The Physics of Music Waves

All instruments make different notes by changing the wavelength of the sound they produce, but they do this in a variety of different ways. Most instruments are tuned by changing the length or the tension of the part that vibrates. This activity will help the student understand how the tension of vibrating components and the length of vibrating components on a stringed instrument affect the instrument's pitch. It will also provide opportunities for students to apply their understanding of how wavelength and frequency relate to one another in the context of a sound wave produced by a musical instrument.

Learning Objectives:

1. Students will evaluate how various instruments make different notes.
2. Students will describe how various instruments are tuned.
3. Students will describe how wavelength affects pitch.

Standards:

HS-PS4-1 Waves and their Applications in Technologies for Information Transfer

Use mathematical representations to support a claim regarding relationships among the frequency, wavelength, and speed of waves traveling in various media.

HS-PS4-5 Waves and their Applications in Technologies for Information Transfer

Communicate technical information about how some technological devices use the principles of wave behavior and wave interactions with matter to transmit and capture information and energy.

Materials Required:

1. Access to YouTube videos (see References below)
2. One stringed and tuned guitar

Safety:

N/A

References:

Sound Wave Vocabulary - https://www.youtube.com/watch?v=_L2TblpI7AA

Tuning of Various Instruments - https://www.youtube.com/watch?v=PSs1fo491tI

Activity:

Your learning objectives are to understand how musical instruments make different notes, and how different musical instruments are tuned. You will also describe how the length of a sound wave affects it pitch. All instruments make different notes by changing the wavelength of the sound they produce, but they do this in a variety of different ways. Most instruments are tuned by changing the length or the tension of the part that vibrates. Take the pretest, watch the two videos and review them until you understand the ways that notes can be changed.

Working with a lab partner, take a guitar and experiment with changing the tension by turning the tuning machine keys. When the tension is increased, the pitch (frequency) is also increased while the wavelength (string length) remains unchanged. Work with your partner to figure out how the pitch can increase at the same wavelength, then check your answer with your instructor (Answer: increasing the tension increases the velocity; $V = f\ \lambda$ so the velocity had to increase if the wavelength stayed the same but the frequency increased) Note: The velocity which increases with tension is velocity with which the wave travels along the string. Once that is transmitted to the air in the form of compression waves, the velocity with which they propagate remains fixed at the speed of sound, and wavelength varies with pitch.

Next, experiment with pressing a string against different frets. Work with your partner to figure out what is changing and what is not changing, then check your answer with your instructor. (Answer: The velocity remains constant, so as the wavelength decreases, the frequency increases)

Next, try "bending" a note by pressing a string against a fret, then pushing the string sideways. Work with your partner to figure out what is changing and what is not changing, then check your answer with your instructor. (Answer: pushing the string increases the tension which increases the velocity; $V = f\lambda$ if the velocity increased and the wavelength stayed the same then frequency had to increase)

Name ________________________________

Assessment
The Physics of Music Waves

1. What is one way that most instruments change the pitch of the sounds they produce?

   A. By changing the speed of sound through air
   B. By changing the length of their vibrating components
   C. By changing the density of the air through which the sound moves
   D. By changing the density of their vibrating components

2. What is another way most instruments change the pitch of the sounds they produce?

   A. By changing the tension of their vibrating components
   B. By changing the temperature of the air through which the sound moves
   C. By changing the material which makes the vibrating components
   D. By changing the diameter of the vibrating components

3. When the tension of a vibrating string is increased, its frequency ________________.

   A. increases
   B. decreases
   C. remains the same

4. When the tension of a vibrating string is decreased, its frequency ________________.

   A. increases
   B. decreases
   C. remains the same

5. When a vibrating guitar string is shortened, as by fretting the string at a higher position on the fretboard, its wavelength ________________ and its frequency ________________.

   A. becomes shorter / increases
   B. becomes longer / decreases
   C. becomes shorter / decreases
   D. becomes longer / increases

6. When a vibrating guitar string is lengthened, as by fretting the string at a lower position on the fingerboard, its wavelength ________________ and its frequency ________________.

A. becomes shorter / decreases
B. becomes longer / increases
C. becomes shorter / increases
D. becomes longer / decreases

7. When a player "bends" a guitar string while playing a note, its pitch ________________.

A. increases
B. decreases
C. remains the same

8. When a player "bends" a string while playing a note, what variable is being changed?

A. The length of the string
B. The note to which the open string is tuned
C. The tension of the string

9. The string length of a Fender-scaled guitar is .648m. The low A (A2) string when tuned to concert pitch vibrates at 110 Hz. Use $V = f\ \lambda$ to calculate the velocity (in m/s) with which this wave propagates along the string.

A. 648 m/s
B. 170 m/s
C. 0.006 m/s

10. What is the frequency of the 4th string (D2) on a Fender-scaled guitar if the wave speed is 47.6 m/s?

A. 73.4 Hz
B. 0.014 Hz
C. 27.3 Hz

Assessment Key:

1. B - By changing the length of their vibrating components
2. A - By changing the tension of their vibrating components
3. A - increases
4. B - decreases
5. A - becomes shorter / increases
6. D - becomes longer / decreases
7. A - increases
8. C - The tension of the string
9. C - 0.006 m/s
10. A - 73.4 Hz

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