Crystal Radio

Overview: Radio waves are a special type of electromagnetic waves that have low frequency and long wavelengths, and we use special equipment in order to "hear" them. A crystal radio is among the simplest of radio receivers, since there's no battery or power source, and nearly no moving parts. The source of power comes directly from the radio waves themselves.

What to Learn: Low-frequency electromagnetic waves are called radio waves, which are *not* the same as sound waves. By using electromagnetism principles, we can convert the radio waves into sound waves you can hear.

Materials

- toilet paper tube
- popsicle stick
- small square of sandpaper
- magnet wire (Radio Shack part #278-1345)
- germanium diode: 1N34A (NWebTronics or try GSST)
- 4.7k-ohm resistor (Radio Shack part #271-1330)
- Alligator clip test leads (Radio Shack part #278-1157)
- 100'stranded insulated wire (for the antenna)
- scrap of cardboard
- brass fasteners (3-4)
- telephone handset OR get a crystal earphone from GSST
- wire strippers
- hot glue gun

Experiment

1. Cut a piece of wire about 8 inches in length.
2. Remove about ½ inch to an inch of the plastic insulation from each end of your cut wire.
3. Remove about ½ inch to an inch of the plastic insulation from your 100' spool of antenna wire.
4. Next you'll make the tuner. Get the popsicle stick, a fastener, and the end of your antenna wire.
5. Insert the popsicle stick into the brass fastener and connect your antenna wire to the fastener by pinching the fastener ends together and wrapping the wire around the fastener. Fold the fastener ends down on the popsicle stick and put this entire piece aside.
6. Begin wrapping the magnet wire around the cardboard tube, making sure that none of the magnet wires overlap. You can wrap around and then slide the windings down so that they are close to each other, but not overlapping. You can put a bit of tape on the wire as you go so that it doesn't unwind and spring up as you're winding. This will take a bit of time to do properly. You'll want about 200 windings with no overlapping. Leave about a 6-inch loose tail at the end of your wire. Be sure to tape the last few windings to secure them to your tube.
7. Use hot glue to attach your wrapped cardboard tube to the cardboard base.
8. Find your germanium diode and connect the side with NO markings to the magnet wire tail that is on the wire-wrapped cardboard coil. Twist the wires together. Use a brass fastener to attach this connection to the cardboard.

9. Attach the marked end of the diode to a resistor (either end) and to one of the wires from your earphone. Attach these to the base with a brass fastener.
10. The third connection has four wires. Take the piece of 8-inch wire and attach it to the resistor, the other unattached side of the wire-wrapped cardboard coil's magnet wire, and the wire to the earphone. Attach these to the base with a fastener.
11. Make sure that the brass fasteners don't touch by covering them with tape. This both insulates them and stabilizes them so that they don't move.
12. Take your sandpaper scrap and use it to sand right on top of the coil, rubbing back and forth VERY gently. This removes the insulation from the very top of the wires. This is where you'll tune the radio.
13. Use a grounding source for your radio by touching the exposed, unattached tip of the 8-inch wire to something metal that's grounded in your house. Some examples are lamps with metal parts, metal faucets, metal refrigerators, etc. DO NOT plug in the end to an electrical circuit.
14. To attach the antenna, untwist the entire coil. You'll use the end of the popsicle stick with the fastener on the end to move along the top of the coil in order to tune the radio.

Troubleshooting: Some large buildings can block radio waves, so try going outside and see if that helps. Also, you might not have a good grounding source, so try another object. Finally, double check all connections to be sure the wires are all connected properly.

15. Be sure to run your experiment a few times before taking actual data, to be sure you've got everything running smoothly.
16. You will be varying the antenna length (start long and snip it shorter as you record your data trials) and measuring strength of the signal using the scoring below:

- 1 – No Signal: You can't hear any signal at all.
- 2 – Inaudible Sound: You can barely hear a signal, but can't make out any words.
- 3 – Weak Signal: You can hear a few words here and there, but nothing that makes sense.
- 4 – Medium Signal: You can hear most words, but it still sounds scratchy.
- 5 – Strong Signal: You can clearly hear words or songs.

Crystal Radio Data Table

Trial #	Antenna Length (Feet)	Signal Strength (Min = 1, Max = 5)
1		
2		
3		
4		
5		
6		
7		
8		

Reading

Radio waves are actually low frequency, long wavelength electromagnetic waves. They are not the same thing as sound waves. Crystal radios turn radio waves directly into a signal that our ears can detect. Transmitters are radio stations that emit radio waves. We also need a tuning coil, detector, antenna, and earphones to hear the waves. Today we will use a cardboard tube wrapped in magnet wire as our tuning coil and a geranium diode as our detector.

Your crystal radio will detect in the AM band that have been traveling from stations (transmitters) thousands of miles away. After working with the electromagnetic spectrum where we played with frequency and wavelengths of light, you'll find that you've got all the basics for picking up AM radio stations using simple equipment from Radio Shack.

The radio is made up of a tuning coil (magnet wire wrapped around a toilet paper tube), a detector (germanium diode) and crystal earphones, and an antenna wire.

One of the biggest challenges with detecting low-power radio waves is that there is no amplifier on the radio to boost the signal strength. You'll soon figure out that you need to find the quietest spot in your house away from any transmitters (and loud noises) that might interfere with the reception when you build one of these. You'll also have to figure out the best antenna length to produce the clearest, strongest radio signal in your crystal radio.

Power from the radio comes from the radio waves themselves, so we won't need batteries or any other outside power source. We will also need an electrical ground so that the current will make a complete circuit for our radio.

Exercises

1. What are radio waves?
2. Name some of the parts needed for any radio that we also used in this radio.
3. What serves as the tuning coil for the crystal radio?
4. Why do you need a ground for the radio?

Answers to Exercises: Crystal Radio

1. What are radio waves? (low-energy, low-frequency, long-wavelength electromagnetic waves)
2. Name some of the parts needed for any radio that we also used in this radio. (tuning coil, detector, antenna, earphone)
3. What serves as the tuning coil for the crystal radio? (the cardboard tube wrapped in magnet wire)
4. Why do you need a ground for the radio? (Grounding completes the circuit and makes the radio work.)