STEM Outreach Presents:

STEM Every Day Keeps the Boredom Away

Sound and Music Edition

Always ask a trusted adult before starting a Science or Engineering project.

Seeing Sound

DIFFICULTY LEVEL: NOVICE

PURPOSE

Explore sound as a vibration and amplitude as the size of the vibration.

MATERIALS

1 Big Bowl
Plastic Wrap
Sprinkles
1 Metal Pan
1 Metal Spoon

INSTRUCTIONS

1. **Put** the plastic wrap tightly over the bowl. (One sheet, as tight as you can get it.)

2. **Put** about 1 teaspoon of sprinkles on the plastic.

3. **Hold** the metal pan close to the bowl and hit it with the spoon. The harder you hit it the better. The sprinkles will dance!

CONCEPT #1

Vibrations and Amplitude

As you hit the pan, the pan vibrates. The vibrations of the pan cause the air around it to vibrate as well, this vibration is a sound wave. As the air around the pan vibrates, it causes the plastic wrap to start vibrating too. We can see these vibrations because the sprinkles will bounce around as the plastic wrap vibrates.

<u>Amplitude</u> is the maximum disturbance a wave creates. When we're talking about sound, the greater the amplitude, the louder the sound. If you strike the pan hard, you will see more vibration than if you lightly tap the pan.

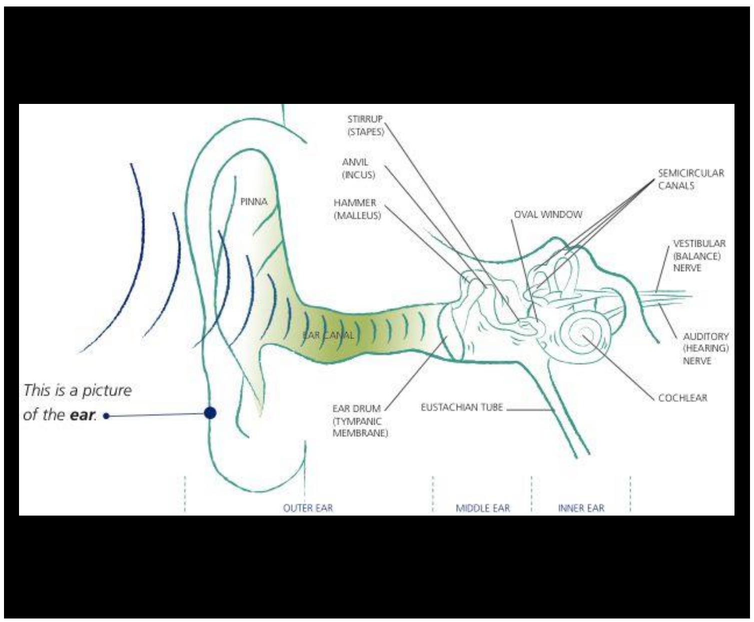
https://team-cartwright.com/sound-science-activities/

CONCEPT #2

Hearing

Sound waves enter the ear canal and hit a membrane, known as the "ear drum". The sound waves cause the eardrum to vibrate (like the plastic wrap vibrated in the experiment). There are three tiny bones in the inner ear that are connected to the ear drum which also vibrate (like the sprinkles in the experiment).

The last of these bones is connected to a tiny bone structure that called the cochlea (looks like a tiny snail shell). The cochlea is filled with a liquid that transmits the vibrations to thousands of tiny hairs. Nerves detect the movement of each hair and send the signals to the brain. The brain interprets this signal as a particular noise.



https://www.aussiedeafkids.org.au/how-we-hear.html

https://www.youtube.com/watch?v=j9IvcwZFx9s

REFERENCES

Adapted from:

https://team-cartwright.com/sound-science-activities/

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https://www.aussiedeafkids.org.au/how-we-hear.html

DIFFICULTY LEVEL: INTERMEDIATE

Straw Oboe

PURPOSE

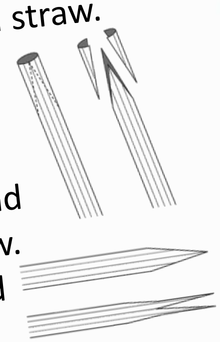
Explore physics of wind instruments by create a straw oboe

MATERIALS

1 Jumbo (Milkshake) Plastic Straw
¼" Hole Punch
Scissors

INSTRUCTIONS

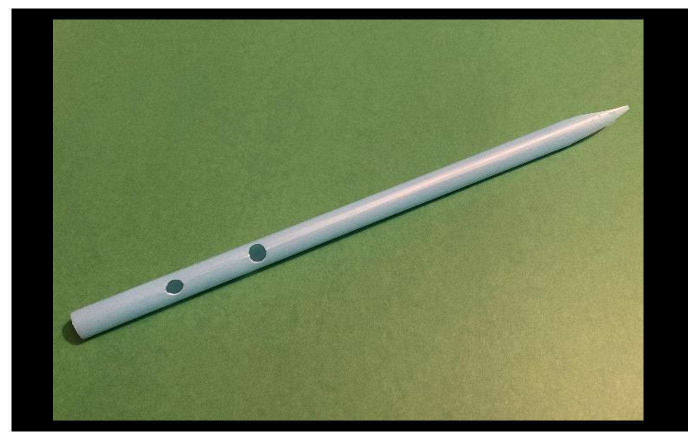
1. **Flatten** one end of the straw by sticking the end in your mouth, biting down with your teeth, and pulling it out. Do this several times to make a flexible, flat-ended straw.
2. **Cut** equal pieces from each side of the flattened end, so that the straw has two "lips" at the end. See image to the right.
3. **Put** the cut end of the straw in your mouth and make a seal with your lips. Blow into the straw. You'll have to experiment blowing harder and softer while biting down with different amounts of pressure until you make the straw sing.
4. **Use** the hole punch to create 2 holes along the front side of the straw; start about one (1) inch from the bottom of the straw and place each hole about one (1) inch apart.
5. **Start** by covering both holes with your fingers while blowing into the straw. While blowing, uncover the bottom hole. While blowing, uncover the both holes. What happened to the sound as the holes were uncovered? You can choose to add more holes to continue to experiment.



CONCEPT #1

Vibrations

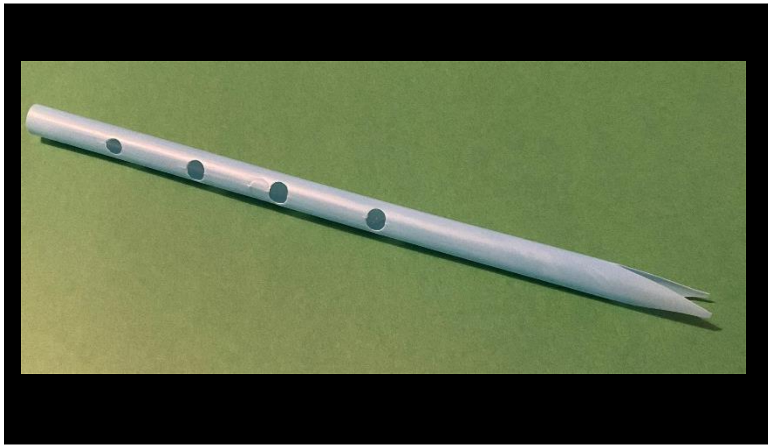
The beveled "lips" you cut into the squashed end of the straw act as a reed for your instrument.
When you blow into the reed, it vibrates, sending pulses of compressed air down the straw, which causes the air in the tube to start vibrating, too. When the reed vibrates at just the right frequency, the air in the straw vibrates powerfully, and you hear a loud, buzzing note, sort of like an oboe.



Simple straw oboe

CONCEPT #2
Frequency

Frequency is how many waves there are per second. The higher the frequency, the more quickly air particles vibrate and the higher the pitch. In sound waves, a high pitch means a high note and a low pitch is a low note.



Straw oboe modified with four holes.

Straw oboe modified with four holes and another straw for extra length.

CONCEPT #3
Resonance

The sound from your straw oboe is an example of a phenomenon called resonance. Every object has a natural frequency, a tendency to vibrate at a particular rate. When you vibrate something at its natural frequency, it resonates, meaning that the vibrations build and grow more and more extreme.

The straw oboe resonates when the sound waves bouncing back and forth inside make a special pattern called a standing wave. Standing waves occur when waves going one way overlap with waves going the opposite way, creating a set of peaks and valleys that seem to stand still.

The exact note that you hear when you blow your straw oboe depends on the length of the straw. In a shorter straw, the standing wave inside the straw will be shorter (higher frequency), causing the pitch to be higher. In a longer straw, the standing wave will be longer (lower frequency), and the note you hear will be lower.

REFERENCES

Adapted from:
https://www.exploratorium.edu/snacks/straw-oboe
https://www.funkidslive.com/learn/waves/sound-waves/#

Engineering Music

DIFFICULTY LEVEL: ADVANCED

PURPOSE

To explore the engineering design process, and then design, construct, test, and evaluate a working musical instrument using easily found materials.

SUGGESTED MATERIALS

Nontoxic glue
String
Paperclips
Paper
Cardboard
Cardboard tubes
Paper
Rubber bands
Wire
Aluminum foil
Plastic wrap
Tape
Juice box
Wooden dowels
Aluminum pans
Electronic tuner or phone app

(the materials list may be adapted to a specific instrument, such as a drum or a xylophone).

INSTRUCTIONS

Goal: Design and build an instrument that can produce 3 different notes consistently.

1. **Research** different types of musical instruments: percussion, wind, string, etc.
2. **Develop** a plan for the instrument. Determine the materials you will need (see suggested materials above for inspiration.
3. **Record** the design on paper by drawing a detailed picture.

CONCEPT #1

Engineering Design Process

Engineers use the Engineering Design Process to develop and refine their solutions:

1. **Identify the need or challenge**
2. **Research and develop possible solutions**
3. **Draw a possible solution**
4. **Build and test the solution**
5. **Modify and retest the device**

https://www.learningliftoff.com/make-homemade-music-with-these-6-diy-instruments/

Engineering Music (cont.)

INSTRUCTIONS (cont.)

4. **Build** the instrument design with the assistance of a trusted adult.
5. **Test** the instrument design using an electronic tuner or phone app.
6. **Modify** the design based on the results.

Monochord used to study mathematical patterns in music
https://www.researchgate.net/figure/Ancient-Greek-Kanun-Monochord-made-and-used-for-demonstrations-at-Kings-College_fig5_313549975

CONCEPT #2

Math in Music

Mathematics is the study of patterns. Algebra is patterns in numbers, geometry is patterns we can *see*, music is patterns we can *hear*. So math and music are very closely related.

Each note played by an instrument has a specific frequency. The note known as "middle C" has a frequency of 261 Hz (vibrates 261 times per second). Playing the same note C, one octave lower has half the frequency. In fact, fractions are responsible for all musical notes.

A taut string that produces a C note, when cut in 1/2, will produce a C note one octave higher. If the string were cut to 1/3 its original length, it would produce a G note. Other notes can be created by cutting the string into other fractions. You can build your own monochord to explore these relationships with instructions found at http://tuvalu.santafe.edu/projects/musicplusmath/index.php?id=20.

CONCEPT #3

Engineering Music

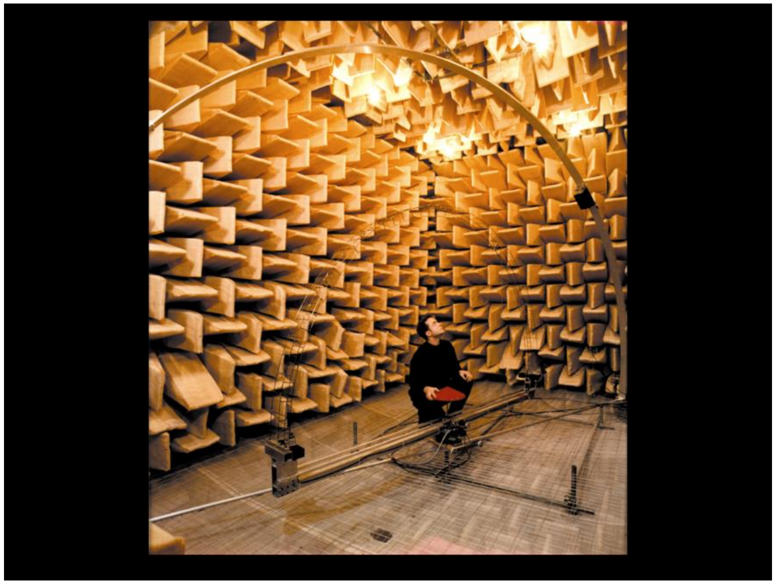
There are many engineering careers that involve sound and music.

An <u>acoustical engineer</u> is an engineer who specializes in the science of sound and vibration (physics). Their primary function is the control of noise or vibration that can affect individuals, and the improvement of the sound environment for the population. Acoustical engineers can find work controlling sound in industry, the environment, and entertainment.

Some acoustical engineers:

- **design and optimize the acoustics of theaters and concert venues, in order to make the acoustic experience of the room more enjoyable for the audience**
- **invent new musical instruments as well as modify and improve old designs.**

Companies that make amplifiers, speakers, microphones, sequencers, mixers, etc., also hire engineers.



https://www.teachengineering.org/lessons/view/uod-2270-decibels-acoustical-engineering

Learn more about the relationship between math and music with this video series:

http://www.ams.org/publicoutreach/math-and-music

REFERENCES

Adapted from:

https://new.engineering.com/story/musical-instrument-design-jobs

https://tryengineering.org/wp-content/uploads/engineeredmusic.pdf

https://www.softdb.com/what-is-an-acoustician/#:~:text=An%20acoustical%20engineer%20is%20an,sound%20environment%20for%20the%20population

More Music STEM Activities

See Sound with a Chladni Plate

https://makezine.com/projects/chladni-plate/

Build your own Diddley Bow (one-string guitar)

https://www.scholastic.com/parents/school-success/learning-toolkit-blog/make-it-diddley-bow-string-wonder.html

Build Musical Jars

https://coolscienceexperimentshq.com/musical-jars/

Build a Monochord

http://tuvalu.santafe.edu/projects/musicplusmath/index.php?id=20

Build an "Awesometastical" PVC Flute

https://www.instructables.com/How-to-make-an-Awesometastical-PVC-Flute/

Sound and Music Edition