

Suggested Educational Lessons / Demos

for the Homemade Musical Instrument S.T.E.A.M. project.

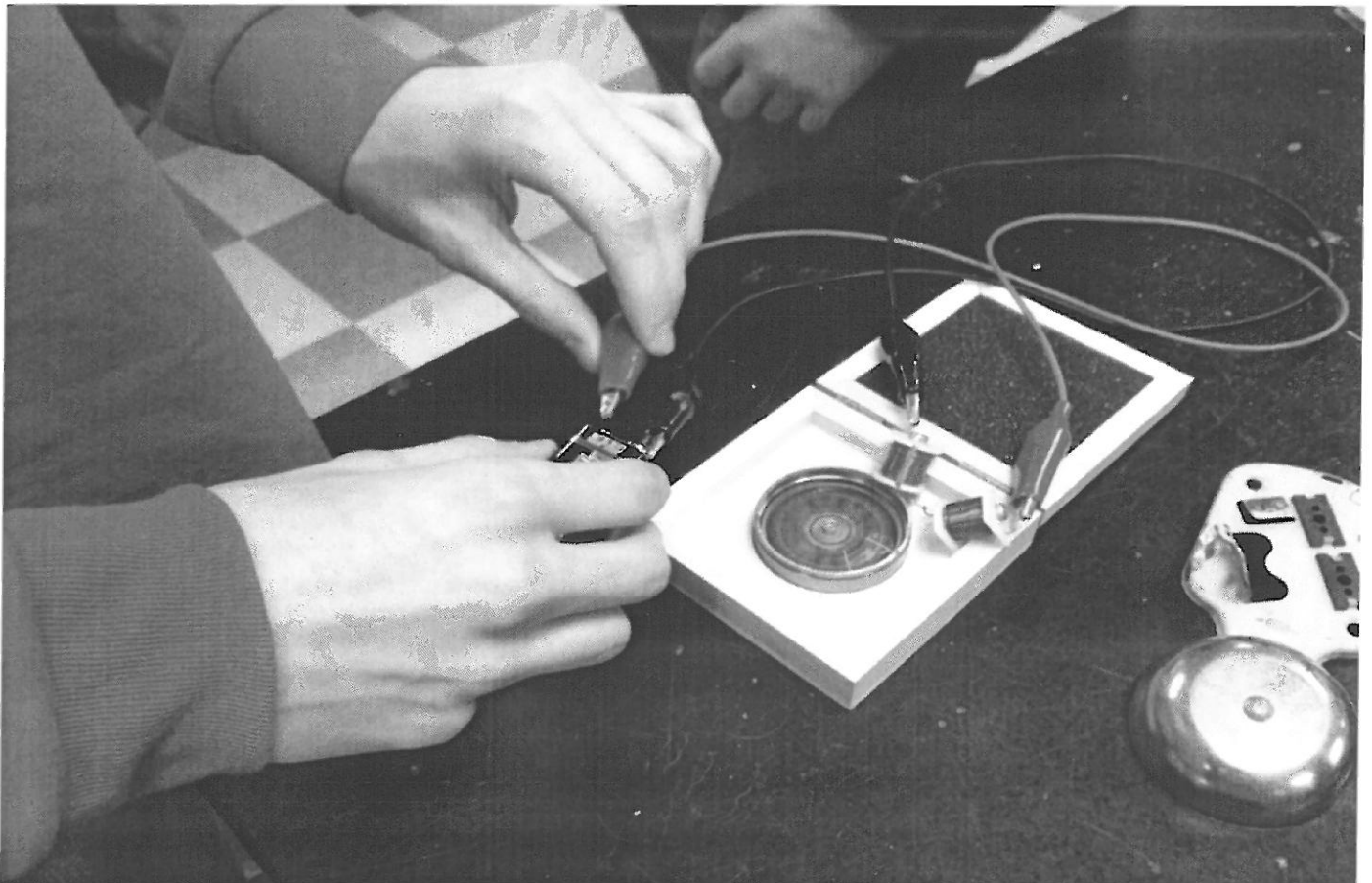
(Science, Technology, Engineering, Arts and Mathematics)

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These are not in set order nor do they go into topics in-depth. They are just examples to inspire your own projects and to wet your appetite for your own research and education.

- 1) Tear out the guts from a standard electric door bell or take an iron nail and wrap coated wire around it. This will be the electromagnet. Take two alligator clips and attach one end of each to the electromagnet and the other to a 9 volt battery. Set up a compass next to the electromagnet and have students explore the interactions. If students time the on / off of the electromagnet they can perpetuate the turning of the compass needle (introduction to how a motor works).



- 2) Connect a Galvanometer to a large coil of wire with two alligator clips. If you do not have a galvanometer you can use a volt meter. Drop a large magnet through the center of the coil of wire. You should have an output voltage. Have students explore the difference in the number of coils and the voltage output as well as stronger magnets. Students should explore the connection to generators.



- 3) Take a signal generator and connect a small speaker. Take an oscilloscope and connect it to the speaker. Students can explore the changing of frequency (PITCH) both with multiple sensory inputs. Students can then explore ultrasonic and infrasonic signals. Students can now explore sine waves.

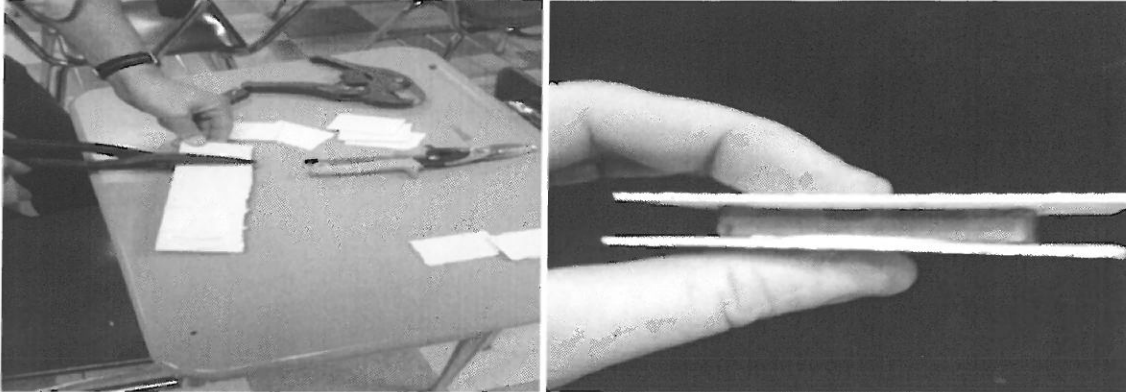


- 4) Disconnect the signal generator and attach the output stereo cable from an electric guitar or acoustic-electric guitar to the speaker and oscilloscope (This works better if you have an amplifier). Attach the amplifier headphone output to the oscilloscope. Now students can examine the wave frequency of a musical scale. Students can now explore sine waves.



- 5) Transformers can be used as amplifiers. Most transformers are step down meaning they take 120 Volts AC and convert it to some lower voltage (say 12 Volts AC). Then they are put through a bridge rectifier to convert AC to DC. We are not going to use the bridge rectifier. We are going to use the step down transformer backwards (the input becomes the output and the output now becomes the input). Thus creating a step up transformer (a Voltage Amplifier). The more windings the better, for example an old microwave step up transformer. Also see video <http://www.youtube.com/watch?v=R7zjfaPKMSE>
- 6) Make an AM (amplitude modulation) Crystal Radio. No power source need, power is derived from the radio wave itself. <https://www.youtube.com/watch?v=9VqVaFMQd2o>
- 7) Homemade Headphone Amplifier step by step directions. <https://www.youtube.com/watch?v=Z-RHKYjQVfE>

- 8) Make an Electric pick-up. Take a magnet and wrap coated wire around it (Use a drill to wrap the wire this saves time and your sanity). See video. <http://www.youtube.com/watch?v=wKSOZWCHI4g> Have students explore how the motion of a wire (nail, anything metal) through the magnetic flux produces a change in Voltage in the pick-up (use a voltmeter, oscilloscope etc.) Students should explore the connection to generators. (Hint: a pick-up is a generator)



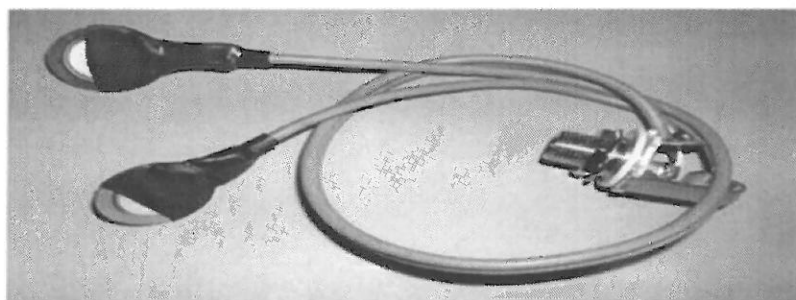
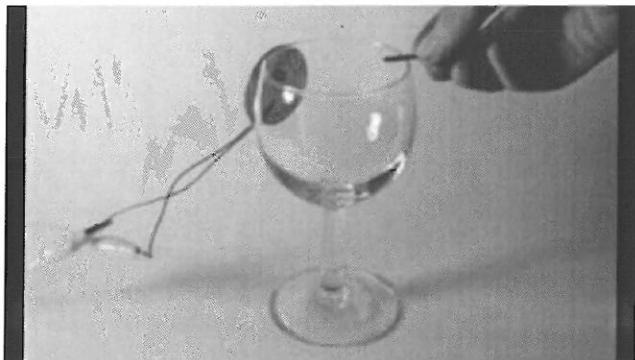
- 9) Glass Harmonica: Set up several glasses and put water in the glasses. When you rub the top of the glass the glass will produce a frequency (natural frequency) based on the amount of water in the glass and the material of the glass itself. Have students explore the history of Ben Franklin and his glass harmonica. Use an electric tuner (like one for tuning a guitar) to tune your glasses to certain notes by adding or subtracting water. Put cards next to the glasses with the proper notes placed upon them. For quicker set up you can put a piece of scotch tape on the glasses and mark the proper water level and musical note on the glass with a permanent marker. Have a few songs that the students can explore playing. For the advanced teacher: Can you use a synthesizer – frequency generator and a loudspeaker and create a resonance catastrophe. Entertaining for students and only costs one glass. This teaches a lot about harmonics, natural frequency and you can relate this to engineering by introduce a video on the Tacoma Narrows Bridge destruction.



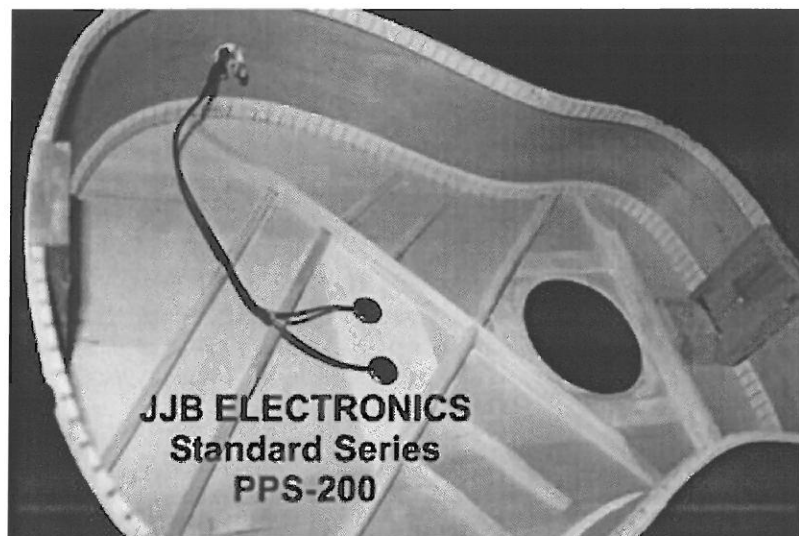
- 10) Take old transformers apart in class so students see the inner workings of AC to DC step transformers. Show students the windings inside can be used for a homemade preamplifier. This will cut the cost and excuses for not building a preamp.

11) Contact microphone otherwise known as a Piezo pick-ups can be easily made from piezo buzzers from RadioShack. You can get them from gift cards that play songs or messages. Toys that make noise and phones use them for the ringer. Piezo contact microphones can be bought in the internet for 3 cents each if you buy a hundred of them, so really cheap. This is a good way for drums, acoustic guitars any instrument to be electrified (plugged into an amplifier). They are sometimes called Piezo Transducers or Piezo Ceramic Elements if you are having trouble finding them online.

<http://dx.com/p/zx-18t9a1-18mm-piezo-transducer-sound-discs-w-leads-10-pcs-147962>



Double piezo Pickup for acoustic guitar. This is a double element piezo pickup. This is a little more versatile than the single element pickup. These piezo's are approximately 3/4" in diameter.



12) Get old radios, record players, tape decks and convert them into amplifiers. It is an easy conversion and the older the better. Tube radios make the best tube amplifiers and are preferred by musicians for their analog capability. A radio with a CD player while not being really old is great Amplifier because you can still use the CD player and you can play along with your favorite songs. Collect as many older electronic devices as possible Hacking this older technology is the perfect way for students to learn while making something they want / need. An engineer friend of mine suggested getting a spectrum analyzer to see wave form distortions, amplification and saturation. As well as nonlinear amplification, as he says it is all about linearity. It is also a great way to save some landfill space by Recycling. The other parts can be used for other projects (e.g. knobs, potentiometers, transformers etc.)

see video example: https://www.youtube.com/watch?v=SG9-_KDNZEg

<http://www.youtube.com/watch?v=w6pWlwsPD5Y>

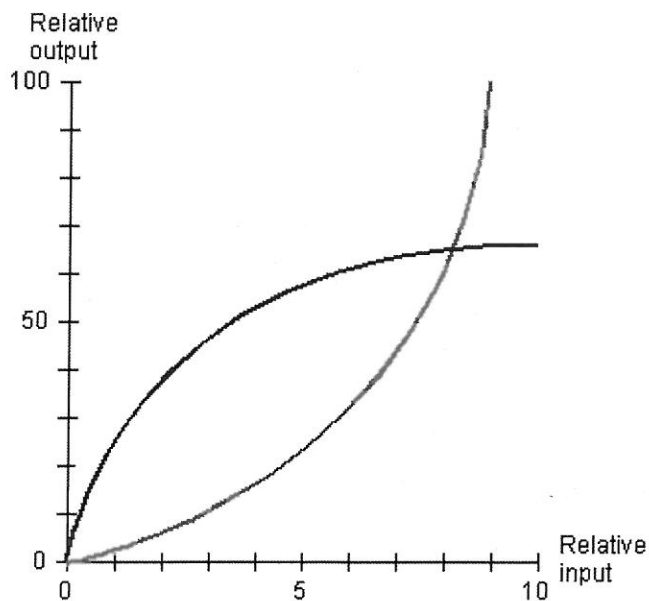
<https://www.youtube.com/watch?v=chy-UW5DnIY>

See below for a visual and explanation on the above discussion:

As a side note on analog vs. digital (linearity vs. non-linearity)

Nonlinearity is the behavior of a circuit, particularly an amplifier, in which the output signal strength does not vary in direct proportion to the input signal strength. In a nonlinear device, the output-to-input amplitude ratio (also called the gain) depends on the strength of the input signal.

In an amplifier that exhibits nonlinearity, the output-versus-input signal amplitude graph appears as a curved line over part or all of the input amplitude range. Two examples are shown below. The amplifier depicted by the red curve has gain that increases as the input signal strength increases; the amplifier depicted by the blue curve has gain that decreases as the input signal strength increases.



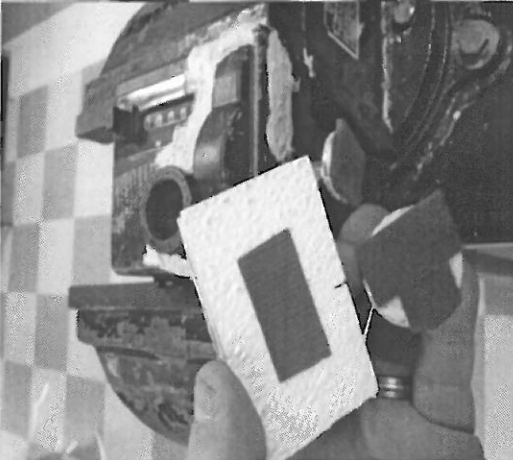
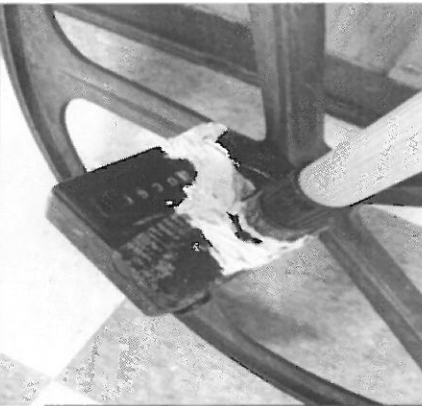
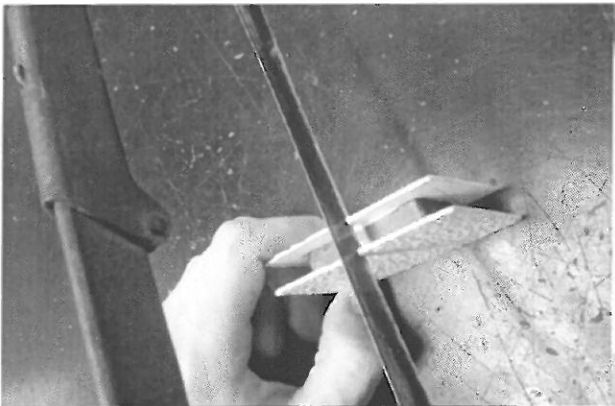
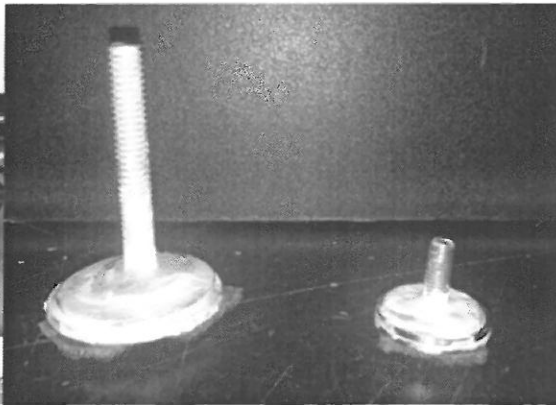
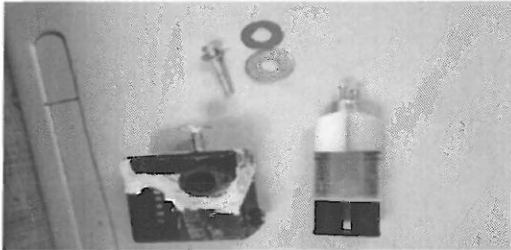
Examples of nonlinearity

Nonlinearity can be tolerated in devices and systems that use digital modulation, and also in frequency modulation (FM) wireless transmitters. These signals are either full-on or full-off; the amplitude waveforms are not analog, so analog distortion cannot occur. In analog devices and systems, however, linearity is important. Nonlinear circuits generally cause distortion in applications such as amplitude-modulation (AM) wireless transmission and hi-fi audio.

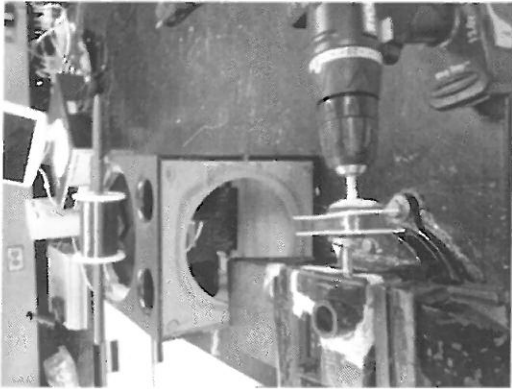
13) Make your own Counter Winding Machine for your magnetic pickups. We took an old broken measuring wheel, a drill, two bolts, a few washers and some epoxy and created a Counter Winding Machine for your magnetic pickups; it very easily . You could also use an old calculator to create a digital version of this.

See here: <http://www.youtube.com/watch?v=93l89rRVb4k>

See below for pictures of our Counter Winding Machine.



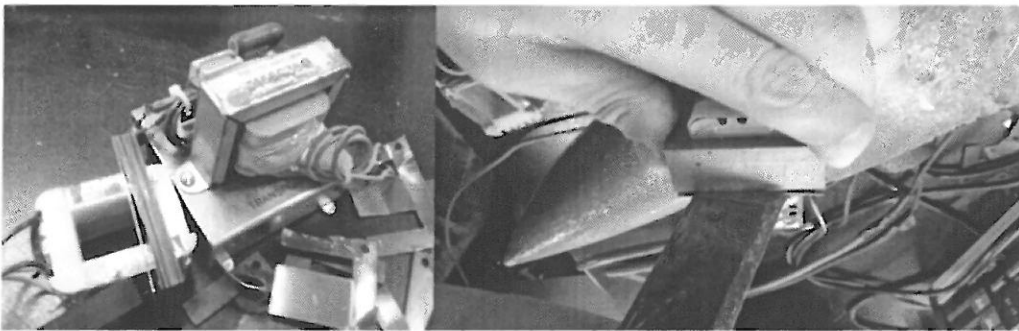
Our counter with magnet to be wound to make a pick-up. We found that for every rotation our counter read 5, this is because for every rotation of our measuring wheel the circumference was 5 ft. No big deal just multiplied the # of windings we wanted by 5.



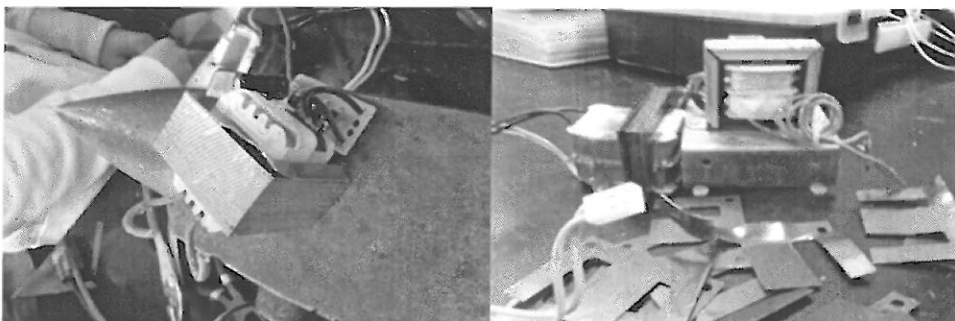
Red Velcro worked but had a tendency to wander, hot glue would have been better.

14) Next, try converting a calculator into a counter. See Here: <http://www.youtube.com/watch?v=YhdbsYCznss>

15) Free copper Magnetic Wire for your Pick-ups: Take an old transformer and have the students' take it apart being careful not to damage the input or output coils. This is a great way to introduce the concepts of transformers and induction.



Have students use a hammer and chisel to remove the core the first few are difficult and the rest are easy. They are weaved together one from one side and another from the other side. You will destroy the first one you do but after that they are all basically the same.

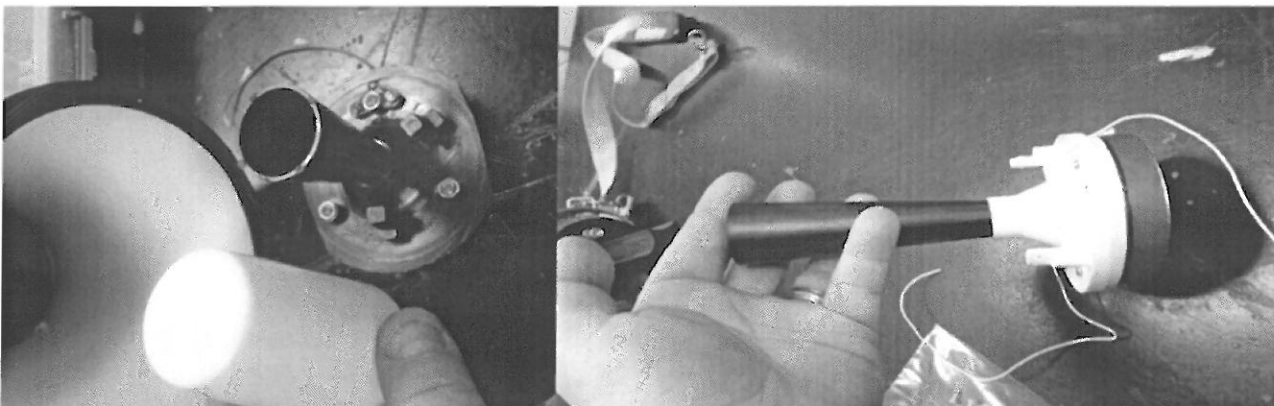
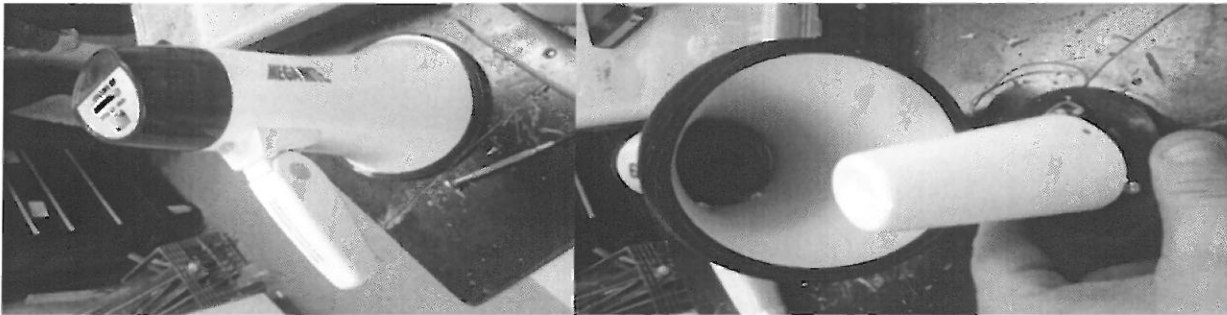
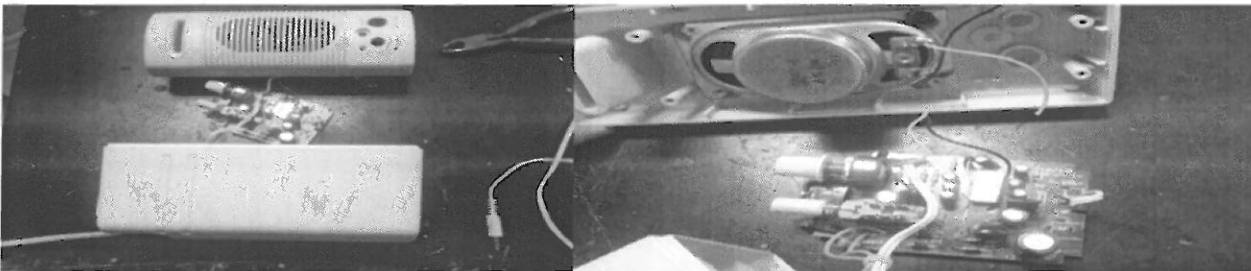




You now have two different gauge wires, one is the input coil and the other is the output coil.

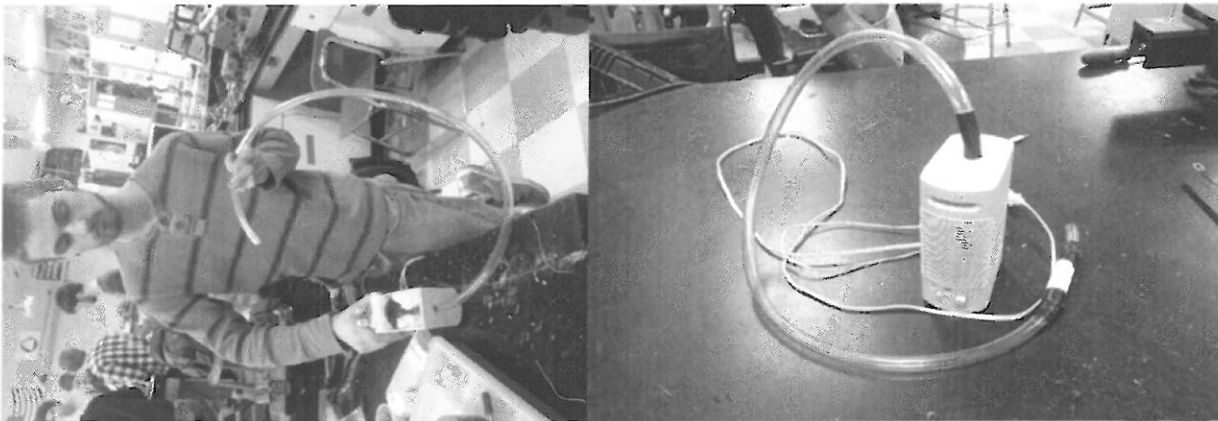
16) Talk Box or Voice Box (Peter Frampton "Do you feel like we do."):

Take an old pair of computer speakers and open them up and remove the speakers. You will see a circuit board this is your amplifier. Take a mega phone and take out the speaker (called a driver). Attach this driver to the amplifier circuit where the speaker once was attached.



This is the driver. It being from a toy fit perfectly in the computer speaker box. This is another Driver taken from a large broken Megaphone.

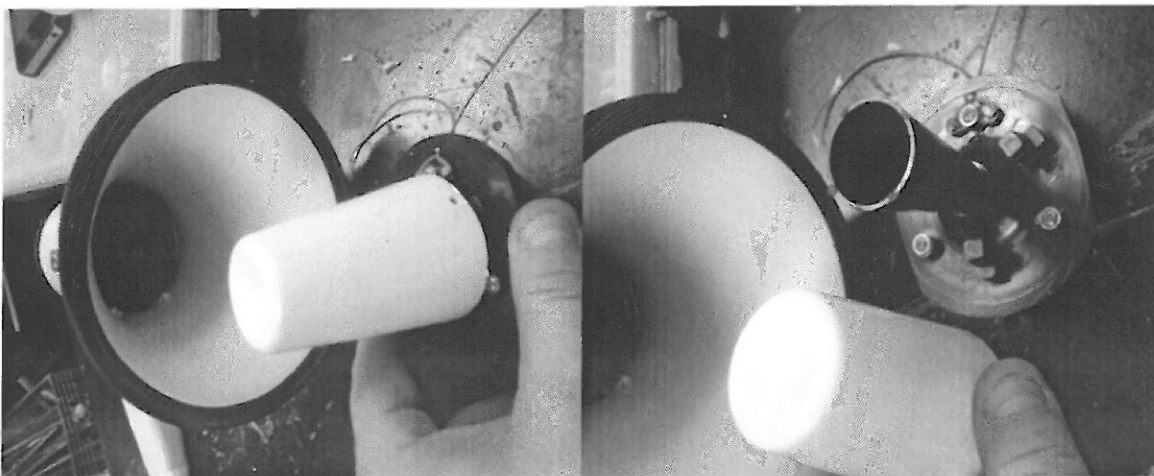
Drill a hole in the computer speaker box just big enough to fix your hose (large diameter is better than small) (we used ½ inch flexible hose.)(An old garden hose would work just fine.) Put the hose inside the driver cone and duck tape them together. We also taped the hose near the hole so it could not be pulled out. The insulation was already in the speaker box for sound and rattling reduction, we just reused it.



The finished product we duct taped a piece of PVC to the end of the hose so multiple people could try the voice box by swapping out the mouth piece (a small section of tube that we tape in place.) You can now plug this into your electric piano or guitar or computer and play music. Take a microphone and place it near your mouth. If you have a microphone stand it is much easier and you can tape the hose to the stand to free your hands. The sound waves enter your mouth via the tube. By changing your mouth / lips you distort the waves. You can also try mouthing (not speaking) words. (e.g. mouth someone's name) this will also give you really cool distortions.

17) This project took off and we were inspired to put it on steroids after seeing this video on Youtube. Having a voice box placed inside a standard guitar amplifier. We put a double poll double throw switch in so that you could run your amp like a regular guitar amp or flip the switch to make a talk box.

See the link. <https://www.youtube.com/watch?v=qqIqxM-BNp0>

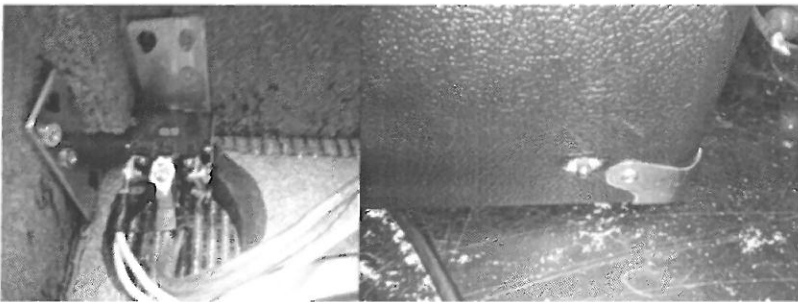


Take driver (speaker) out of Megaphone

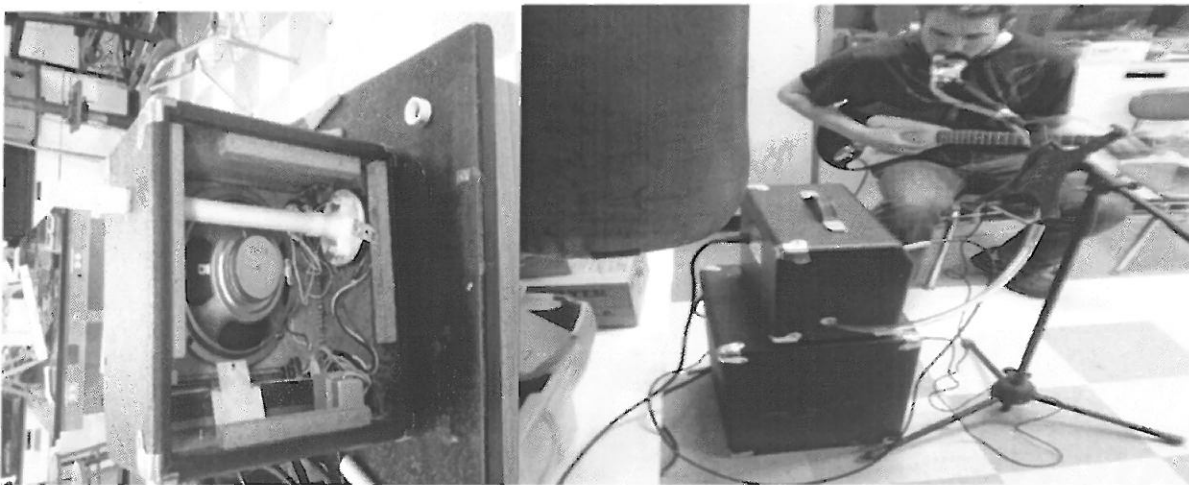
Take protective cover off Driver



Remove the cone from the Driver, so that driver can fit inside PVC tube. Use hurricane strapping for mounting in amplifier.



Students made bracket for Double Pole Double Throw (DPDT) Switch.



Driver mounted in my Fender Amp. Cut off excess PVC from outside of Amp. Student using the Talk Box

For learning how to use the Talk Box see:

<https://www.youtube.com/watch?v=bZOOEGaKQyE>