Waves and Sound Review

Waves-General

Vocabulary: crest, trough, wavelength, period, frequency, pitch, amplitude, node, anti-node, transverse wave, longitudinal wave, standing wave, compression, rarefaction, infrasonic, ultrasonic, resonance, harmonics, Doppler Effect, red shift, shock wave

Period = time for one wave cycle (unit = seconds); Frequency = # waves/time (unit = 1/sec = hertz)

Pendulum: The period is affected only by length, not by mass or the arc of swing

Types of waves:
- Transverse: water waves, S-waves in earthquakes
- Longitudinal: sound waves, P-waves in earthquakes

Interference: amplitudes add together
- Constructive Interference: crests add to crests, and troughs add to troughs, increasing the amplitude
- Destructive Interference: crests add to troughs, decreasing the amplitude

Energy of a wave: amplitude measures the amount of energy in a wave
- Water: taller waves have more energy
- Sound: louder sounds have more energy

Wave Speed: depends on the medium it travels through: speed = wavelength \times frequency
- Denser mediums = faster wave speed (i.e. sound traveling through air vs. through solids)
- Tension: increasing the tension in a medium will increase the wave speed (i.e. guitar string)

Standing Waves: created when a whole number of wavelengths fit between two fixed points. The fixed endpoints that the wave is traveling between must be located at nodes in order for the wave being reflected back and forth to create a standing wave. The higher the frequency, the more nodes will be created (shorter wavelength)

Speed of waves in various media
- Waves need a medium.
- Waves travel at a measurable speed (speed is fixed for a specific medium).
- Waves travel fastest and best (lose less energy) through solids, then liquids, and they travel slowest and die out the quickest in gases.

Doppler Effect: the change in frequency caused by moving wave source or an observer moving relative to a wave source. The frequency of a wave is increased in front of a moving wave source, and decreased behind the wave source.
Example: The sound of a car engine passing you sounds higher as it approaches you, and lower as it moves away from you. The actual pitch of the car engine is in between the high and low pitch (you hear this pitch for the very brief time that the car is right alongside you).

Sound Waves

Sound -- General
- Sound sources are vibrating objects.
- Standing waves create continuous sounds (vibrating tuning fork, wine glass, etc)
- Sound travels away from source.
- Sound waves are longitudinal waves and create a series of compressions and rarefactions (expansions)
- The size and properties of the vibrating object affect the sound produced.
- While sound is a longitudinal wave, it's often represented as a transverse wave because it's easier to draw.
- Our perception of sound is related to the sound waves properties: frequency ~ pitch, amplitude ~ loudness, complexity ~ quality/tone
Frequency and Pitch
- The faster the frequency, the lower the wavelength, the higher the pitch.
- The frequency created by an object depends on that object's composition, density, tension, and length.
- The pitch of a sound can be manipulated using the things listed above. Music is made this way.
- Notes on instruments are created by standing waves in the object producing the sound.

Resonance and Harmonics
- Everything has a natural vibrating frequency. Something vibrating at this frequency has resonance.
- Objects can also have forced vibrations. (tuning fork making a table top vibrate with the same frequency)
- The amplitude of an object's vibrations can be increased if the vibrations of another object matches the natural frequency of the first object. Examples: Tuning forks of the same note, Tacoma Narrows Bridge, a boy bouncing a ball, a child being pushed on a swing, a singer shattering a glass.
- Standing waves with increasing numbers of nodes create harmonics in a vibrating object.

Practice Problems:
1. Draw a transverse wave and label: Wavelength, amplitude, crest, trough.

2. Draw a spring pulse moving toward a fixed end then draw the reflected pulse as it travels back. (include direction arrows).

Pulse Toward Fixed end

Reflected pulse

3. Describe what constructive and destructive interference is and include a picture in your explanation.

Constructive Interference:

Destructive Interference:
4. The wave below represents a sound wave traveling in the air. Use it to answer the following questions:

a. Draw a wave that has greater energy:
   ![Greater Amplitude]

b. Draw a wave that has a lower frequency:
   - Longer wavelength
   ![Longer wavelength]

c. Draw a wave that had the same pitch but was softer:
   ![Lower amplitude]

d. Draw a wave that would have a higher pitch:
   - Shorter wavelength
   ![Shorter wavelength]

e. Which of the waves that you drew has the longest wavelength (a, b, c, d)? _B_
f. Which of the waves you drew would travel the slowest? _All travel same speed (medium hot's change_
g. Which of the waves you drew has the highest frequency? _D_

5. Explain why an ambulance siren sounds higher pitched when approaching you and lower pitched when moving away from you (use a picture in your explanation).

   ![Doppler Effect]
   Longer 1 → shorter 2
   Pitch is lower
   Pitch higher

   [Diagram of Doppler Effect]
6. Explain what creates a sonic boom and why people at different locations hear it at different times.

7. What is resonance? Describe two situations where it can be observed.

- When the natural frequency of a substance is matched with other vibrations, constructive waves are created.
- Example: rubbing the rim of a wine glass creates waves.

8. There are two bottles below with different levels of water. Describe and explain the pitches that are created in each when blown in and struck on the sides.

A - When struck, less water vibrates more vibrations (shorter wavelength), hence, higher pitch.
B - When blown into, less glass to vibrate, distance to travel, higher pitch is created.

9. Describe three different ways that pitch can be manipulated in a guitar to make music.

- Tension - \( \uparrow \) pitch
- Length - \( \uparrow \) pitch
- Composition (type of string) - More dense \( \rightarrow \) lower pitch

10. Guitars and pianos are both stringed instruments. Why do they sound so different?

- Length of string & type of material

11. Draw the fundamental and second and third harmonics of a standing wave moving between the endpoints shown below. Which note will have the lowest pitch? Which 2 notes will be octaves? Label the nodes, anti-nodes, amplitude and wavelength for the third harmonic.

   Fundamental:

   \[ \text{Octaves} \]

   Second Harmonic:

   Third Harmonic:

12. Why do longer objects make lower-pitched notes than short objects (i.e., rulers, straws...)?

   More to vibrate, hence vibrate at a lower frequency.