



Build Your Own Crystal Radio

Kit Contents

QTY	ITEM DESCRIPTION
1	1N34A germanium diode
1	120 picofarad ceramic disc capacitor
1	82kΩ, 5% ¼-watt carbon resistor
1	Ceramic earphone
1	150 feet 22 AWG enamel-coated magnet wire
1	Cardboard tube, 2 ½ inches diameter, 4 inches long
4	#6 nickel-plated Fahnestock clips
7	#6 x ½ inch screws
1	#6 washer
1	#8 x ¼ inch screw
2	#8 washers
1	¼ inch inner diameter black plastic knob
1	Brass rod, ¼ inch diameter, 7 inch long
1	Mono audio cable
1	Mini audio amplifier
1	Wooden mounting board
1	2" square sandpaper, fine grit

You will also need from home:

- Philips head screwdriver
- Metal grounding rod; this can be an exposed metal water pipe, metal fence, or a 3 foot length of copper pipe from the hardware store
- Plastic zip ties
- Wire cutters or a strong pair of scissors
- Double sided tape
- 9V battery
- Masking tape
- Permanent marker
- Access to a yard, park, or other open space

Summary

Prerequisites	To do this science project, you must live in an area where you can receive at least one strong AM radio station. You can check for this with a car or portable radio.
Safety	Never operate your crystal radio during a thunderstorm. When not in use, always disconnect your antenna from the radio circuit, and connect it directly to the ground rod. Be sure to wear safety goggles when installing the ground rod, especially if you are using a metal hammer. An adult's help might be necessary for some steps in the Procedure.
Frequently Asked Questions	



http://www.sciencebuddies.org/science-fair-projects/project-ideas/Elec_p014/electricity/crystal-radio#help

Abstract

Have you ever wondered how a radio can grab signals that are transmitted through the air and convert them into sound? In this science project, you will build your own AM radio receiver from scratch and use it to listen to AM radio broadcasts. With your crystal radio you will be able to experiment with the circuit and the antenna to get the best reception.

Objective

Build a simple crystal radio receiver and experiment to improve your reception.

Introduction

Before the 1950s and the dawn of television, people would gather in their homes with family and friends around the radio —just as we do with our TVs today—to listen to sports, music, news, and entertainment programs. Then, as now, the radio acted as a gateway to the world. But what exactly is a radio and how does it work?

A radio is an electrical device that receives an invisible signal, or **radio wave**, from a radio station and converts the signal into sound that we hear and understand. A radio wave is a type of **electromagnetic radiation** that can be used to convey audio information. Radio waves have energy associated with them. Using a transmitter and an antenna, radio stations transmit waves like the ones in Figure 1, below, which shows both a 1-cycle wave and a 3-cycle wave, each occurring in the span of 1 second (s). The number of cycles per second is called **frequency**. The unit for frequency is the **hertz (Hz)**. A 1-cycle wave per second is a 1 Hz wave, and a 3-cycle wave per second is a 3 Hz wave. Every AM radio station transmits its signal at a given frequency, and the frequency band for AM radio stations in the United States is from 530,000 Hz to 1,710,000 Hz. So a radio station transmitting at 1,590,000 Hz (expressed in kilohertz as 1,590 kHz) is sending out a signal that is 1,590,000 cycles per second.

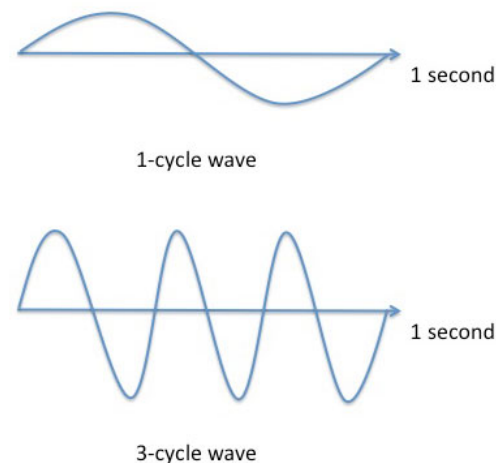


Figure 1. (Top) A 1-cycle wave, and (bottom) a 3-cycle wave.

Radio stations send out waves, and the radios in our homes receive those waves. But how do our radios turn these waves into sounds and how do stations transmit different sounds? Waves have both a frequency and an **amplitude**, which is the height of the wave. If someone yells at you from across a room, the amplitude of the sound wave is high. But if someone whispers to you from across the room, the amplitude of that sound wave is very low. It is important to note that a *sound wave* is different from an *electromagnetic wave*; radio stations send electromagnetic waves, which are then

converted into sound waves by your radio. When radio stations transmit electromagnetic waves, they can vary or **modulate** the amplitude of the wave and that is one way we hear the different levels and frequencies of sound. Stations that transmit signals via amplitude modulation are called AM radio stations (as opposed to FM stations, which use frequency modulation, but these will not be discussed in this science project).

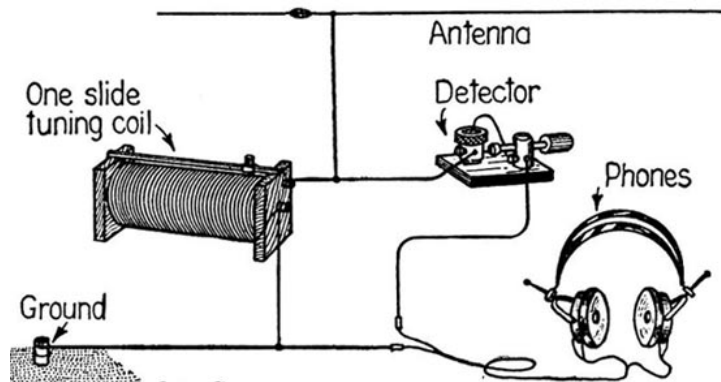


Figure 2. A diagram of the various parts of an early crystal radio. In the early days of radio, the detector was literally a "crystal." Modern radios use a diode instead of a crystal.

A **crystal radio** is a very simple radio that was popular in the early history of radios. It is an **electrical circuit** that can pick up and play sound from AM radio stations. Rather than rely on outside electrical sources, like a batteries or plugs, crystal radios get their power directly from the radio waves. The diagram in Figure 2, above, shows the parts of a crystal radio: antenna, tuning coil, diode (labeled as "detector"), earphones, and a connection to an electrical "ground."

- The **antenna** picks up AM radio waves, which create an **alternating current (AC)** in the antenna wire. An alternating current is one with a voltage that oscillates between positive and negative. See Figure 3A, below.
- A **diode** (or "detector") is an electrical component that allows current to flow in only one direction (positive *or* negative). Think of a diode like a "door" for electrical current that only opens in one direction. Consequently, when a diode is in a circuit with an alternating current (positive *and* negative), it blocks either the positive or the negative half of the radio wave. The other half of the radio wave passes through unchanged. This process is called **rectification**, and it results in alternating current being changed to **direct current** or **DC**. In Figure 3B, the rectified wave only has the positive portion of the original AC wave. When crystal radios were first made, the diode was composed of a thin wire that scratched against the surface of a crystal of semiconductive material, thus imparting the name "crystal" radio.
- The **earphones** convert the direct current to sound. The electrical current is converted into vibration, and that vibration generates sound waves. The sound waves are not very strong though, which is why earphones that fit close to the ear drum, as opposed to a speaker, are required to hear the sound (the Science Buddies kit for this science project includes a speaker powered by a separate battery, which will make the radio stations you tune in to easier to hear).
- The **tuner** allows you to select the AM frequency for the crystal radio to zone in on. The tuner has many coils of wire. By changing how much coil is used, you change the tuner's **resonant frequency**. This allows you to "tune" in to a specific station (remember that each station broadcasts at one frequency), by matching the tuner's resonant frequency to the station's broadcast frequency.
- The **electrical ground** allows current to flow through the circuit. All circuits need a ground to work properly.

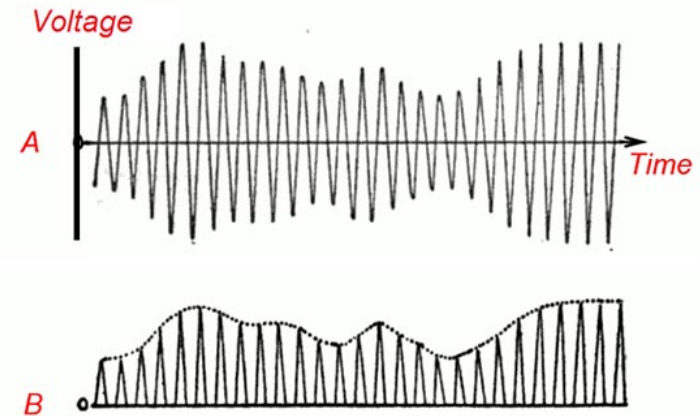


Figure 3. AM radio stations transmit signals via amplitude-modulated (AM) waves. The antenna of the crystal radio converts these waves to alternating current (shown in A). In order for the current to be converted into sound, the current is rectified by the diode so that only the positive halves of the waves get through. This rectified current (shown in B) is known as direct current.

In this science project, you will build your own crystal radio from scratch, and make adjustments to tune in to as many stations as possible.

Technical Note

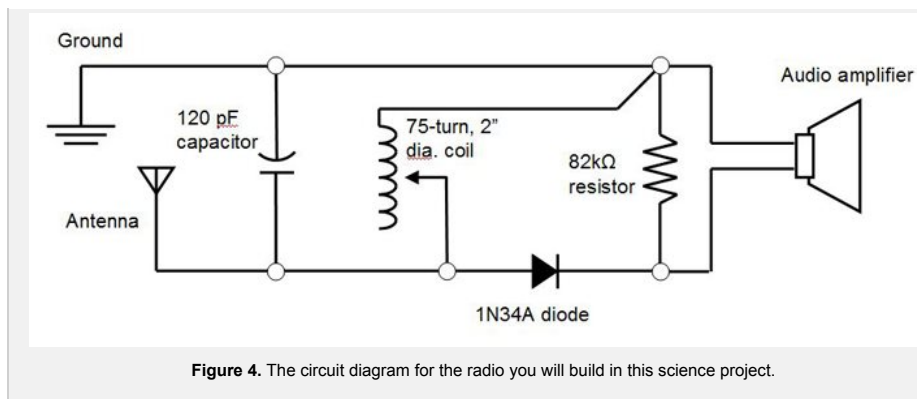
The circuit you will build in this science project also includes a **capacitor**. A capacitor is a circuit component that can store electrical charge. The old-fashioned crystal radio in Figure 2 just relied on the capacitance of the antenna itself, but adding a separate capacitor allows for better tuning. The tuner coil in the circuit is also called an **inductor**. When a capacitor and an inductor are combined in a circuit, it is called an **LC circuit** for short. This is because *L* is the mathematical symbol for inductance, which has units of **henries (H)**, and *C* is the mathematical symbol for capacitance, which has units of **farads (F)**. An LC circuit has a resonant frequency, *f*, defined by the following equation:

Equation 1:

$$f = \frac{1}{2\pi\sqrt{LC}}$$

- *f* is the resonant frequency in hertz (Hz).
- *L* is the coil inductance in henries (H).
- *C* is the capacitance in farads (F).

In the circuit you will build, the capacitor has a fixed value, but when you move the tuner along the receiver coil, you change the inductance of the coil, and thus the resonant frequency of the circuit. This is what allows you to tune into a certain station. Figure 4 shows the circuit diagram for the radio. The capacitor and adjustable coil act as a tuner, and the diode acts as a rectifier.



Terms and Concepts

- Radio wave
- Electromagnetic radiation
- Frequency
- Hertz (Hz)
- Amplitude
- Modulate
- Crystal radio
- Electrical circuit
- Antenna
- Alternating current (AC)
- Diode
- Rectification
- Direct current (DC)
- Earphones
- Tuner
- Resonant frequency
- Electrical ground
- Capacitor
- Inductor
- Henries (H)
- Farads (F)

Questions

- How do radio waves transmit information through the air? How is this information converted into sound?
- What is amplitude modulation? How does it help you hear different sounds?
- How can a crystal radio generate sound without being connected to a power source like a battery?
- What factors can affect AM radio reception? Do geography (mountains, valleys, forests, bodies of water, etc.), weather, or distance between the radio broadcast tower and the receiving radio matter? You may need to do your own background research to answer this question.

Bibliography

Here are some sources to get you started:

- Brain, M. (n.d.). *How Radio Works*. Retrieved August 28, 2013, from <http://electronics.howstuffworks.com/radio.htm> (<http://electronics.howstuffworks.com/radio.htm>)
- Wikipedia Contributors. (2012, January 26). *Crystal radio*. *Wikipedia: The Free Encyclopedia*. Retrieved August 28, 2013, from http://en.wikipedia.org/w/index.php?title=Crystal_radio&oldid=473353441 (http://en.wikipedia.org/w/index.php?title=Crystal_radio&oldid=473353441)

If you want to learn more about radios, visit The Amateur Radio Relay League website:

- ARRL. (2009). *ARRL: The National Association for Amateur Radio*. Retrieved August 28, 2013, from <http://www.arrl.org> (<http://www.arrl.org>).

This FCC website can be used to locate AM radio stations in your area:

- Federal Communications Commission. (n.d.). *AM Query Broadcast Station Search*. Retrieved September 2, 2013, from <http://www.fcc.gov/encyclopedia/am-query-broadcast-station-search> (<http://www.fcc.gov/encyclopedia/am-query-broadcast-station-search>)

Experimental Procedure

Note Before Beginning: This science fair project requires you to hook up one or more devices in an electrical circuit. Basic help can be found in the [Electronics Primer](http://www.sciencebuddies.org/science-fair-projects/project_ideas/Elec_primer-intro.shtml) (http://www.sciencebuddies.org/science-fair-projects/project_ideas/Elec_primer-intro.shtml). However, if you do not have experience in putting together electrical circuits you may find it helpful to have someone who can answer questions and help you troubleshoot if your project is not working. A science teacher or parent may be a good resource. If you need to find another mentor, try asking a local electrician, electrical engineer, or person whose hobbies involve building things like model airplanes, trains, or cars. You may also need to work your way up to this project by starting with an electronics project that has a lower level of difficulty.

Building Your Crystal Radio

1. The first step in building your crystal radio is to wind the receiver coil using the 22 AWG (Average Wire Gauge) enamel-coated magnet wire and the cardboard tube.
 - a. The cardboard tube has a total of six holes punched in it, three at each end. The larger holes are to attach the cardboard tube to the wooden base with screws. The smaller pairs of holes are to thread the magnet wire through.
 - b. Put two pieces of double-sided tape lengthwise in the middle of your cardboard tube, one on each side (opposite each other), as shown in Figure 5. This will help keep your coil in place as you wrap it.
 - c. Thread one end of the magnet wire through a pair of holes, as shown in Figure 5. Pull about 12 inches of wire through the holes.
 - d. Now, begin to carefully and tightly wrap the magnet wire around the cardboard tube, starting just above the holes you just threaded. Each new wrap should be pushed up against, but not overlapping, the previous wrap, as shown in Figure 5.
 - e. Continue tightly wrapping the coil until you reach the set of holes on the other end of the cardboard tube. Keep approximate count as you go; you should be able to fit approximately 75 complete turns of wire.
 - f. Cut the wire, leaving about 12 inches extra dangling off the tube. Thread this end of the wire through the open set of holes at the opposite end of your coil from where you started.



Figure 5. Steps for making the receiver coil for your AM radio receiver. Be sure to leave at least 12 inches of wire sticking out on both ends of the coil, after threading it through the holes.

2. Attach the cardboard tube to the wooden base board using two #6 x 1/2 inch screws (these are the smaller screws that came with your kit; notice how the other types of screws are larger) and your Phillips head screwdriver. The wooden mounting board has multiple pre-drilled holes; be sure to use the correct ones for the cardboard tube, as

shown in Figure 6.

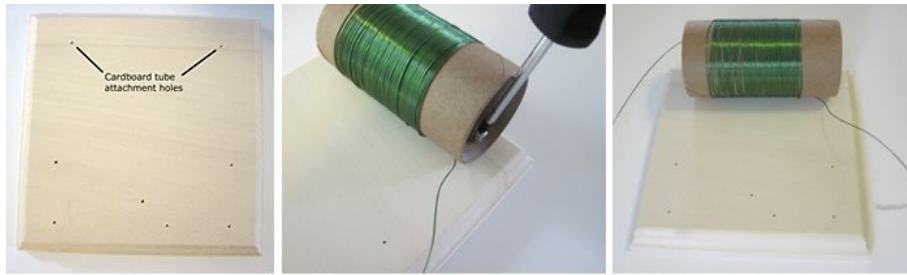


Figure 6. A diagram of Attach the cardboard tube to the wooden baseboard. Be sure to use the correct holes, as labeled in the figure.

3. Attach the Fahnestock clips to the base.
 - a. Loosely mount the four Fahnestock clips to the wooden base using four #6 x 1/2 inch screws, as shown in Figure 7. Do not tighten the screws all the way yet.
 - b. Use scissors to cut apart the "ANTENNA," "GROUND," and two "HEADPHONE" labels. Peel off the adhesive backing and place them on the board, as shown in Figure 7.

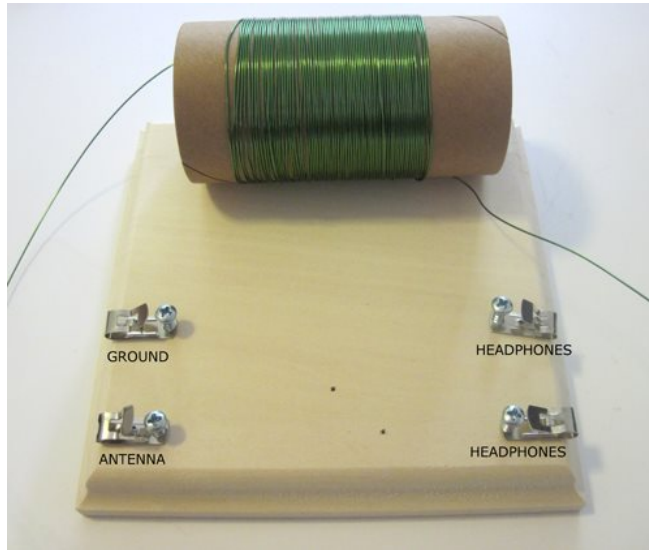


Figure 7. Attach the Fahnestock clips and the labels to the wooden mounting board.

4. Install the detector tie point.
 - a. Attach the final #6 x 1/2 inch screw and the #6 washer to the wooden mounting board in the open hole closest to the edge, as shown in Figure 8. Note this is the smaller washer that came with your kit. Do not tighten the screw all the way.

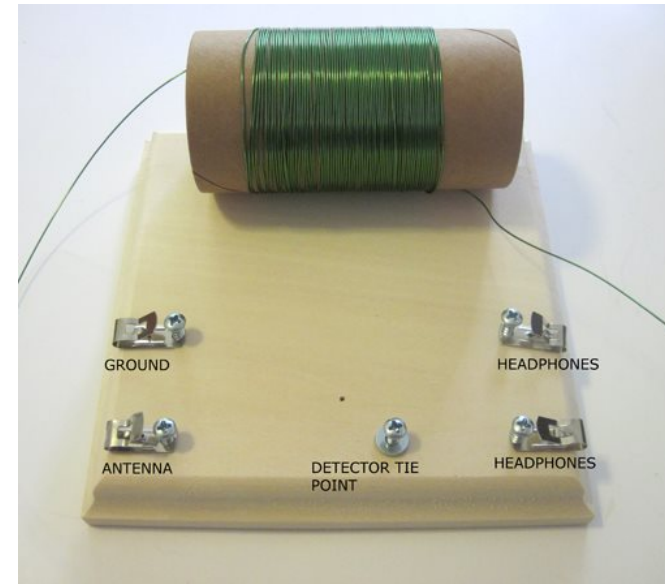


Figure 8. Attach a screw and a washer to the detector tie point.

5. Mount the tuning rod to the wooden board.
 - a. Slide the loop at the end of the brass rod and two #8 washers onto the #8 x 3/4 inch screw (these are the *bigger* screws and washers that came with your kit), as shown in Figure 9.
 - b. Insert the screw into the remaining open hole in the wooden mounting board, as shown in Figure 9. Do not tighten the screw all the way yet.
 - c. **Important:** *Carefully and gently* press the black plastic knob onto the end of the brass rod. You may need to gently wiggle the knob or twist it back and forth to get it to slide onto the rod. The end of the rod might be sharp, so be *very careful* and get an adult to help if necessary.

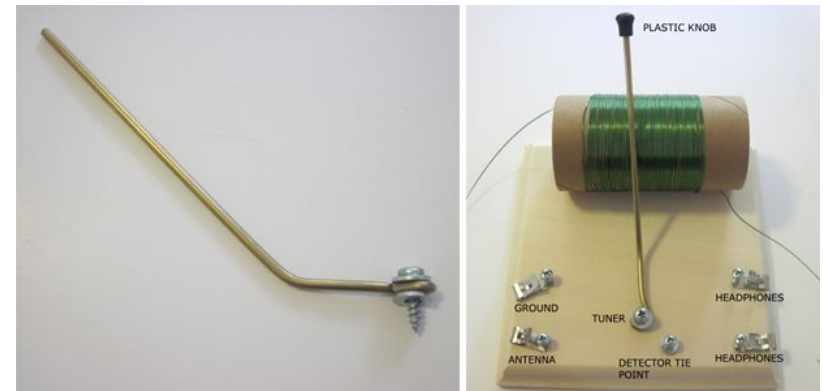


Figure 9. Sandwich the loop of the brass rod in between two #8 washers on the #8 x 3/4 inch screw. Then insert the screw into the wooden board, but do not tighten it all the way yet.

6. Connect the tuning coil to the "HEADPHONE" and "GROUND" clips.
 - a. With the wooden mounting board in front of you and the tuning coil farthest from you, loop the extra wire on the right-hand side of your tuning coil around the screws *under* the top "HEADPHONE" and "GROUND" clips, as shown in Figure 10. Make a mental note or use your finger to mark approximately where the wire is

under the "HEADPHONE" screw. This will give you an idea of where you need to remove insulation from the wire, so it can be electrically connected to the clips.

- b. Unwrap the wire and use the sandpaper supplied with the kit to rub insulation off a short (about 1 inch) section of the wire where it loops under the "HEADPHONE" clip. Be sure to remove the insulation around the entire perimeter of the wire.
- c. Loop the wire back under the headphone clip (wrap it completely around the screw at least once so it stays in place), ensure the stripped piece of wire is wrapped around the screw, and stretch the end out to opposite side of the wooden mounting board to the "GROUND" clip. Again, make a mental note or use your finger to mark approximately where the wire is under the screw.
- d. Unwrap the wire from the "GROUND" screw (you can leave it under the "HEADPHONE" screw) and use the sandpaper to remove insulation from a short (about 1 inch) section of the wire where it will loop under the "GROUND" clip.
- e. Once you have removed the insulation, loop the wire back under the "GROUND" clip. Wrap the wire completely around the "GROUND" screw at least once so it stays in place. Do not tighten the screws yet.

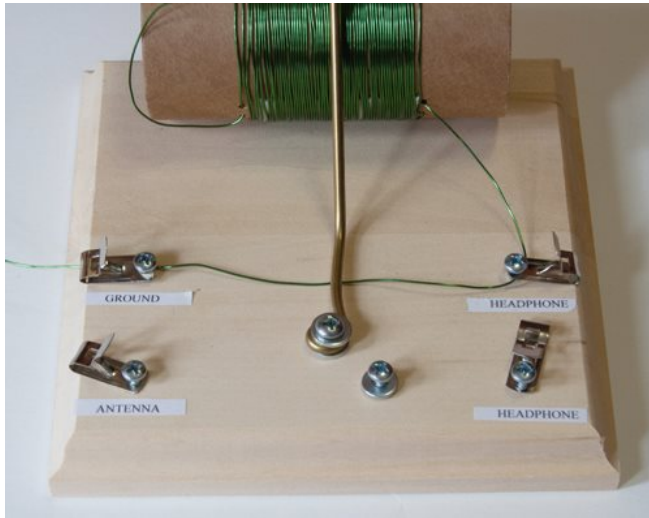


Figure 10. Loop the stripped portions of the tuning coil wire under the top "HEADPHONE" and "GROUND" clips.

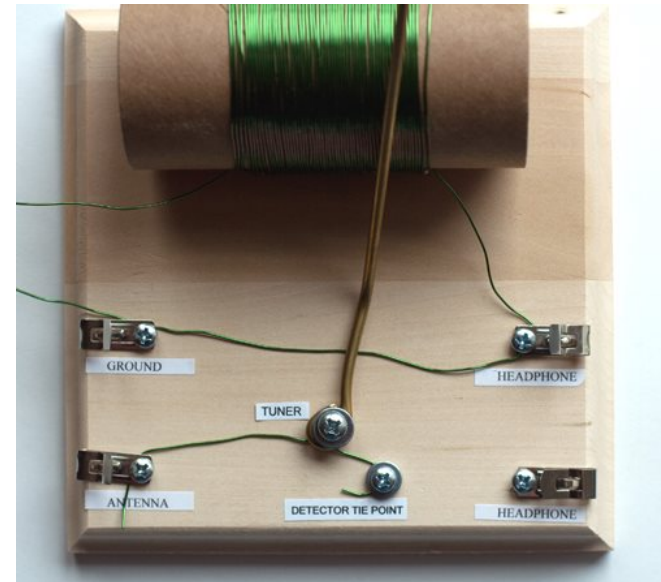


Figure 11. Connect the "ANTENNA" screw, the tuning rod screw, and the detector tie point screw with an extra piece of 6 inch wire. Be sure to sand off insulation in the appropriate spots first.

7. Connect the antenna clip to the tuning rod and detector tie point.
 - a. Cut a segment of the enamel-coated magnet wire about 6 inches long.
 - b. Loop the wire under the "ANTENNA" screw, the tuning rod screw, and the detector tie point screw, as shown in Figure 11. This will give you an idea of where you need to sand off insulation.
 - c. Remove the wire from under the screws, and sand off roughly a 1 inch strip of insulation from where the wire will connect to each of the three screws.
 - d. Loop the wire back under the three screws again, as shown in Figure 11, ensuring the stripped sections are under the screws. Be sure to wrap the wire around each screw at least once so it stays in place. Do not tighten the screws yet.

8. Attach the capacitor, resistor, and diode to the circuit. *Note:* No insulation stripping is needed in this step.
 - a. Slightly bend the ends of the leads of the capacitor, and loop these around the screws *under* the "GROUND" and "ANTENNA" clips, as shown in Figure 12. The direction of the capacitor does not matter. Tighten the screws to hold the capacitor in place.
 - b. Slightly bend the ends of the leads of the resistor, and loop these around the screw *under* the two "HEADPHONE" clips, as shown in Figure 12. The direction of the resistor does not matter. Tighten *only* the top "HEADPHONE" screw to hold the resistor in place for now.
 - c. Slightly bend the ends of the leads of the diode, and loop these around the screw *under* the bottom "HEADPHONE" clip and the detector tie point screw, as shown in Figure 12. *Important:* Make sure the black stripe on the diode is facing toward the "HEADPHONE" clip.
 - d. Double check and tighten all of the screws *except* the tuning rod screw.

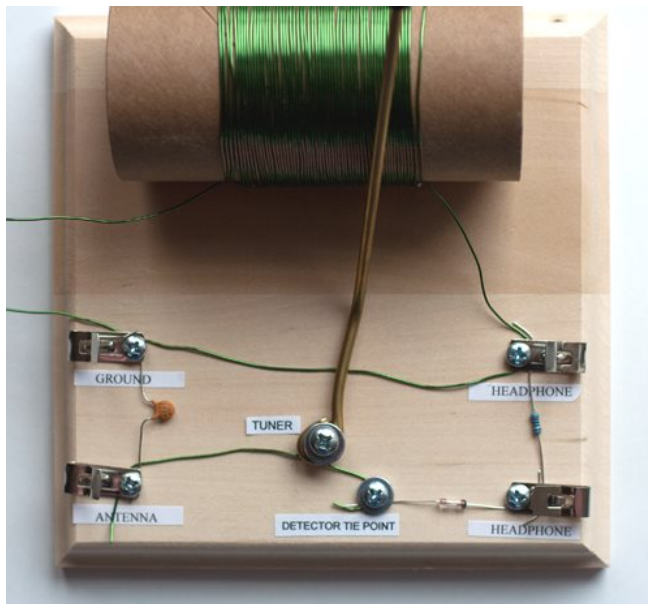


Figure 12. Wrap the capacitor, resistor, and diode leads around the screws under the appropriate clips, as pictured.

9. Sand insulation off the tuning coil where the brass tuning rod contacts it.
 - a. Move the tuning rod all the way to one side of the coil.
 - b. Test the tuning rod's contact with the tuning coil by sliding the tuning rod back and forth across the coil, making sure it always touches the coil and applies even pressure. If it presses too hard, or loses contact with the coil, you may need to bend the tuning rod slightly using pliers (do this near the base, where it is already bent).
 - c. Place your sandpaper between the brass rod and the coil wire, and pinch it around the tuning rod, as shown in Figure 13. Move the tuning rod back and forth in order to remove the enamel insulation where it contacts the coil.
 - d. When you are done, you should see exposed, shiny copper, which is a different color than the enamel insulation, as shown in Figure 13.
 - e. For now, you are done working on the wooden mounting board, and your circuit is complete. Double check that your crystal radio circuit looks like the one shown in Figure 12, and that you have sanded off insulation like in Figure 13. You can use scissors to trim any excess lengths of magnet wire that are dangling off your wooden board, then move on to step 10 to go outside and set up your ground rod and antenna.

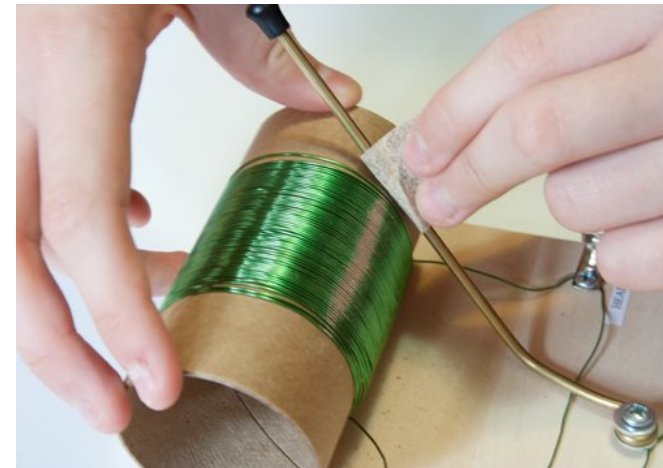


Figure 13. The tuning coil, showing exposed copper, after sanding off insulation where the tuning rod contacts it.

10. Set up your antenna. **Warning:** Never work outside during a thunderstorm. Do **not** install your antenna near power lines.
 - a. Use plastic zip ties to string up a length of the enamel-coated magnet wire from the Science Buddies kit that is as long and as high off the ground as possible. If possible, have an adult use a ladder to attach the ends of the antenna to high places like rain gutters. *Important:* Leave enough wire at one end of your antenna to reach the ground and connect to your radio.
 - b. The plastic zip ties will ensure that the antenna does not "ground out," or become electrically connected to the ground, if some of the insulation wears off (for example, if you have the antenna connected to a sharp corner on a metal fence). Try to make sure your antenna is at least 50 ft. long, but longer is better. You should have about 150 ft. of wire left after assembling your radio.
 - c. Figure 14 shows an example antenna strung up in a back yard, connected to a rain gutter and a wooden fence using plastic zip ties.
 - d. **Safety note:** Thin wires hanging in midair can be hard to see. If your antenna is close enough to the ground that someone might walk into it, you should hang "flags" on it to make it more visible. The flags do not need to be anything fancy; you can just fold pieces of paper in half and tape them to the antenna.



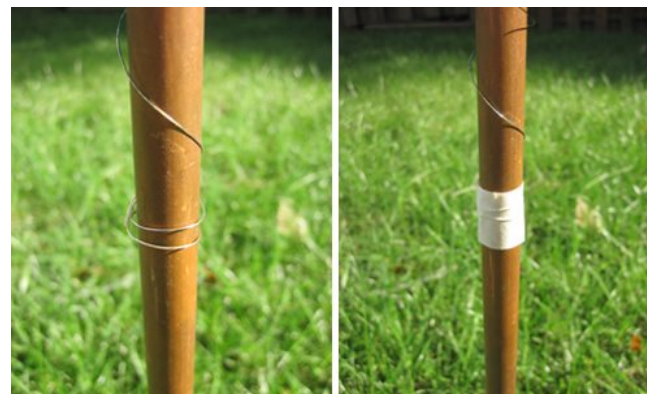
Figure 15. A copper pipe used as a ground rod with a ground wire attached (which will be used to connect the radio circuit to ground).



Figure 14. An antenna strung up between the gutter of a house and a wooden fence in a back yard (the antenna is highlighted with a red line in the bottom photo, since the wire is too thin to see easily). This antenna is about 60 ft. long.

11. Install the ground rod.

- a. If you have a metal fence or exposed metal water pipe in your yard, it will work as a ground rod *only* if it is not rusted or painted.
- b. If you purchased a ground rod, have an adult use a mallet to pound it at least 2–3 ft. into the ground, preferably near the end of the antenna that has extra wire to attach to your radio.
- c. Cut a segment of enamel-coated magnet wire that will be long enough to reach from your ground rod to your radio, with an extra 2 ft. to wrap around the ground rod. Use the sandpaper to sand the insulation off of 2 ft. at the end of the wire.
- d. *Tightly* wrap the un-insulated end of the magnet wire around the ground rod, and tie a tight knot so it doesn't fall off. You can also wrap the wire in masking tape to make sure it stays in good contact with the ground rod. Figure 15 shows a ground rod with the wire wrapped and secured around it.



12. Take your crystal radio outside and hook it up to your antenna and ground rod. **Remember not to operate your crystal radio during a thunderstorm.**

- a. Use sandpaper to sand insulation off 1 inch of wire at the end of the extra wire dangling off your antenna, and from the free end of the wire connected to your ground rod.
- b. Attach the antenna and ground wires to the "ANTENNA" and "GROUND" Fahnestock clips on the wooden mounting board, respectively. Figure 16 shows a close-up of how to use a Fahnestock clip, and Figure 17 shows both wires attached to the circuit.



Figure 16. To connect a wire to a Fahnestock clip, first press down on the tab of the clip with your finger. Use your other hand to thread the end of the wire through the clip, as pictured, then release the tab.

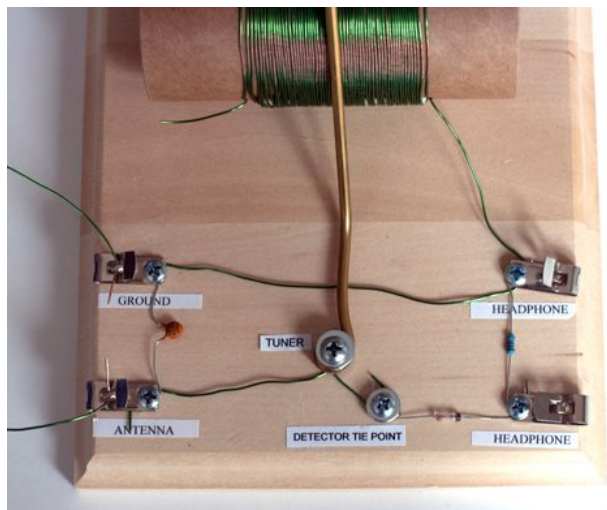


Figure 17. Connect the antenna and ground wires to the appropriate Fahnestock clips on the wooden mounting board. The two wires leaving the left side of the picture connect to the ground rod and antenna respectively.

13. Attach the audio amplifier to your crystal radio.
 - a. Use a Philips head screwdriver to remove the back cover of the audio amplifier, and install a 9V battery. Replace the back cover.
 - b. Insert the $\frac{1}{8}$ inch plug end of your audio cable into the port labeled "Input" on the audio amplifier, as shown in Figure 18.
 - c. Connect the split ends of the audio cable to the two "HEADPHONE" Fahnestock clips, as shown in Figure 18. It does not matter which of the two cables you plug into which clip.
 - d. Your kit also comes with a pair of headphones, but these do not have a separate battery so they can be hard to hear with. You can test the headphones out, but we recommend using the audio amplifier instead.

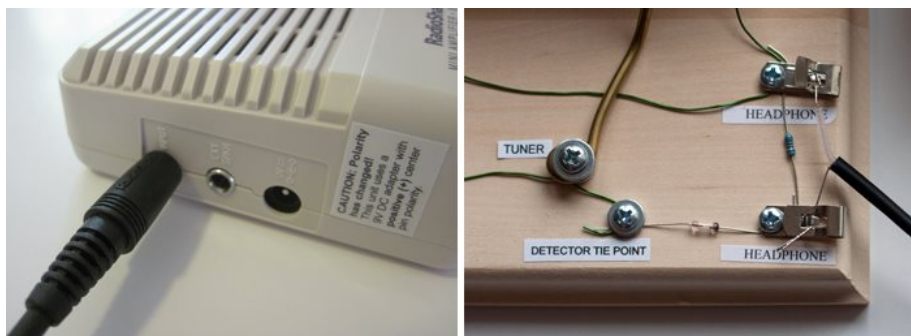


Figure 18. Attach the split ends of your audio cable to the two "HEADPHONE" Fahnestock clips, and plug the other end into the audio amplifier's "Input" jack.

14. As a last step, install the felt footpads on the bottom of your crystal radio. Congratulations! You have finished building your crystal radio. It should look like the completed radio shown in Figure 19. You are now ready to move on to the next section, *Testing Your Crystal Radio*.

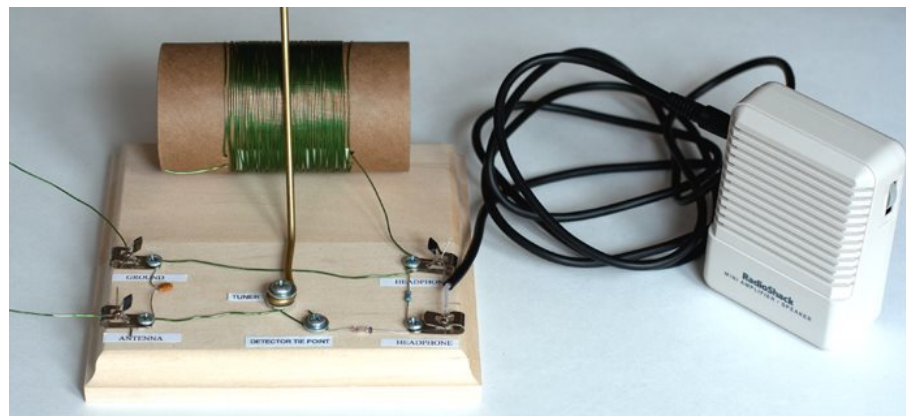


Figure 19. A diagram of A completed crystal radio. The two wires leaving the left side of the picture connect to the ground rod and antenna respectively.

Testing Your Crystal Radio

Note: The experiments you can do with your radio may vary greatly depending on where you live and how many AM radio stations there are in your area. This procedure is a suggestion, but you may need to modify it based on your location.

1. Turn on your audio amplifier using the volume dial on the side. Adjust the volume to a comfortable level.
2. Now, adjust your tuning rod to see if you can get clear reception of different stations. Take your time adjusting the rod to different positions on the tuning coil, and make sure that the tuning rod always makes physical contact with the coil. Check the full range of the coil, from one end to the other.
3. If you check the full range of your coil but cannot receive any clear stations, try re-orienting your antenna (for example, rotating it by 90 degrees). The orientation of your antenna relative to the AM broadcast towers can have a big impact on reception.
4. Once you have identified stations that you can receive, put a strip of masking tape lengthwise on your coil. Use a permanent marker to mark the location where you heard the station, and write down the station's **call sign** (for example, you may hear the DJ say "You're listening to WHCU", which is the call sign). You may also hear a number associated with the station, such as "WHCU 870." The number is the frequency at which the station broadcasts in kilohertz (kHz). You can also write this number down, as shown in Figure 20. This will help you find stations again easily. *Note:* Depending on the strength of a station, there may be a wide range (a couple centimeters) on which you can receive it using your tuning coil. If this happens, make a mark in the middle of the range.

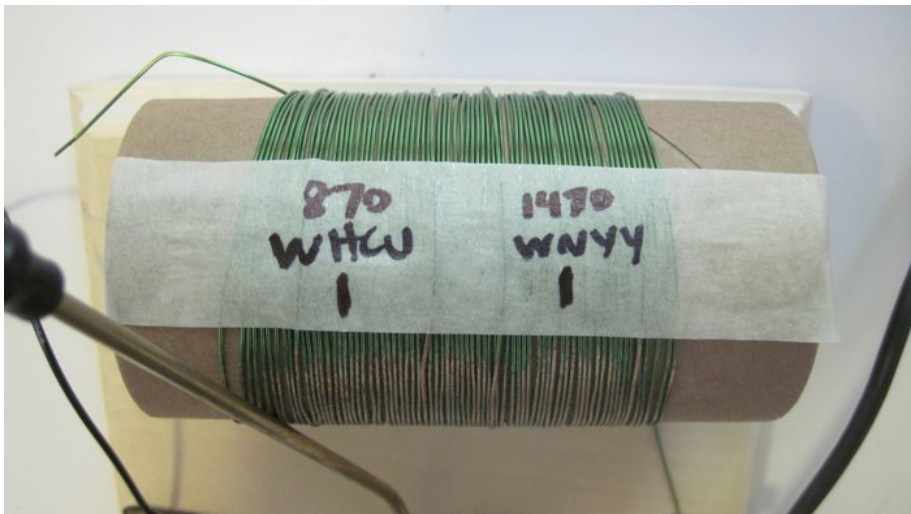


Figure 20. Use a strip of masking tape and a permanent marker to help you identify stations more easily on your coil.

4. Once you have identified some stations using your tuner, you can also use the Federal Communication Commission (FCC)'s [AM Query Broadcast Station Search](http://www.fcc.gov/encyclopedia/am-query-broadcast-station-search) (<http://www.fcc.gov/encyclopedia/am-query-broadcast-station-search>) to search for AM radio stations in your area.
 - a. Search for AM radio stations by city and/or state using the link above. If you search by city, remember to search neighboring cities as well, not just the one you live in.
 - b. This will bring up a list of results that list each station's call sign, frequency, and some other information, as shown in Figure 21. You can click on a station's call sign to bring up more detailed information, including the coordinates (**latitude** and **longitude**) of their broadcast tower, as shown in Figure 22.
 - c. Use an online mapping program like Google Maps™ to look up the location of the towers relative to your house. Note that you will have to check for the specific format to search for latitude and longitude in the mapping program you are using. For example, as of May 2013, in Google Maps the latitude and longitude 42° 27' 54.00" N, 76° 22' 23.00" W (from Figure 22), must be entered as a single line of text with spaces between the numbers and no symbols: 42 27 54 N 76 22 23 W.
 - d. Print out a paper map of your area, or use an online mapping tool like Google Maps or Google Earth™, and mark the locations of your house and all the radio stations in your area. Figure 23 shows an example map.

WHCU	AM 870	kHz	DAN	Daytime	B B LIC	ITHACA	NY US
WHCU	AM 870	kHz	DAN	Nighttime	B B LIC	ITHACA	NY US
WNYU	AM 1470	kHz	DAN	Daytime	B B LIC	ITHACA	NY US
WNYU	AM 1470	kHz	DAN	Nighttime	B B LIC	ITHACA	NY US

Figure 21. The search results for Ithaca, NY show two stations. The stations' call signs are hyperlinks that bring up more information about each individual station.

WHCU NY ITHACA USA Daytime

Licensee: SAGA COMMUNICATIONS OF NEW ENGLAND, LLC

870 kHz Licensed

Domestic Station Class: B Region 2 Station Class (corresponds to W. Hemisphere): B
 Coordination Status: Canada: - Mexico: - Region 2: -
 File No: BL-2011031ALH Facility ID No.: 18048
 CDBS Application ID No.: 1457632

42° 27' 54.00" N Latitude
 76° 22' 23.00" W Longitude (NAD 83)

Power: 5.0 kilowatts (kW) Daytime

DAN - Directional Antenna: Nighttime only
 Number of Augmentations to standard directional pattern: 0
 RMS Standard: 0.00 mV/m at 1 kilometer
 RMS Theoretical: 318.65 mV/m at 1 kilometer

1 tower CDBS Ant. System ID: 116643

Tower information:

Tower No.	Field Ratio	Phase (deg)	Spacing (deg)	Orientation (deg)	Electrical Height (deg)	Twr Ref.	No Top Loaded or Sectionalized Tower(s)	Antenna Structure Registration Number
1	1.000	0.00	0.00	0.00	110.50	0	A B C D	1048236

Additional Individual Tower Information from the Antenna Structure Registration database.
 Use the Registration Number links for detailed information

Tower No.	ASRN	Site Elevation (meters)	Overall Height Above Ground (meters)	Overall Height Above Mean Sea Level (meters)	NAD 83 Tower Coordinates	Convert to FAA Study Number
1	1048236	543.4	108.2	651.6	N 42° 27' 54.0" W 76° 22' 23.0"	To NAD27 1973-FA-129-0E

FAA: [Obstruction / Airport Airspace searches](#)

Approximate Sunrise & Sunset Times => [Eastern](#) time zone

CDBS: [Station Info](#) [Application Info](#) [Mailing Address](#) [Assignments and Transfers](#)
[Application List](#) [CDBS Search Page](#) [Ownership Info](#) [EEO](#) [Call Sign Changes](#)
[Correspondence for WHCU](#) [Correspondence for application BL-2011031ALH](#)

Site Map: [USGS Topographic map for WHCU's transmitter site \(MSRMaps\)](#)

ULS: [Related facilities in ULS](#)
[ASRNs within 0.5 km radius](#)

Figure 22. Detailed station information, including the latitude and longitude of the broadcast tower.

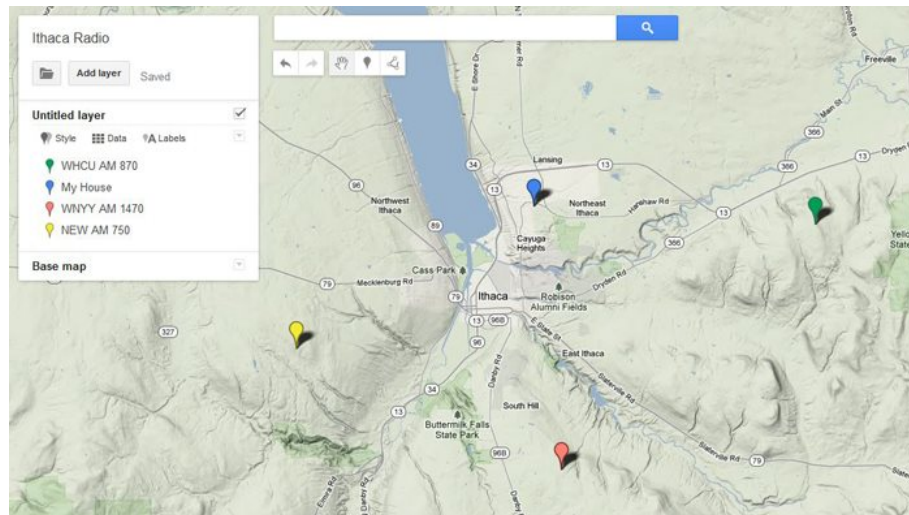


Figure 23. This custom map shows the location of three radio towers relative to a house (this map was made using Google Maps Engine Lite in May 2013).

5. Now, compare the stations listed on your map to the stations you marked on your strip of masking tape. Ask

yourself a couple questions:

- a. Is there any correlation between location on the map and how loud/clear the stations sound on your radio? For example, does your radio do a better job picking up stations that are closer to your house? Or does distance not seem to matter?
 - b. Are there any stations listed on the map that you could *not* pick up with your radio? If so, do you see any potential reasons, such as a mountain between your house and the broadcast tower (it may help to view a terrain or elevation map to determine this)?
6. Now, try to adjust the position, orientation, and/or shape of your antenna to get better reception. **Warning:** Remember not to put your antenna near power lines.
- a. For ideal reception, your antenna should be *perpendicular* to a line drawn on the map between your house and the radio tower. So, if your antenna is pointed straight toward a radio tower, you may get poor reception for that station. What happens if you rotate your antenna, and then try adjusting the tuner again? Can you pick up new stations that you couldn't hear before, or do you lose stations that used to be clear?
 - b. What happens if you change the location of your antenna; for example, move it from your back yard to your front yard? Does this affect the reception of different stations?
 - c. What happens if you change the *shape* of the antenna? For example, instead of stringing it out in a straight line, you could tie it to different fence posts (remember to use zip ties) to form a square. You could even coil it around something like a barrel or a roll of paper towels.
 - d. Can you find an "optimal" antenna configuration that gets you the best reception on the most stations?
7. **Important:** When you are done using your radio, disconnect the antenna and ground wire from the Fahnestock clips, and bring your radio inside (it is not waterproof, so should not be left outside). Then, *connect the antenna directly to your ground rod*. This will protect the antenna from lightning and static charge buildup.

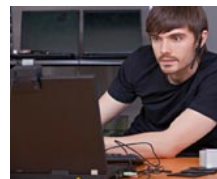
Variations

- Test your radio with different-sized ceramic capacitors. How does this affect the resonant frequency range of your radio, and your ability to tune in to different stations?
- What about changing the size of your radio's coil (the diameter, length, or number of turns)? Does this affect the radio's reception?
- What happens if you use a different gauge of wire for the antenna?
- How does changing the shape and orientation of your antenna affect your radio's reception?
- Check out the Science Buddies project [Make Your Own Low-Power AM Radio Transmitter](http://www.sciencebuddies.org/science-fair-projects/project_ideas/Elec_p024.shtml) (http://www.sciencebuddies.org/science-fair-projects/project_ideas/Elec_p024.shtml). Can you build your own transmitter and use it in conjunction with your AM radio?
- Can you build a radio from scratch using scrap materials instead of a kit? Historically, some prisoners of war had to be resourceful and do just that. For more information, see <http://bizarrelabs.com/foxhole.htm> (<http://bizarrelabs.com/foxhole.htm>). Try building one of these radios and comparing its performance to the radio from your kit.
- Can you use a multimeter to measure the current and voltage delivered to your audio amplifier from the radio circuit, and use them to calculate the electrical power of each radio station you receive? Do stations that sound clearer also have a higher power?
 - *Hint:* this might be more difficult than it sounds at first. You will need to hook the multimeter up in *series* with the amplifier to measure the current, and in *parallel* with the amplifier to measure the voltage. If you need help using a multimeter, refer to the Science Buddies [Multimeter Tutorial](http://www.sciencebuddies.org/science-fair-projects/multimeters-tutorial.shtml) (<http://www.sciencebuddies.org/science-fair-projects/multimeters-tutorial.shtml>).
 - Note that this method is not completely accurate. Remember that the signal from your radio circuit is AC (alternating current). Many consumer multimeters can only make DC (direct current) measurements. However, you may still be able to get an "average" reading for both current and voltage, which will allow you to calculate an average power, and compare the relative power levels of two or more different stations. It may be easier to do this using an analog multimeter (the kind with a needle gauge instead of a digital display). Just remember that what you are doing is an approximation, and not a true measurement of the amplitude (or average value) of the AC signal.

Related Links

- [Science Fair Project Guide](http://www.sciencebuddies.org/science-fair-projects/project_guide_index.shtml) (http://www.sciencebuddies.org/science-fair-projects/project_guide_index.shtml)
- [Other Ideas Like This](http://www.sciencebuddies.org/science-fair-projects/search.shtml?v=solt&pi=Elec_p014) (http://www.sciencebuddies.org/science-fair-projects/search.shtml?v=solt&pi=Elec_p014)
- [Electricity & Electronics Project Ideas](http://www.sciencebuddies.org/science-fair-projects/recommender_interest_area.php?ia=Elec) (http://www.sciencebuddies.org/science-fair-projects/recommender_interest_area.php?ia=Elec)
- [My Favorites](http://www.sciencebuddies.org/science-fair-projects/recommender_show_favorites.php) (http://www.sciencebuddies.org/science-fair-projects/recommender_show_favorites.php)

If you like this project, you might enjoy exploring these related careers:



Radio Frequency Engineer

Radio frequency engineers help make sure that information gets from one place to another. This information is transmitted wirelessly as radio waves between electronic devices. Anything you can wirelessly send from one computer to another, listen to on the radio, download on a mobile phone, or see on the television (not connected to cable) is sent wirelessly using radio waves, and the transmission and devices were designed by a radio frequency engineer. Radio frequency engineers are typically

electrical engineers who decided to specialize in radio frequency engineering. [Read more](http://www.sciencebuddies.org/science-fair-projects/science-engineering-careers/EE_radio_device_engineer_c001.shtml) (http://www.sciencebuddies.org/science-fair-projects/science-engineering-careers/EE_radio_device_engineer_c001.shtml)



Sound Engineering Technician

Any time you hear music at a concert, a live speech, the police sirens in a TV show, or the six o'clock news you're hearing the work of a sound engineering technician. Sound engineering technicians operate machines and equipment to record, synchronize, mix, or reproduce music, voices, or sound effects in recording studios, sporting arenas, theater productions, or movie and video productions. [Read more](http://www.sciencebuddies.org/science-fair-projects/science-engineering-careers/Music_soundengineeringtechnician_c001.shtml)

(http://www.sciencebuddies.org/science-fair-projects/science-engineering-careers/Music_soundengineeringtechnician_c001.shtml)



Electrical & Electronics Engineer

Just as a potter forms clay, or a steel worker molds molten steel, electrical and electronics engineers gather and shape electricity and use it to make products that transmit power or transmit information. Electrical and electronics engineers may specialize in one of the millions of products that make or use electricity, like cell phones, electric motors, microwaves, medical instruments, airline navigation system, or

handheld games. [Read more](http://www.sciencebuddies.org/science-fair-projects/science-engineering-careers/Elec_electricalandelectronicsengineer_c001.shtml) (http://www.sciencebuddies.org/science-fair-projects/science-engineering-careers/Elec_electricalandelectronicsengineer_c001.shtml)



Electrician

Electricians are the people who bring electricity to our homes, schools, businesses, public spaces, and streets—lighting up our world, keeping the indoor temperature comfortable, and powering TVs, computers, and all sorts of machines that make life better. Electricians install and maintain the wiring and equipment that carries electricity, and they also fix electrical machines. [Read more](http://www.sciencebuddies.org/science-fair-projects/science-engineering-careers/Elec_electrician_c001.shtml) (http://www.sciencebuddies.org/science-fair-projects/science-engineering-careers/Elec_electrician_c001.shtml)

Credits

Ben Finio, Ph.D., Science Buddies

The *Crystal Radio* Project Idea is dedicated to the memory of Richard Morton Hess, a lifelong builder and creator. In 2001, Hess was named a member of the Packard Electric Excellence Hall of Fame. He inspired many young people in his local community of Warren, Ohio through his passion for engineering.

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Contact Us

If you have purchased a kit for this project from Science Buddies, we are pleased to answer any question not addressed by the FAQs on our site. Please email us at help@sciencebuddies.org (mailto:help@sciencebuddies.org?

subject=Build%20Your%20Own%20Crystal%20Radio) after you have checked the Frequently Asked Questions for this PI at http://www.sciencebuddies.org/science-fair-projects/project-ideas/Elec_p014/electricity/crystal-radio#help

In your email, please follow these instructions:

1. What is your Science Buddies kit order number?
2. Please describe how you need help as thoroughly as possible:

Examples

Good Question *I'm trying to do Experimental Procedure step #5, "Scrape the insulation from the wire. . ." How do I know when I've scraped enough?*

Good Question *I'm at Experimental Procedure step #7, "Move the magnet back and forth . . ." and the LED is not lighting up.*

Bad Question *I don't understand the instructions. Help!*

Typesetting math: 100%