Sound exploration kit

In this kit you will have the following experiments:

1. Physics Phun with Mini-washtub bass
   Designed by Josh Cameron and Sylvia Marccarelli
2. Surfing on Sound waves
   Designed by Olivia Heinen, Sandra Gabel, and Elizabeth Lesser

These kits are designed to explore the properties of sound. Access to some tools on the internet are required for this kit. You will make an instrument in Physics Phun with Mini-washtub bass. You will be surfing on sound waves with the videos by the Physics Phriends.

This kit contains some of the materials needed, but we highly encourage you to explore how you can use the stuff around your house. Be creative, be curious, and have fun!

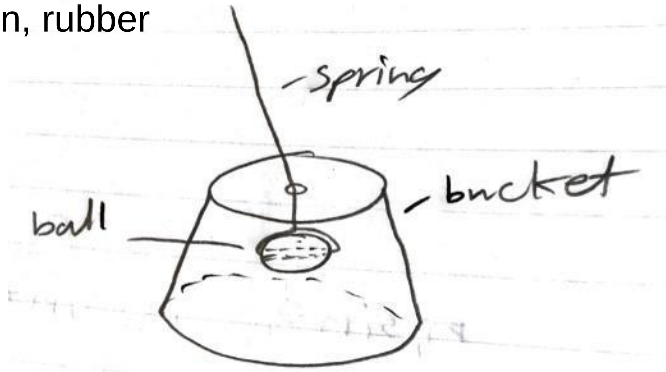
Kit Contents

- 1 small metal bucket with hole
- Strings and rubber bands
- An Allen wrench for Surfing on Soundwaves.

Physics Phun with Mini Washtub Bass

Ever wonder why instruments sound different? You'll explore what variables impact the tone of a miniature washtub bass! Explore how different string materials, lengths, and tensions change the pitch!
Materials (all provided in kit):

- a variety of strings (fishing line, yarn, rubber band)
- Small cup/bucket or soup can
- Ball



Exploration:

To start, select a string, tie to the ball, and feed it through the hole in the cup so the ball is on the inside. Pull on the string to increase and decrease the tension as you pluck the string. How does the pitch change when you pull it harder? Find a note you like, hum it and try to remember it. Now try attaching a different string - can you recreate the same pitch you had before? Did you have to pull more to get to that pitch, or less? Now try pinching the string in the middle (this effectively makes the string shorter), when you pluck the string how does the sound change?

Challenge!
Without pinching the string - instead, just lay your thumb on it - can you find a place where the note still sounds full?

Parents/Teachers

Thank you for using our kit! Generally, you can follow along the same directions as the student and have fun with it! We've included some of the math behind the physics and a couple hints that may help answer some curious questions!

The wavelength (λ (lambda)) of the wave is the distance between crests, so bigger wavelength, less crests in the string's vibration

The frequency (f) of the wave is the amount of waves that travel in a given time, so higher frequency, faster vibration of the string

The tension (T) in the string is how tightly it's pulled

The mass density (μ (mu)) is the mass per unit length of the string

Pitches relate to wavelength and frequency: a higher frequency and/or shorter wavelength will result in a higher pitch.

And the equation below shows that as tension increases, frequency and/or wavelength will increase, It also shows that as the density increases, the frequency and/or wavelength will increase.

The string with a higher density (heavy) will sound lower than a less dense string at the same tension.

These quantities are related by this expression:

$$f = \left(\frac{1}{\lambda}\right)\sqrt{\frac{T}{\mu}}$$

Hints and Possible Problems:

Make sure that as you use the mini washtub bass that the string is tightly wound around the dowel rod to prevent slippage and unintentionally decrease the tension.

The challenge asks the student to find the first harmonic. This is a special point on the string here there is no displacement while it vibrates. It should sound an octave above the original frequency (the fundamental), and it should be found about halfway down the string!

Concepts/Exploration

The primary topic considered here is the relation:

$$f = \left(\frac{1}{\lambda}\right)\sqrt{\frac{T}{\mu}}$$

This type of an exploration could be beneficial even for the experienced physicist since one could use an app like PhyPhox to measure the frequency, and then knowing properties of rope to solve for applied tension force. This is useful for building intuition about what exactly a Newton of force "feels" like.

By performing a fourier transform on the tone produced, one could explore the differences in timbre between different materials. Are there certain material properties that produce a purer tone?

When pulling the string tighter, the length of our string does extend. Explore how to account for this, and how does varying the elasticity impact the string's tonal qualities?

Does the amplitude of the sound wave change when playing a harmonic? Are there material properties where this change is more dramatic than others?

Surfing on Sound Waves

Hey Physics Phriends! Today you will be exploring sound waves! With the kit provided, you will experiment with sound and discover the science behind it. Scan the QR code to find instructional videos for these projects or go to this website: https://www.youtube.com/channel/UC4ucNF8XsYc9eSiTDfQVhvw/featured

Materials:

- Wrenches, bolts any thing that can make some noise.
- String
- You will need to find a metal object in your house. This could be a spoon or something similar!

Instructions are listed on the worksheets provided. You will need internet access in order to complete the experiments.

Parents/Teachers

Hello! In the kit, there should be a worksheet provided that you can use to walk your student through the experiment. There are also instructional videos which can be found with the QR code on the other page. If the link provided does not work, search “Physics Phriends” on YouTube. The videos will explain and answer all questions on the worksheet. Encourage your student to have fun and learn something new about sound!

SOUND WAVE VISUALIZATION

All experiment videos can be found at the following YouTube channel:
https://www.youtube.com/channel/UC4ucNF8XsYc9eSiTDfQVhvw
If this does not work, search "Physics Phriends"

Experiment Setup:

To begin, watch the experiment walk through video. This is titled "Sound Wave Visualizations Walk Through". After tying the Allen wrenches to the string, have your student try hitting each of them with the metal stick, being careful to hold on to the wrench by the string. Then have them make observations about each one.

Leading Questions:

Ask students questions such as the following. Encourage them to be creative and come up with as many explanations for what they observe as possible. Science is all about testing lots of different ideas!

•Make observations about the sounds from hitting the wrenches. Examples: which one has the highest sound or the lowest sound? Can they see the wrench vibrating? Or other similar phenomena.
•Do different wrenches make different sounds? Different in what way?
•Why do you think the wrenches sound different?
•Do you notice how the size impacts the sound?

Science Principles:

Next, watch the video titled "Sound Wave Science Principles," which will refer to the following diagrams.

Image 1

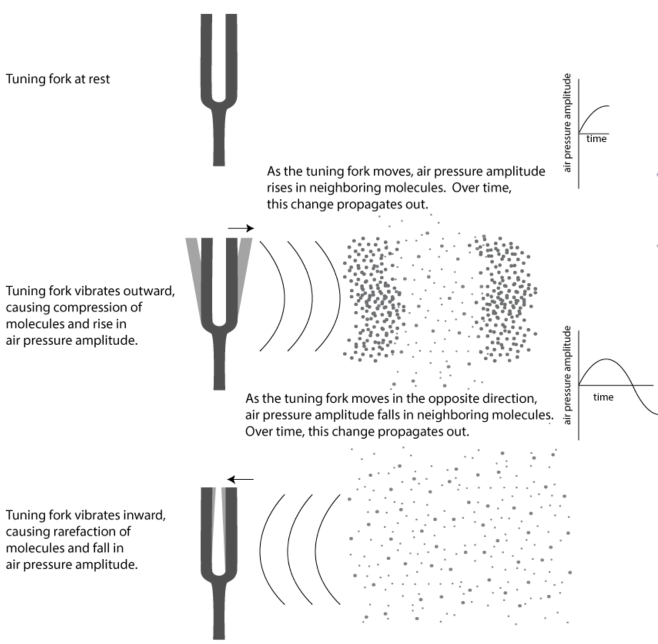


Image 2

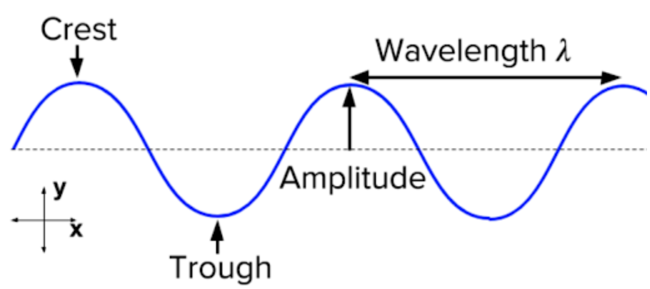


Figure 1: Parts of a transverse wave.

Image 3

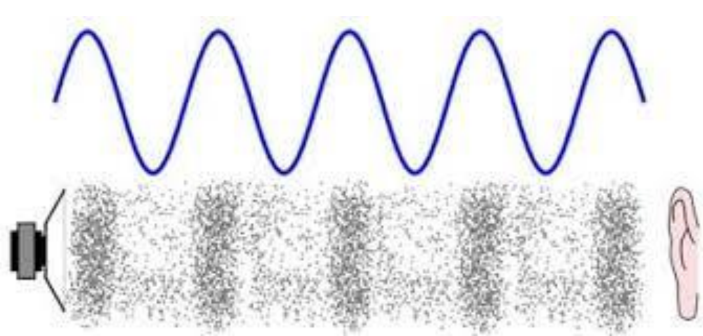


Image Sources:

1. 2.1.1 Sound Waves, Sine Waves, and Harmonic Motion. (2018, January 23). Retrieved October 18, 2020, from http://digitalsoundandmusic.com/
2. Wave characteristics review (article). (n.d.). Retrieved October 18, 2020, from https://www.khanacademy.org
3. Sound Visualization Stations - Activity. (2020, July 09). Retrieved October 18, 2020, from https://www.teachengineering.org

Optional Extension
Watch the extension video after completing the following experiment. This is titled “Sound Wave Challenge”.

First, make a prediction about what will happen when two similar pitched tones are played at the same time.

How do you think the sounds will combine?
What do you think happens when the waves overlap?

On a computer with two different tabs (or on two different devices), open the tone generator here: https://www.szynalski.com/tone-generator/ (or google "szynalski tone generator")

In the first tab, play a consistent tone that does not change throughout the experiment, for example 440 Hz. In the second tab, play a range of tones with similar frequencies that do not exceed more than a 20 Hertz difference from the consistent tone

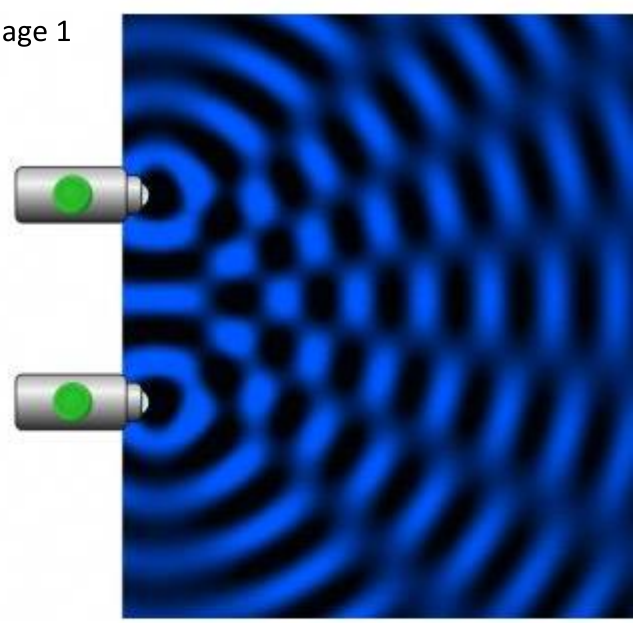
Image 1


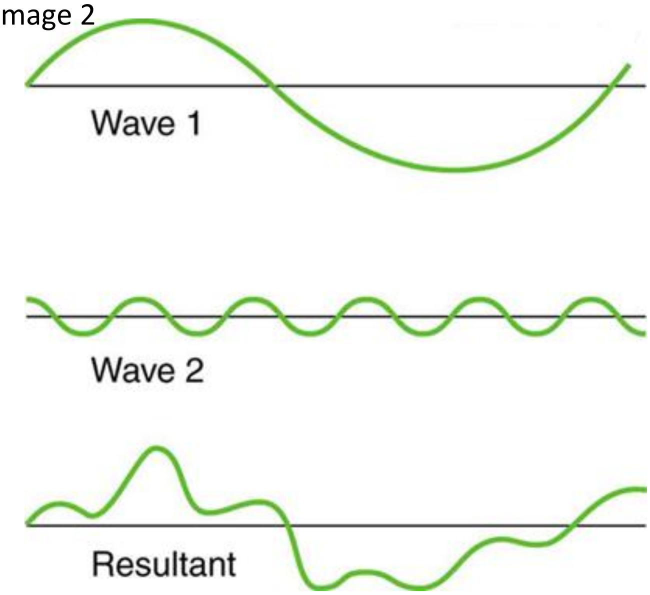
Image 2


Image Sources:
1. Lab Owner PhET Interactive Simulations. (n.d.). Wave Interference. Retrieved October 18, 2020, from https://www.golabz.eu/lab/wave-interference
2. OpenStax. (n.d.). Physics. Retrieved October 18, 2020, from https://courses.lumenlearning.com/physics/chapter/16-10-superposition-and-interference/

SOUND WAVE VISUALIZATION ANSWER KEY

All experiment videos can be found at the following YouTube channel:

https://www.youtube.com/channel/UC4ucNF8XsYc9eSiTDfQVhvw

If this does not work, search "Physics Phriends"

As a reminder, it is perfectly acceptable to answer the following questions incorrectly. If your students answer any questions incorrectly, encourage them to explain their answers and to look at the question from another perspective. Please do not give the student the answer. This experiment is all about exploration, curiosity, and fun!

Leading Questions:

Ask students questions such as the following. Encourage them to be creative and come up with as many explanations for what they observe as possible. Science is all about testing lots of different ideas!

• Make observations about the sounds from hitting the wrenches. Examples: which one has the highest sound or the lowest sound? Can they see the wrench vibrating? Or other similar phenomena.

• A: Discuss any and all of the above. Encourage the students to be curious and ask their own questions.

• Do different wrenches make different sounds? Different in what way?

• A: The wrenches will make different tones or pitches depending on the wrench. Some will make a higher pitched sound and some will make a lower pitch sound.

• Why do you think the wrenches sound different?

• A: The wrenches make different sounds because they are different sizes.

• Do you notice how the size impacts the sound?

• A: The larger wrenches will create lower pitches than the smaller ones.

NOTES AND CHORDS

All experiment videos can be found at the following YouTube channel:

https://www.youtube.com/channel/UC4ucNF8XsYc9eSiTDfQVhvw

If this does not work, search "Physics Phriends"

Experiment Setup:

To begin, watch the experiment walk through video. This is titled "Notes and Chords Walk Through". Then, on a computer(or multiple devices), open the tone generator found at the link below.

•Tone generator website: *https://www.szynalski.com/tone-generator/* (if this does not work, google "szynalski tone generator")

You will need the student to have two or three tabs open at one time. Each of these will be playing different frequencies. Have the student make observations about combinations on the following tones: *B(493 Hz), D(587 Hz), A(440 Hz), C(523 Hz), E(329 Hz)*

Leading Questions:

Ask students questions such as the following. Encourage them to be creative and come up with as many explanations for what they observe as possible. Science is all about testing lots of different ideas!

•What happens when you play two(or three) notes together?

•What note combinations sound good together? What note combinations sound bad together?

•Do you know what a sound wave looks like?

Science Principles:

Next, watch the video titled "Notes and Chords Science Principles," which will refer to the following diagrams.

Image 1

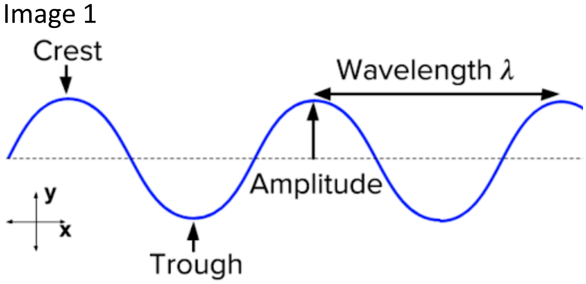


Figure 1: Parts of a transverse wave.

Image 2

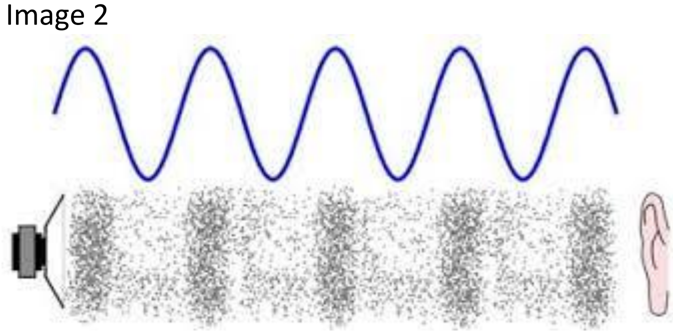


Image Sources:

1. 2.1.1 Sound Waves, Sine Waves, and Harmonic Motion. (2018, January 23). Retrieved October 18, 2020, from http://digitalsoundandmusic.com/
2. Sound Visualization Stations - Activity. (2020, July 09). Retrieved October 18, 2020, from https://www.teachengineering.org

Optional Extension

Watch the optional extension video after completing the following experiment. This will be titled “Chords Challenge".

First, play a C and an F from the tone generator website. These notes are a perfect fifth, which means their frequency ratio is 3:2. Therefore they interfere with one another to create another note that is not being played. If you listen closely can you hear an extra pitch?

Image 1

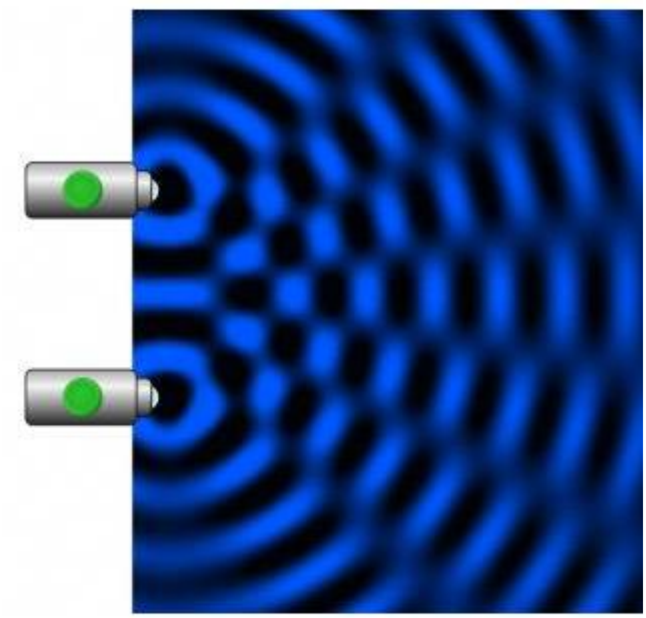


Image 2

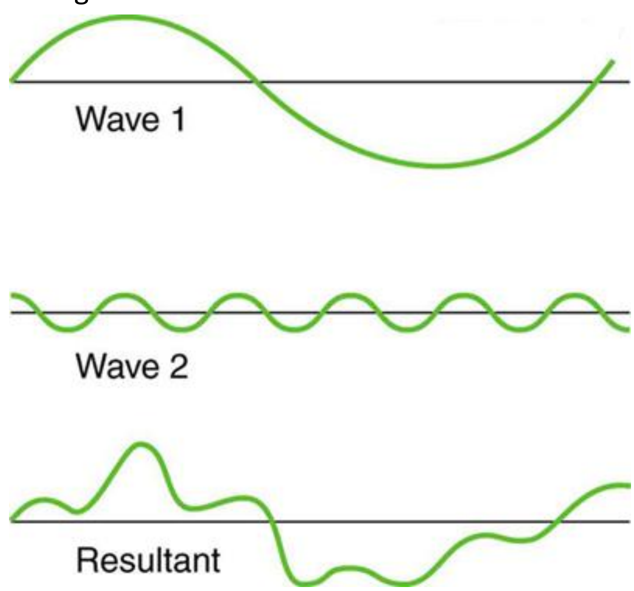


Image Sources:

1. Lab Owner PhET Interactive Simulations. (n.d.). Wave Interference. Retrieved October 18, 2020, from https://www.golabz.eu/lab/wave-interference
2. OpenStax. (n.d.). Physics. Retrieved October 18, 2020, from https://courses.lumenlearning.com/physics/chapter/16-10-superposition-and-interference/

NOTES AND CHORDS ANSWER KEY
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Leading Questions:
Ask students questions such as the following. Encourage them to be creative and come up with as many explanations for what they observe as possible. Science is all about testing lots of different ideas!
•What happens when you play two(or three) notes together?
A: The two (or three) tones interact with each other to create a stable sound or a wobbly sound depending on the combination of notes. The stable sound is a musical chord.
•What note combinations sound good together? What note combinations sound bad together?
•A: The following combinations sound good together: B and D, B and E, D and A, D and E, A and C, A and E, C and E. The following combinations sound bad together: B and A, B and C, D and C.
•Do you know what a sound wave looks like?
•If your student knows what sound waves look like, have them draw it out. If your student does not know what sound waves look like, have them make some predictions and explain their reasoning.
•The following is an example of what a student might draw