Fun Demos and Activities

The following are demos and hands-on activities addressing a variety of electrical engineering and physics related phenomena.

Magnetic Levitation – Shows how a beam of light can be used to control the position of a magnetic object made to float in space by an electromagnet.

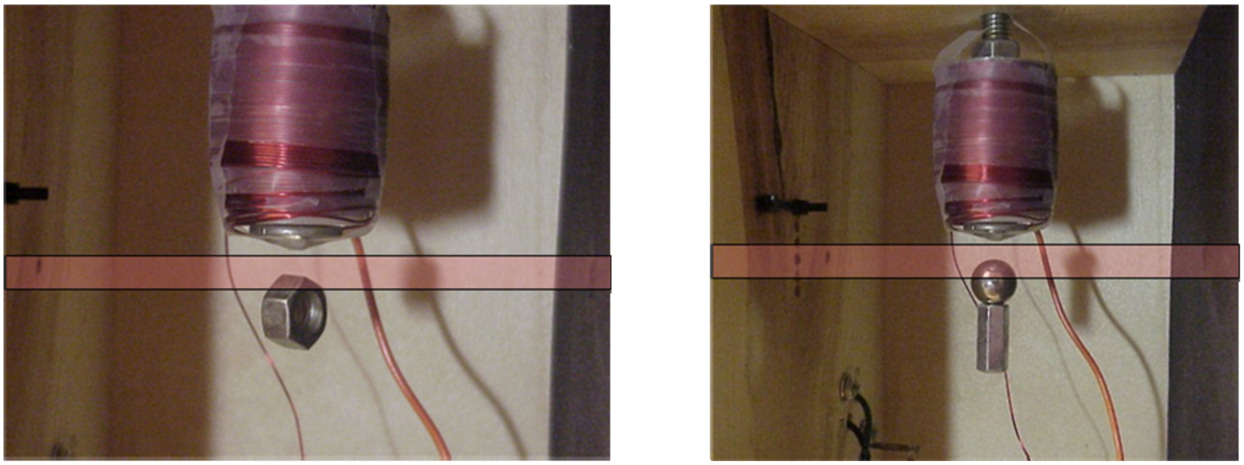
The Theremin – One of the strangest electronic devices. (Once you have tried the Theremin as it usually is experienced, see if you can make it work with the light saber. Do not touch Theremin with anything. This will not damage it, but it is meant to be used without anything touching it.)

The Coin Flipper – Is this the best decision maker? What do you think is the most interesting thing you could launch with this device?

Using Light to Show Motion – Induced voltages turn on LEDs as magnets pass through coils of wire.

Magnetic Breaking – Dropping a strong magnet down a copper pipe shows the large drag force that can be exerted on a magnet that tries to pass rapidly by a good conductor. If there is also a copper plate available, observe how slowly a strong magnet slides across it.

Magnetic Levitation – Using a light beam and magnet to make a ball float in space



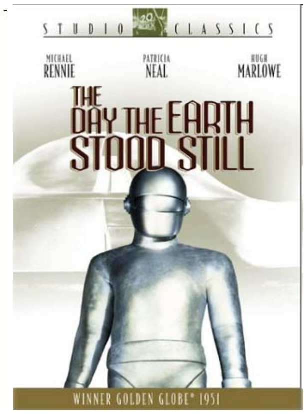
- Close up photos showing levitation of washer and ball bearing with magnet attached. Some preferred orientation is necessary for stability.

An invisible (IR) light beam 'sees' where the object is and tells the magnet how powerful it has to be to hold it in place.

In this activity, you should try to get the magnet to levitate the ball. Remember that you have to keep your fingers out of the beam of light, otherwise you will block the light sensor and the system cannot work. This is an example of a smart system that can do a job for us without us doing anything, at least once the ball in floating. The light beam is IR so we cannot see it, but we can definitely feel the magnet once the light beam tells it to turn on.

1. How much of the IR beam do you think you blocked when you succeeded in getting the ball to levitate?
2. Use another light source to see if you can interfere with the IR beam. Be sure not to block the beam, only try to increase the background light signal in some way.
3. Using any other magnet (permanent magnet, electromagnet), try to suspend a magnetic object below it without touching the object. Is it possible to do this if you cannot independently control the strength of the magnet?
4. This is an example of negative feedback. Can you identify at least one other example of negative feedback in some every day device? You may want to look online for some ideas.

The Theremin – Maybe the strangest musical instrument ever made

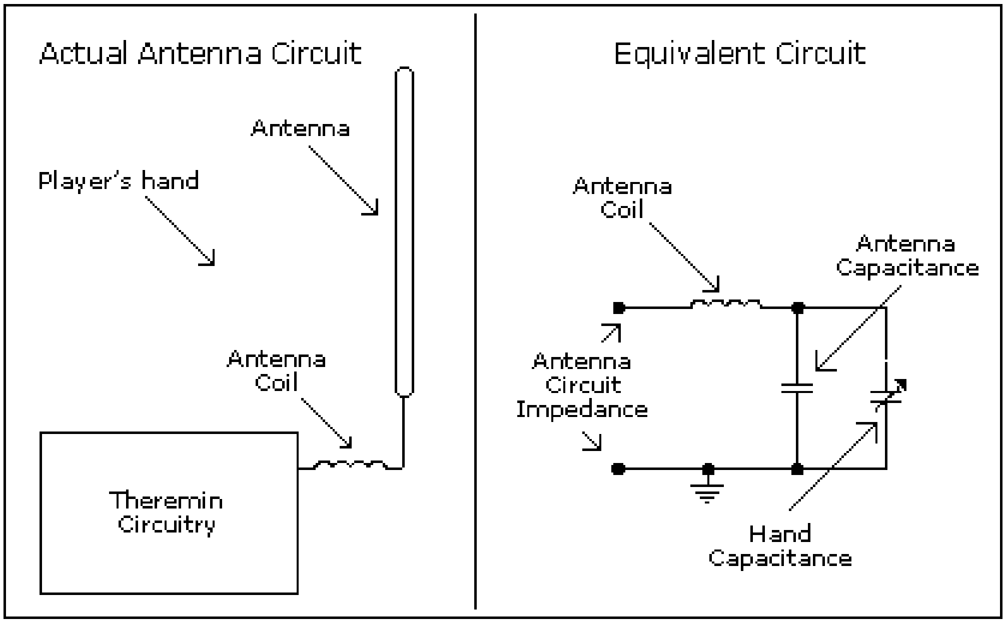


In this activity we learn how sensors, like airport metal detectors, can sense that we are nearby. You can control the volume and pitch of this musical instrument by bringing your hands close to two metal electrodes. When you do this, you become part of the electrical circuit (a capacitor, actually), which changes the way it operates. In an airport metal detector, any metallic object you have will change the inductance of the circuit, but otherwise the effect is the same.

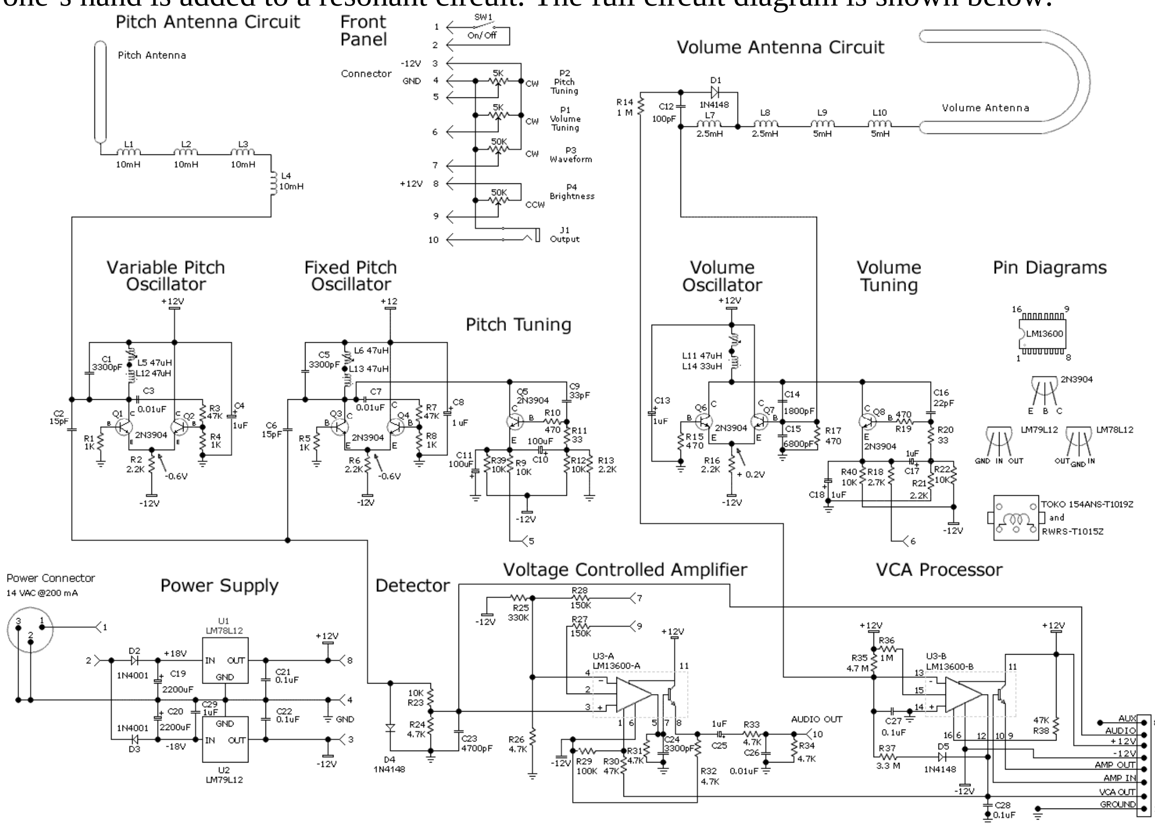
This instrument works by creating a beat frequency between two pitches that are too high for us to hear. (They are a little less than 300,000Hz) The difference in pitch is very small, so we can easily hear it.

Instruments similar to this are used by many music groups. It is also used in science fiction movies to make weird and scary noises.

1. The left electrode is volume control and the right electrode is pitch control. Your first task is to explore the sounds you can make with this device, how close you must be to the electrodes, etc. Basically, just have fun with it and then write down a description of your experience.
2. This device works by adding capacitance to the circuit by placing our hands near the electrodes. Any two conductors make a capacitor. In this case, our hands are one of the conductors and the electrodes are the other. Given the expression shown on the next page for the frequency of the oscillators in the circuit, can you determine how much we have to change C to increase this frequency by 1000Hz so we can hear a tone of 1000Hz?
3. Go online and look for information on the Theremin. Definitely look at YouTube to watch a video or two of people playing this interesting instrument.



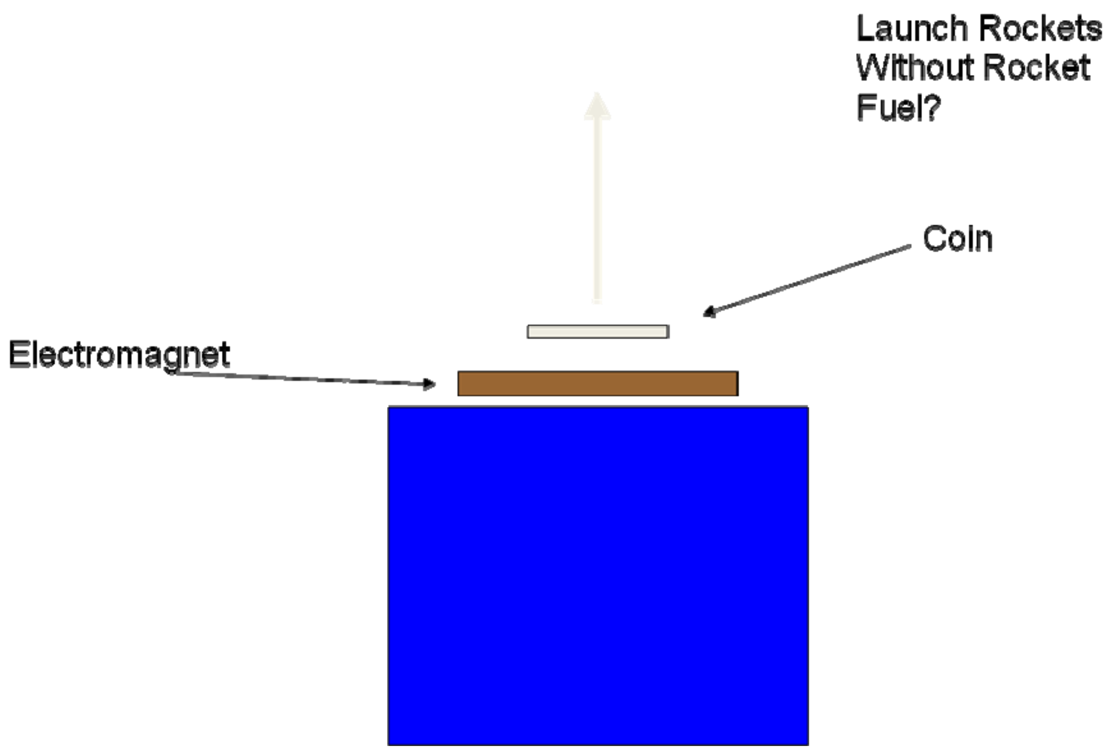
Shown above is the basic idea behind the Theremin, where the capacitance from one's hand is added to a resonant circuit. The full circuit diagram is shown below.



The circuit resonates at a frequency given by

$$f = \frac{1}{2\pi\sqrt{LC}} = \frac{1}{2\pi\sqrt{(94\mu H)(3300pF)}} = 286kHz$$

Coin Flipper – Using one electromagnet to repel another



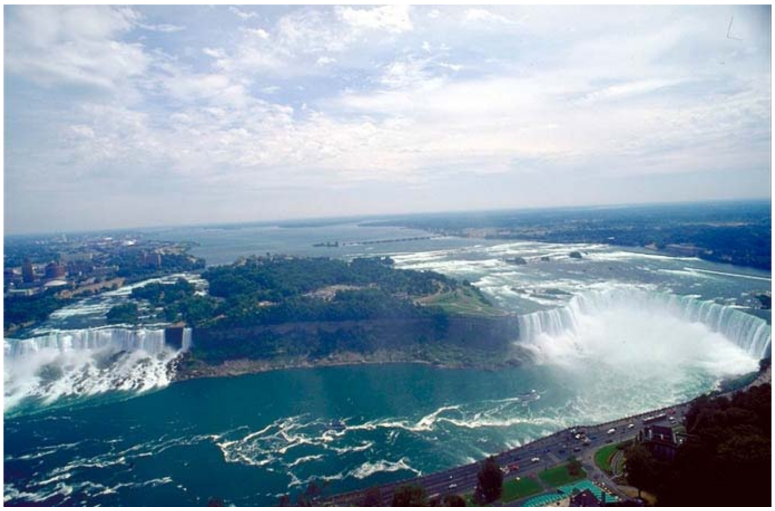
In the maglev activity, we saw that a magnet can put a force on a ball that pulls the two objects together. There is a second kind of magnetic force that pushes things apart. The second force happens when one electromagnetic makes currents flow in another conductor (called eddy currents). The current in the second object also forms an electromagnet, but with its poles pointed in the opposite direction. Since north poles repel north poles and south poles repel south poles, the two magnets will repel one another. There is sufficient force produced to launch objects at high speed. In this case, we launch coins and similar disk shaped objects. Also required for this force is that the disk be a very good conductor but not magnetic. If it is magnetic, it will be both attracted and repelled and little will happen.

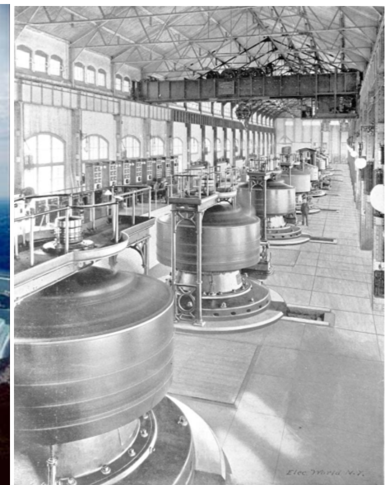
We can measure the speed of the coin using light, but that is not yet included in this activity.

1. Try several different coins and other conducting objects. Which ones were launched the best (fastest, farthest, etc)? Which ones did not move much at all?
2. Launch a ping pong ball using a copper ring. Obviously, it is the ring that is being launched and it transfers its momentum to the ball by pushing on it.

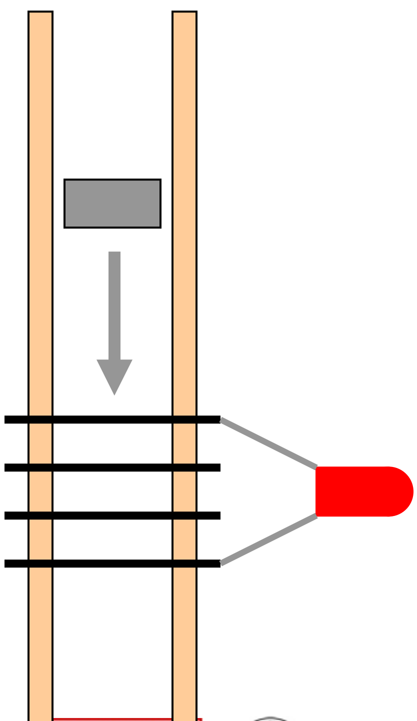
Using Light to Show Motion – Moving Magnet Makes Light

If we drop a strong magnet down a pipe and wrap a coil of wire around the pipe, we will be able to generate electricity. This is the same principle used by the big electrical generators at places like Niagara Falls. (The water going over the falls causes the magnets to move).





If it is available, drop the magnet down the plastic pipe and watch the LEDs light up as the magnet passes by.



Magnetic Braking

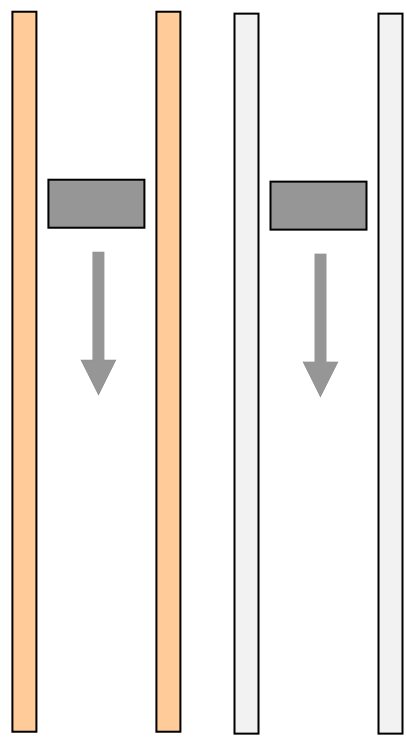
We have seen with the coin flipper and the magnet dropping through a copper coil, that a changing magnetic field can produce a current in a nearby conductor. For the coin flipper, the changing field occurs because the current that produces the field changes rapidly with time. The permanent magnet dropping through the coil has a changing field because the magnet itself is moving. In this exercise, we will observe the differences when we drop a magnet down a plastic pipe and a copper pipe. One will go rapidly and one will be quite slow.

1. Drop the magnet down the plastic pipe and measure the time it takes to fall from one end of the pipe to the other. There is a good online stopwatch to make this measurement at http://www.online-stopwatch.com/full-screen-stopwatch/ Calculate the time to drop and then compare it to your measurement. Drop it on the carpet to avoid making noise or damaging anything. From basic Physics:

$$h = \frac{at^2}{2} = \frac{gt^2}{2} \quad \text{or} \quad t = \sqrt{\frac{2h}{g}} \qquad g = 9.8\,{}^{m}\!/_{s^2}$$

2. Now drop the magnet down the copper pipe and measure the time.
3. Also try sliding the magnet on the copper plate.
   Describe what you observe.

Now describe how you might use this effect to make a brake for a car or tru



Copper pipe with strong magnet falling through it

Plastic pipe with the same strong magnet