The Big Ideas—Chapter 18

(Serway and Beichner, Physics for Scientists and Engineers, 5th Edition)

Sections 1 **Sinusoidal waves of the same frequency interfere in a manner that depends on their phase difference.** When that phase difference is zero, we say the waves are "in phase" and they interfere "constructively" to form a wave whose amplitude is the *sum* of the amplitudes of the constituent waves. When that phase difference is 180°, we say the waves are "out of phase" and they interfere "destructively" to form a wave whose amplitude is the *difference* of the amplitudes of the constituent waves. The phase difference is *often* directly the result of a *difference in the distances* (the "path difference") to two sources or along two paths to the *same* source.	$\varphi = 2\pi\frac{\Delta r}{\lambda}$
Section 2 **When two waves of the same amplitude and frequency traveling in *opposite* directions interfere, the result is a standing wave.** Standing waves are characterized by nodes (places where the resulting disturbance is zero) and antinodes (places where the resulting disturbance is twice that of either wave individually.) Nodes are separated by half a wavelength as are the antinodes. Strictly speaking, standing waves transmit no energy; they are simply stationary patterns of oscillation.	
Section 3 **Standing waves on a string that is fixed at both ends have a discrete set of "resonant" wavelengths (and, therefore, frequencies) due to the condition that both ends must be nodes.** The allowable frequencies are integer multiples of the lowest ("fundamental") frequency.	$\lambda_n = \frac{2L}{n}$ $f_n = \frac{v}{\lambda_n} = nf_1$
Section 4 **When a periodic force is applied to a system that has a natural frequency that matches that of the force, the system vibrates with large amplitude. This *very* important and common phenomenon is called "resonance."**	

Section 5 **Standing waves in an air column have a discrete set of possible wavelengths (and, therefore, frequencies) due to the condition that the ends must be either nodes or antinodes for the pressure variations depending on whether the ends are either open or closed (respectively.)** An open end is a node for the pressure variations because of the overwhelming control of the atmosphere to which it is exposed. A closed end is a node for the displacement variations since the molecules there can not move. Because of the 1/4 cycle phase shift between displacement and pressure waves, a node for displacement is an antinode for pressure. Therefore, an open-open, or closed-closed pipe has resonant wavelengths and frequencies that are directly analogous to those on a string as seen in section 3. An open-closed pipe has allowable frequencies are *odd* integer multiples of the lowest ("fundamental") frequency.	$\lambda_n = \frac{2L}{n}$ (n =integer $f_n = \frac{v}{\lambda_n} = nf_1 = n\frac{v}{2L}$ $\lambda_n = \frac{4L}{n}$ (n = odd integer) $f_n = \frac{v}{\lambda_n} = nf_1 = n\frac{v}{4L}$
Section 6 **Standing ("resonant") waves can also be set up in rods, plates, rooms full of air, and *any* other physical system in general!**	
Section 7 **When two waves of slightly differing frequencies interfere, they produce a time varying amplitude that is referred to as "beating." The "beat frequency" is simply the difference between the individual frequencies.**	$f_{beat} = \lvert f_1 - f_2 \rvert$
Section 8 **Periodic, but nonsinusoidal, waves can be considered to be the result of interference from an infinite number of strictly sinusoidal waves with frequencies that are integer multiples of the wave period. This is referred to as "Fourier's theorem" and the constituent waves are referred to as a "Fourier series."**	