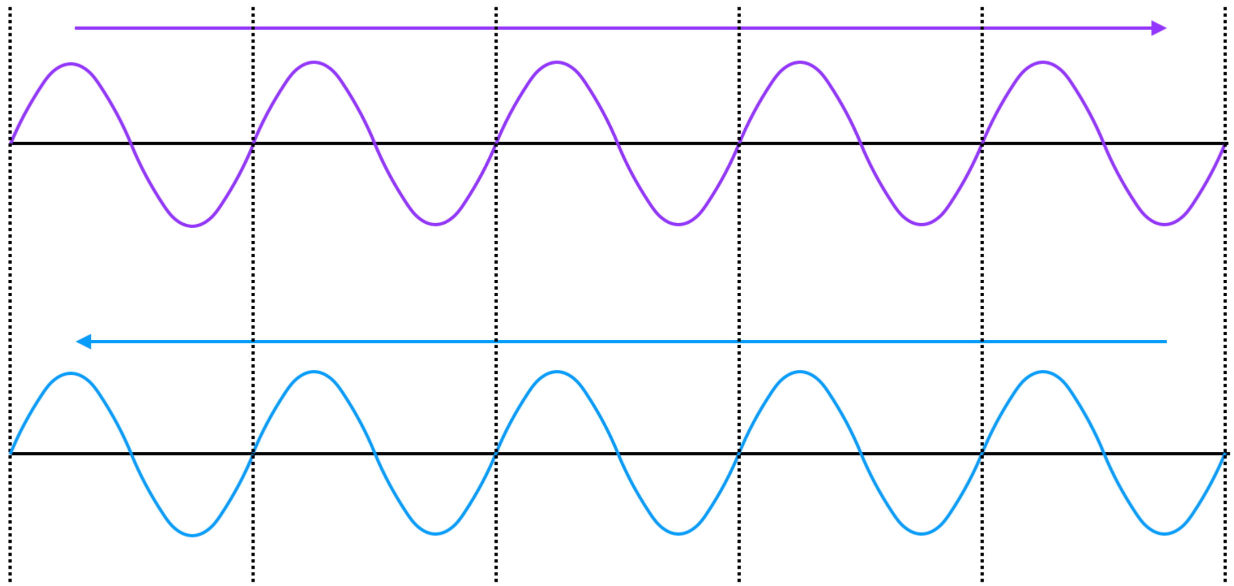
Lesson 5. Standing Waves

Suppose you have two equal waves traveling down a string in opposite directions.



The two waves will interfere with one another at various points in their cycles. In the moment diagrammed above, positive interference will double the wave's amplitude.

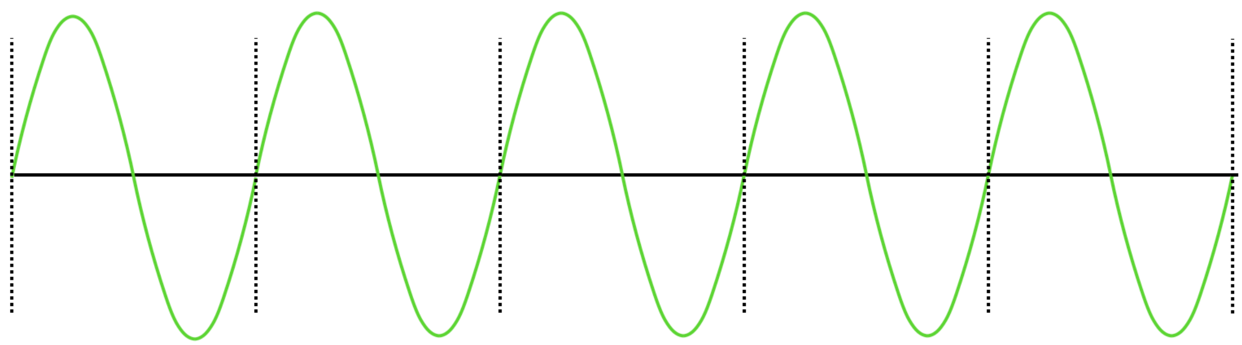
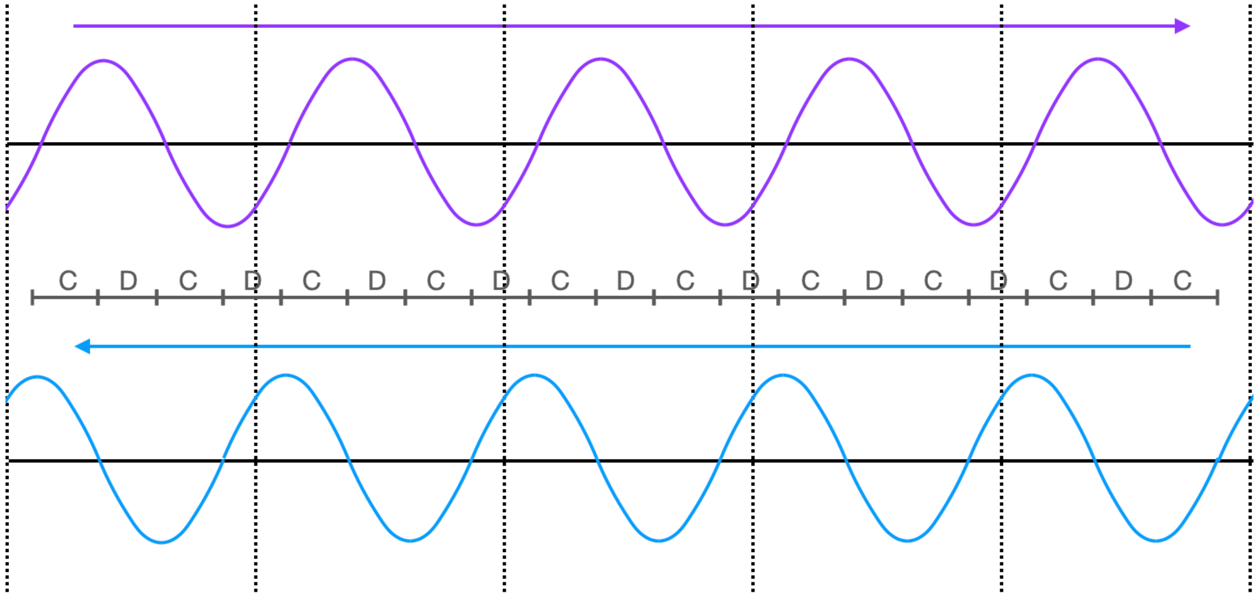


Figure 1. Constructive Interference

One eighth of a cycle later, the waves are out of phase, with both constructive and destructive interference present (marked by “C” and “D” in the diagram.)



This will produce a wave in the same shape as the previous one, but with a smaller amplitude.

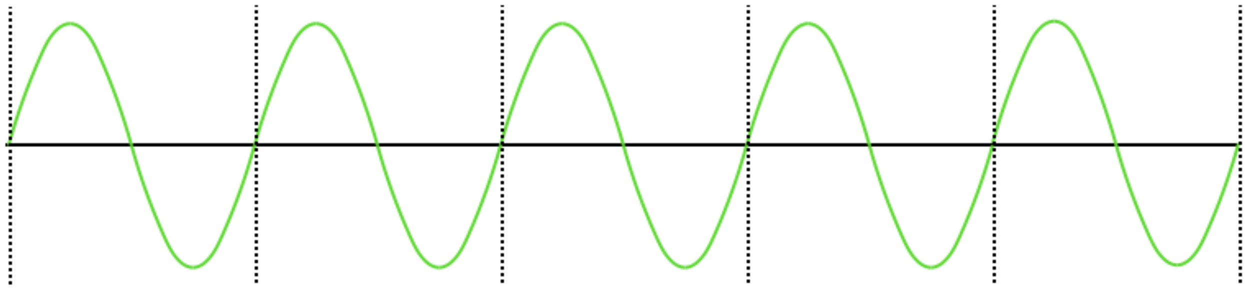
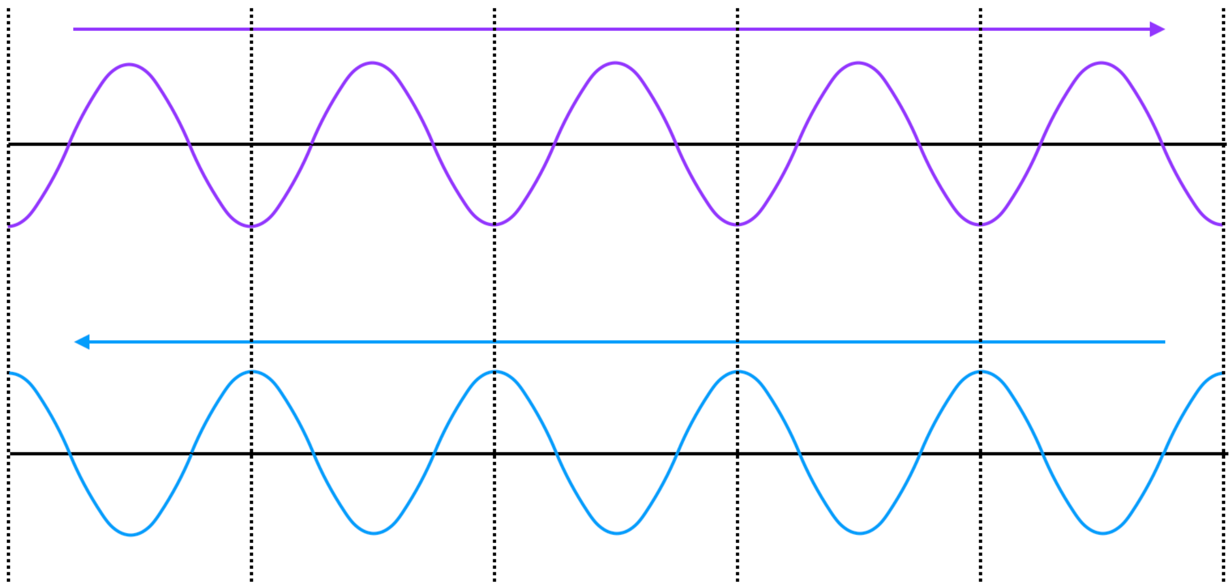


Figure 2. Constructive and Destructive Interference

Another eighth of a cycle later, the waves will be in opposition to each other.



The resulting negative interference will result in a zero amplitude across the wave.

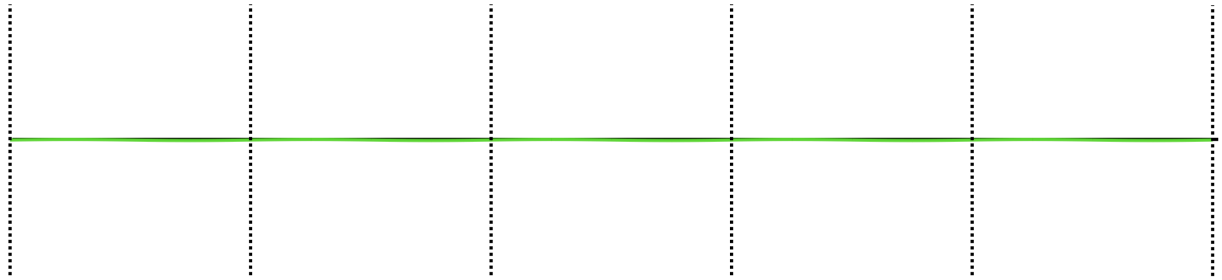


Figure 3. Destructive Interference

After another eighth of a cycle, the waves will be out of sync, producing the mirror image (i.e. the constructive interference is now destructive and vice versa) of Figure 2.

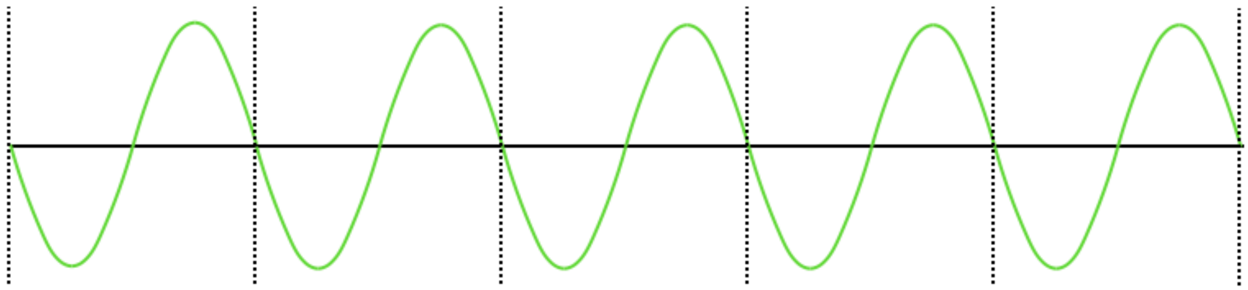


Figure 4. Constructive and Destructive Interference, Mirror Image

An eighth of a cycle after this, the waves will once again be aligned, producing the mirror image of Figure 1.

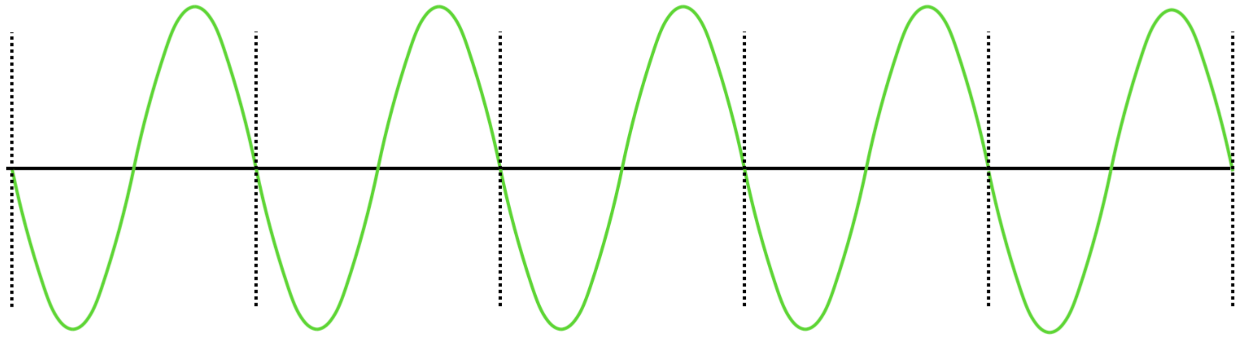
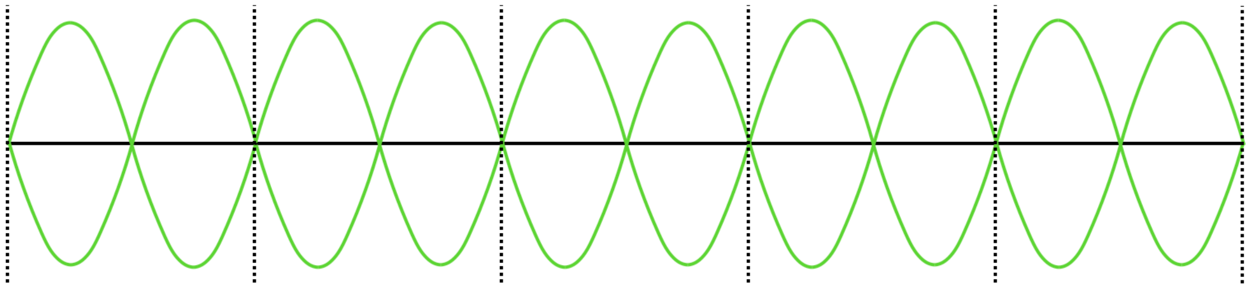
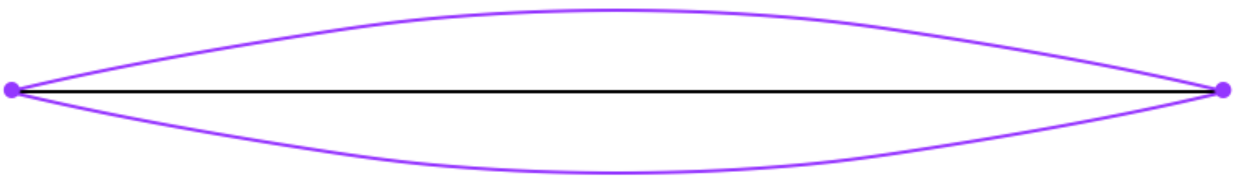


Figure 5. Constructive Interference, Mirror Image

The remaining half-cycle will recreate the same interference pattern as the first. The result is a **standing wave**, the crests, troughs, and nodes of which remain physically stationary along the string and only the amplitude appears to change with each cycle. Nearly all instruments produce standing waves.



A string of a given length *L* has several vibration modes. The first or **fundamental** is when the entire string appears to waver back and forth. In this circumstance, the top and bottom ends of the string can be considered nodes.



Since the distance between two nodes in a standing wave is exactly is half the wavelength λ, we can conclude that $\lambda = 2L$. Since the wave relation equation is $S = f\lambda$, frequency of the fundamental mode can be expressed as

$$f = \frac{S}{2L}$$