Waves in Motion

What happens when a wave hits something?

- 1. **Reflection**. Waves can bounce off and go in a new direction (Law of Reflection: angle of incidence = angle of reflection).
- 2. **Refraction**. Waves can cross the boundary and pass into or through objects. The speed of the wave changes and so its direction in the second medium changes. Frequency remains the SAME. Wavelength Changes. (EX: light, earthquake waves, water waves

What happens when a wave hits something? (continued)

- 3. **Absorption**. Waves can be absorbed as they pass into and through objects.
- 4. **Diffraction**. Waves can bend around obstacles and go through openings. Diffraction changes the direction and shape of the wave.

Interference

- **Interference** happens when two or more waves come together.
- **Constructive interference** occurs when the individual wave displacements are in the same direction. They “add” together.
- **Destructive interference** occurs when individual wave displacements are in opposite directions. They “cancel” or “destroy” each other .
- After they interfere, both waves separate again and travel on their own.

Resonance

- **Resonance** happens when something is vibrated at its own characteristic natural frequency (or a multiple of the natural frequency). Resonance is used to transfer power into all kinds of waves from lasers to microwaves to musical instruments. (Examples: playground swing, pendulum, musical instruments (guitar, violin), goblet, suspension bridges)

Resonating String (vibrating at its own natural frequency) produces families of standing waves

- 1. One string length is the fundamental or first harmonic. One string length = ½ wavelength of the sound produced. "Nodes" at each end.
- 2. A string with a node at the center (and the two on each end) is at the second harmonic with wavelength = one string length.
- 3. A string with two nodes in the center (and the two on each end) is at the third harmonic with wavelength = 3/2 string length.

Nodes and Anti-nodes

- Nodes are points where the string does NOT move. Nodes occur at both ends of a vibrating string and may include points in the middle of the string.
- Anti-nodes are points of greatest amplitude---crests and troughs. Anti-nodes contain the maximum energy of the wave.

Standing wave (on a string)

- When two waves having the same amplitude and frequency travel in opposite directions through a uniform medium, a standing wave is formed. A standing wave is a pattern of wave crests and troughs that remains stationary in a medium. The nodes and antinodes are stationary and the wave appears “to stand still.” (Examples: string)

Resonating frequencies for a string

Wavelength	# nodes	loops	frequency
2 x L of string	2	1	f
1 x L of string	3	2	2f
2/3 x L of string	4	3	3f
½ x L of string	5	4	4f
2/5 x L of string	6	5	5f

Sounding board/box

- Musical instruments have a board or a box that have more surface area relative to the air and so they can amplify the sound of a vibrating string. The sound board/box produces a much stronger sound wave than the string itself. (Examples: voice box in animals, violin box, guitar box, piano spruce sound board)

Doppler Effect

- If the distance between the source and the observer is decreasing (**d is less**), then more waves are coming to the observer and the frequency is increasing (**f is more**).

  If the distance between the source and the observer is increasing (**d is more**), then fewer waves are coming to the observer and the frequency is decreasing (**f is less**).

  Both sound waves and light waves show this Doppler Effect.