Section1.5

Waves

What is a VIBRATION?

- A “wiggle” in time.
  - A mass bobbing up and down on a spring.
  - A swinging pendulum.
  - A beating heart.

What is a WAVE?

- A “wiggle” in space as well as time.
  - A pulse traveling down a rope.
  - A sound disturbance.
  - A light flash.
  - A tsunami.

Wave Description

- Amplitude: Distance from the midpoint to a crest (or trough) of the wave. (The "height" of the wave.)
- Wavelength, λ: Distance between identical parts of the wave. (say, from the top of a crest to the next.)
- Frequency, f: The number of complete oscillations per unit of time. (How often the vibrations occur. Measured in "Hertz" where 1 Hz = 1 cycles/s.)
- Period, T: The time for one complete oscillation.

  (The inverse of the frequency: $T = 1/f$.)

Wave Speed

Recall from (Chapter 3):

Speed = Distance /Time

Wave Speed, v = Wavelength / Period = λ/T.

Since $T = 1/f$, then $f = 1/T$, so $v = \lambda f$.

The wave speed only depends on the properties of the medium through which the disturbance passes.

Types of Waves

Transverse Waves: Disturbance is perpendicular to the direction of propagation of the wave. A “side-to-side” disturbance. (Examples: Shaking a rope, light, the “wave” at sports stadiums.)

Longitudinal Waves: Disturbance is along the same direction as the propagation of the wave. A “push-pull” disturbance. (Example: sound waves)

Combinations: Exhibit both transverse and longitudinal motions. (Examples: water waves, Rayleigh waves.)

Wave Interference

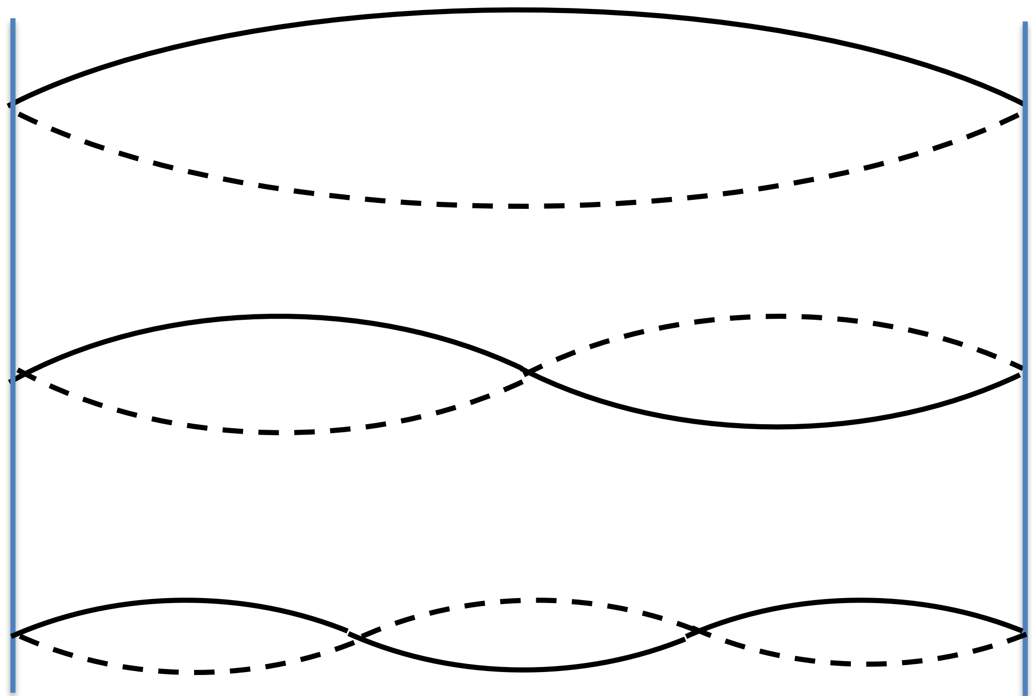
When waves overlap, they can either reinforce each other or they can cancel each other (wholly or partially). This is called wave interference.

- Constructive Interference: occurs when the overlapping waves produce a resulting wave that has a greater amplitude then either of the individual waves (like “crest” meets “crest”).
- Destructive Interference: occurs when the overlapping waves produce a resulting wave that has a smaller amplitude then either of the individual waves (like “crest” meets “trough”).

Standing Waves

- Waves that appear to stay in place. These are the result of interference and resonance.
- When you continuously shake a rope, the disturbances you send reflect form the other end and interfere with the waves that you are sending. If you get the frequency just right, you achievement "resonance" and produce a standing wave. Only certain frequencies will produce a standing waves. These frequencies are called "resonant frequencies" or "harmonics."

Standing waves on a string fixed at each end. The first three vibrational modes are shown below:



1st Harmonic: $f_1 = \frac{v}{2L}$

2nd Harmonic: $f_2 = \frac{2v}{2L}$

3rd Harmonic: $f_3 = \frac{3v}{2L}$

In general the frequency of the "nth" harmonic is $f_n = \frac{nv}{2L} = nf_1$

Doppler Effect

- Perceived change in frequency due to motion of the source and/or observer.
- When source moves toward listener, the waves "bunch up" shortening the wavelength. The wave speed, v stays constant, the received frequency increases. (Recall $v = \lambda f$.)
- When the source moves away from the listener, λ is stretched, so the perceived f decreases.
- When listener moves toward source, the waves listener intercepts the wave fronts more often, so the perceived f increases.
- When listener moves away from the source, the waves listener intercepts fewer wave fronts in a given time, so the perceived f decreases.