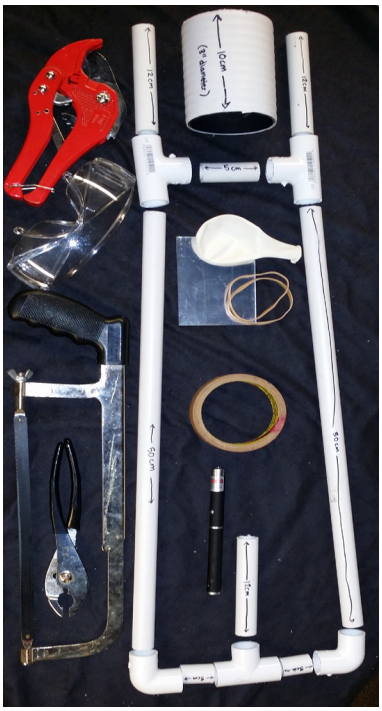
Vocal Visualizer
Simple Sound Oscilloscope

Introduction:
By humming, singing or talking, create a variety of cool laser light patterns. This device will allow one to see sound as vibrations (or pressure waves).

This is one of several designs for this device known as the "Vocal Visualizer."

Directions to make this device can also be found on the Teacher Institute You Tube channel, at www.youtube.com/teacherinstitute.

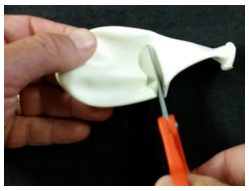
Materials:



- Laser pen/pointer – low power output. 1.5 cm diameter pointer recommended.
- Rubber bands
- Balloon (Standard 11" diameter size)
- Double stick tape
- A small plastic mirror
- PVC pipe
  - ½" pipe about 2 meters total (or about 6 feet)
  - 2-PVC elbows – ½" size
  - 3- "T" joint – ½" size
  - 3" PVC Drain pipe (solid smooth-walled)
- Tools:
  - PVC cutter
  - Hacksaw
  - Scissors
  - Pliers
  - Safety goggles

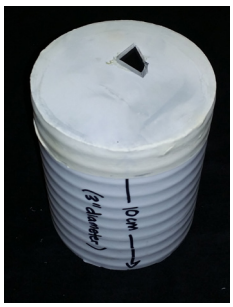
Assembly:

Vibration chamber:



1. Using a hacksaw cut the smooth-walled drainpipe into a segment 10 cm long.
2. Cut the nozzle of the balloon off. Cut about halfway between the nozzle and the widest part of the balloon.
3. Stretch the balloon over one of the openings of the 10 cm long drain pipe. This is your balloon membrane.
4. With safety goggle on and using the pliers, break-off a small pieces of plastic mirror. The piece can be an irregular shape, but shouldn't exceed about 1 cm^2
5. If the mirror has a protective film on it, remove it now.
6. Place a small piece of double stick tape on the balloon membrane. Locating it between membrane's center and edge will give better results.

7. Now, attach the small mirror onto the exposed side of the double stick tape.
8. This is your vibration chamber



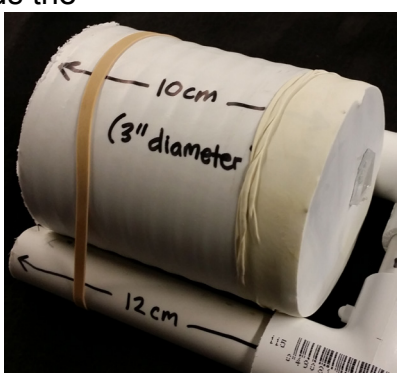
Main Frame:

1. Using a hacksaw or PVC cutter, cut the ½" pipe into the following lengths:
   - 2 pc– 3 cm each
   - 1 – 5cm
   - 3 pc – 12 cm each
   - 2 pc – 50 cm each
2. Arrange your ½" pipe, elbows and "T" joints according to the image below.

3. Snugly insert all pieces. NOTE: The portion on the right will form a trapezoid. The narrowing of the pipes on the left helps to better seat/support the vibration chamber.

Final Assembly:

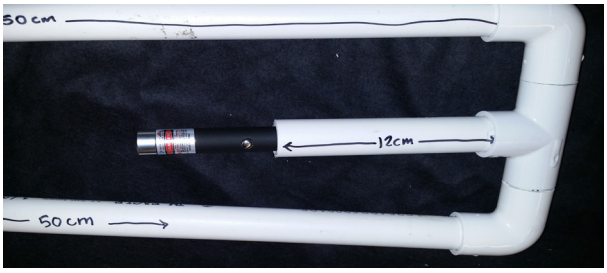
1. Attach the vibration chamber
   a. Place the chamber on top of the 2-12cm long pieces to the left.
   b. The membrane and small mirror should face towards the trapezoidal area.
   c. The membrane can touch, but should not sit on top of the "T" joints.
   d. The open end of the vibration chamber should extend a little beyond the ends of the 12 cm long



pipes (this will allow your mouth to get closer to the opening).

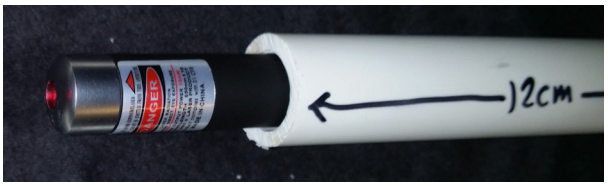
e. Secure the vibration chamber to the device by placing two rubber bands around the 2 - ½"pipes and the chamber (aka: drain pipe).

2. Insert the laser into the single 12 cm ½" PVC pipe located inside of the trapezoidal area.



Note:

- If you using a 1.5 cm diameter laser pointer, inserting the laser further into the tube will turn it on. The diameter of the pipe is large enough to allow the body of the laser to pass through, but small enough to depress the laser's switch.



- If the pocket clips hinders the insertion of the laser into the pipe, you can easily remove the clip with a pair of pliers.

Aiming the laser:

Note: Never point a laser into your or someone else's eyes

1. Carefully, point the laser beam at the mirror attached to the membrane.
2. The "T" joint will allow the pipe and laser to be rotated.
3. Since the laser can only be rotated up and down, it might be necessary to rotate the vibration chamber too…. do this carefully.
4. Make sure the laser hits the center of the plastic mirror for best results.
5. Ensure that a crisp reflected laser spot is visible.

To do and Notice:

1. Aim your device at a wall, screen, floor or other flat reflective surface.
2. Hold the device close to your mouth.
3. Hum, sing or just make some weird noises. As you vocalize, change your pitch (frequency) and your volume (amplitude).
4. See what kind of patterns you can create?
5. Experiment to see what sounds make which patterns?
6. What will make your pattern big or small?
7. Try swinging your device quickly back and forth and see if you can make a wave pattern.

What's going on? :

When you vocalize sounds, you cause air molecules to vibrate. These vibrating molecules strike one another and hit the rubber membrane. The membrane vibrates, which causes the mirror to wiggle. The laser light bounces off this wiggling mirror, tracing out various shapes and patterns that you can see...Vocal Visualizer!
Different amplitudes and frequency of sound emanating from you mouth in turn causes different shapes and patterns.

Some shapes you make will look chaotic, others, more "regular" and repeating (i.e. circle, oval, figure eight, etc.…). Various frequencies will cause the rubber membrane to dance around in resonant vibration modes. In effect, creating standing waves of fluctuating hills and valleys on the membrane's surface.

The harmonic motions traced out by the moving laser beam are called Lissajous patterns. The combination of mirror motion in the up and down direction (y-axis) and the side-to-side direction (x-axis) is what creates these patterns.

Your mirror and laser also act as an optical lever. If you change the distance you broadcast the laser's reflection, you change the size of the image projected.




Troubleshooting:

Laser doesn't stay on –

- Try using a binder clip to depress the switch.
- Try using a toothpick to wedge the laser against the inside wall of the pipe to help depress the switch.

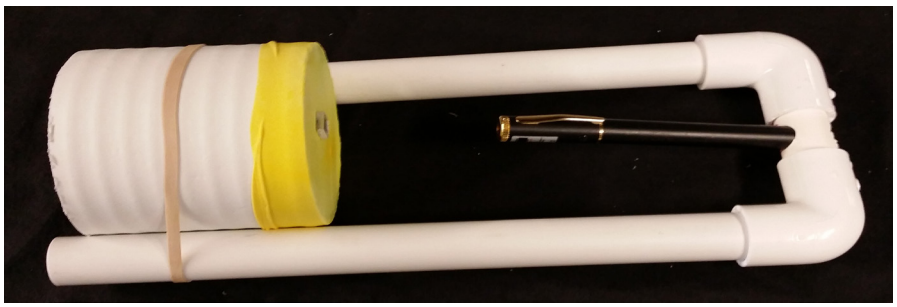
Laser beam is blurry –

- Make sure you removed the plastic film from the mirror.
- Make sure the laser is pointed closer toward the center of the mirror. The edges of the plastic might blur the beam.

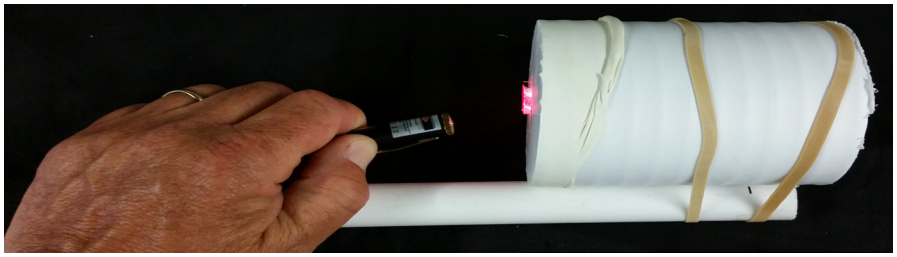
Alternative designs:

A. The design below is similar to the one above. However. This one uses rubber bands to pull the 50cm long pipes together to help seat the vibration chamber.

B. The design below utilizes a narrower brand of laser that is turned on with a binder clip. Instead of "T" joint to move/rotate the laser up and down, a snug fitting hole was drilled into a 5 cm long ½" pipe.



C. The design below is the simplest design. It uses a single stick or in this case, piece of ½" PVC pipe to stabilize the vibration chamber. However, the laser must be held steady as it is pointed. Care must be taken to make sure the laser beam doesn't accidently get aimed into the user's eyes.



Resources:

Laser Lissajous Pattern Formation by Don Rathjen
http://www.exo.net/~donr/activities/Laser_Lissajous_Pattern_Formation.pdf

Laser Lissajous by Don Rathjen
http://www.exo.net/~donr/activities/Laser_Lissajous_PVC.pdf

Lissajous Curves
http://en.wikipedia.org/wiki/Lissajous_curve

Vibrations of a circular membrane
http://en.wikipedia.org/wiki/Vibrations_of_a_circular_membrane

The Exploratorium Teacher Institute You Tube channel
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