

Vocal Visualizer: <https://www.exploratorium.edu/snacks/vocal-visualizer?media=7454> Also includes some instructional videos.

Use your voice to transform laser light into dazzling patterns.

By humming, singing, or talking into the Vocal Visualizer, you'll be able to see sound as vibration (or pressure waves) and experience Lissajous patterns and resonant vibration modes.

Tools and Materials



- Red laser pen/pointer with low power output; we recommend the common variety that is about 9/16 inches (14 millimeters) in diameter, about the thickness of your pinky finger
 - Rubber bands
 - 11-inch diameter balloon
 - Double-sided tape
 - Small plastic mirror
 - Various lengths of PVC pipe (1/2 inch, Schedule 40):
 - One 6-foot (2 meter) length of pipe
 - Two 1/2-inch diameter “elbows”
 - Three 1/2-inch diameter T-joints
 - 3-inch diameter solid, smooth-walled drain pipe, cut to a 4-inch length
 - Safety goggles
 - Measuring tape with both English and metric units
 - Permanent marker
 - Scissors
 - Pliers
 - Hacksaw
 - Optional: PVC cutter
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Assembly

Make the vibration chamber:

1. Use the scissors to snip off the neck of the balloon, cutting about halfway between the opening and the widest part of the balloon. (See image below; click to enlarge.)

2. Stretch the balloon over one of the open ends of the drain pipe. This is your balloon membrane.
3. Put on your safety goggles. Wrap a corner of the plastic mirror in a piece of folded paper and grip the corner with the pliers; use the pliers to break off a small piece of mirror, approximately 1 x 1 cm² (it's okay if the piece is irregularly shaped). If the mirror has a protective film on it, peel it off.
4. Place a small piece of double-sided tape on the balloon membrane somewhere between the membrane's center and its outer edge.
5. Affix the piece of mirror—shiny side up—to the membrane by sticking it onto the exposed side of the double-sided tape.



Make the frame:

1. Using a hacksaw or PVC cutter, cut the 6-foot (2-meter) length of 1/2-inch diameter, Schedule 40 PVC pipe into the following lengths:
 - Two pieces, each 3 cm long
 - One piece, 5 cm long
 - Three pieces, each 12 cm long
 - Two pieces, each 50 cm long

2. Arrange your 1/2-inch pipe, elbows, and T joints according to the image below (click to enlarge).



3. Insert the pieces together, making sure your connections are snug. Note that the frame will form a trapezoid. The narrowing of the pipes helps to better support the vibration chamber.

Make your final assembly:

1. Place the vibration chamber atop the two 12-cm-long pieces of PVC pipe with the membrane and mirror facing towards the trapezoid. The membrane can touch the T-joints but shouldn't sit on top of them. The open end of the vibration chamber should extend a little beyond the ends of the PVC frame.
2. Secure the vibration chamber to the frame by looping two rubber bands around both the two 12 cm-long pipes and the chamber (see image below).



3. Insert the laser pointer into the 12-cm length of half-inch pipe located inside of the trapezoidal area. If the diameter of the laser pointer and the pipe match up, inserting the laser into the tube fully will turn it on. If the pocket clip gets in the way, remove the clip with pliers (see image below). If the pipe's diameter is larger than the laser pointer, bulk up

the diameter of the laser by wrapping some masking tape around it until you get a good fit.



To Do and Notice

Important safety note: Never point a laser into anyone's eyes, including your own!

While your device is on a table, carefully aim the laser beam at the mirror on the membrane. You may need to adjust either the laser pointer or the vibration chamber to get it just right. Use the T-joint to tilt the laser pointer up or down. You might also need to rotate the vibration chamber to line up the laser and the mirror perfectly.



Once the laser is hitting the center of the plastic mirror, check to make sure that a crisply reflected laser spot is visible.

Aim your Vocal Visualizer at a wall, screen, floor, or other flat reflective surface. *Again, never aim the laser pointer or the reflected beam directly at your own or anyone else's face or eyes.*

Hold the Vocal Visualizer's vibration chamber close to your mouth. Hum, sing, speak, or make weird noises into it. As you vocalize, try changing your pitch (frequency) and your volume (amplitude) and take note of the different results.

What's Going On?

When you vocalize, you cause air molecules to vibrate. These vibrating molecules strike the rubber balloon membrane. The membrane vibrates, causing the mirror to wiggle in turn. The laser light bounces off this wiggling mirror, tracing out various shapes and patterns that you can see. (That's why we call this the Vocal Visualizer!) The different amplitudes and frequencies of the sounds emanating from your mouth cause different shapes and patterns.

The harmonic motions traced out by the moving laser beam are called *Lissajous patterns*. The combination of the mirror moving in an up-and-down direction (along the y -axis) and the side-to-side direction (along the x -axis) create the patterns you see on the screen.

Some shapes will look chaotic while others will be more regular and repeating—circles, ovals, figure eights. Various frequencies will cause the rubber membrane to dance around in resonant vibration modes—standing waves of fluctuating hills and valleys on the membrane's surface.

Your mirror and laser also act as an optical lever. If you change the distance from which you broadcast the laser's reflection, you'll also change the size of the image that's projected. Stand closer to your flat surface and the reflected image will be smaller; stand back and the reflected image will be larger. You can achieve a similar effect by experimenting with the volume of your voice—speak or sing loudly into the device and your patterns will be large; speak or sing softly and your pattern will be smaller.

Going Further

What kinds of patterns can you create with your voice and the laser? Which sounds make which patterns? What makes your pattern bigger or smaller? Experiment to see what you can do.

Try swinging your Visual Vocalizer quickly back and forth while you sing or hum and see if you can make a wave pattern.

Hold your Vocal Visualizer up to a stereo speaker and play your favorite song. What kinds of patterns and rhythms does it make on your wall?

Invite a friend who also has a Vocal Visualizer over and make a laser light show together.

