Superposition and Interference – Chapter 17

Because waves are energy, and not matter, they can pass through each other.

<u>Constructive vs. Destructive Interference</u>

- fig. 17.1, 17.2 on p. 503

For <u>constructive</u> interference, sources must have a difference of path lengths of an integer number of wavelengths.

<u>ex.</u> 1λ, 2λ, 3λ, etc.

- fig.17.3 on p. 504

For <u>destructive</u> interference, sources must have a difference of path lengths of a half-integer of wavelengths.

<u>ex.</u> $\frac{1}{2}\lambda$, $3/2\lambda$, $5/2\lambda$, etc.

- fig.17.4 on p. 505

- fig.17.6 on p. 506

Beats – when two sources have different frequency, the loudness will increase and decrease with a frequency that is the difference between the two frequencies. (This is the number of times per second the loudness rises and falls.)

- fig. 17.13 and 17.14 on p. 511

Standing Waves

Standing waves result when periodic identical waves (same f, λ, A) travel in opposite directions.

- fig. 17.15 on p. 512

Standing waves are waves that interfere with each other and produce a vibration that looks like the wave is not moving. The wave is actually moving and interfering in a manner that produces a series of nodes (no displacement) and antinodes (maximum displacement).

Transverse Standing Waves

To create a standing wave on a string (ex. guitar), constructive interference must be produced. To do this, a new wave must be started when the first one returns, otherwise destructive interference will occur.

The time for one complete round trip is:

$$T = \frac{2L}{v}$$

Thus the fundamental (1st harmonic) frequency of one loop must have a frequency of:

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

- fig. 17.15 on p. 513

The nth frequency will be:

$$f_n = n \frac{v}{2L}$$

where: n = harmonic (1,2,3, …)
v = velocity of wave on string (m/s)
L = length of string (m)
f_n = frequency (Hz)

Longitudinal Standing Waves

Musical instruments in the wind family depend on longitudinal standing waves.

- fig. 17.19 and 17.20 on p. 516

If a sound wave is sent down a tube, standing waves can occur with the right frequency. As with transverse waves, 1λ is the distance between the antinodes.

Note: Because the pipe confines the air, waves still reflect at the ends even though they are open.

The standing wave frequencies are:

$$f_n = n \frac{v}{2L}$$

where: n = harmonic (1,2,3, …)
v = velocity of sound in tube (m/s)
L = length of tube (m)
f_n = frequency (Hz)

Standing waves can also exist in a tube with only one open end. Because of the different wave patterns, closed tubes can only vibrate at odd harmonic frequencies.

- fig. 17.22 on p. 519

$$f_n = n \frac{v}{4L}$$

where: n = odd harmonic (1,3,5, …)
v = velocity of sound in tube (m/s)
L = length of tube (m)
f_n = frequency (Hz)