Radio & Wireless Technology Patch Program

Developed by

American Radio Relay League, Inc.

With the assistance of members of

Girl Scouts of the Green and White Mountains

and

Girls Scouts of Greater Atlanta

About ARRL. The ARRL promotes and advances the art and science of radio through education within the amateur radio community and by expanding interest and understanding of the science of radio and the application of wireless technology in daily life among the general population. Through its outreach programs, ARRL engages youth in the magic of radio, inspiring them to further personal investigation in the sciences and engineering as well as expanding their horizons to promote global goodwill through contact with cultures around the world.

ARRL not only reflects the commitment and enthusiasm of American radio amateurs, but also provides leadership as the voice of Amateur Radio in the USA, whether in dealings with the Federal Communications Commission, the World Radio Communication Conference, the International Amateur Radio Union, or with the general public. The ARRL is the primary source of information about what is going on in the world of Amateur Radio. One of the justifications for continued access to the Amateur Radio spectrum is public service. A major part of Amateur Radio's public service and emergency communications activities are conducted within the context of the ARRL's formal agreements with the emergency management, government organizations, non-governmental organizations, non-profits and public service agencies. Visit the ARRL website at *http://www.arrl.org/* to learn more.

Contributors:

Cathy Freeman, KI4SBK
Jill Galus, KB1SWV (Girl Scouts of the Green and White Mountains)
Debra Johnson, K1DMJ (ARRL)
James Neufell, K2GMT (St Thomas Aquinas College)
Laura Northrop, KJ4ECA (Girl Scouts of Greater Atlanta)
Steve Sant Andrea, AG1YK (ARRL)
James Youngberg, K1NKR

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INTRODUCTION

The American Radio Relay League (ARRL) has developed a special Radio and Wireless Technology Patch Program for Girl Scouts with assistance from members of Girl Scouts of the Green and White Mountains and Girls Scouts of Greater Atlanta (GSUSA). The Radio and Wireless Technology Patch Program will inspire girls to learn fundamentals of radio communication and wireless technology and to take action in their communities to apply communications to connect people, provide safety, and explore related careers. Girl Scouts will have the opportunity to learn about Amateur Radio (also known as "ham" radio) and do hands-on activities with Amateur Radio. They can also learn about broadcast radio, emergency and public service communications, and explore ways wireless technologies are used in everyday life and in the workplace. They will be encouraged to take on activities that engage, educate, and empower them and kindle an interest in Science, Technology, Engineering, and Math (STEM) subjects and careers. The program supports the Girl Scout Leadership Development Program by enabling the following goals for girls:

- **Discover** — Explore the natural world to learn about radio communications and wireless technologies.
- **Connect** — Use knowledge of wireless technology to understand its capabilities and its limitations. Be an informed citizen who understands how wireless technologies are regulated and used.
- **Take Action** — Make a difference in their communities by making friends through radio contacts, providing public service and emergency communications, and raising awareness of career opportunities.

This program is designed for adult facilitators' use with Girl Scouts at the Brownie, Junior, Cadette, Senior, and Ambassador levels.

We encourage Girl Scout leaders to reach out to local Amateur Radio clubs in their communities for assistance with the activities associated with this patch program. The Amateur Radio community includes many individuals who have interests and careers in technology, and who, because of their interest in radio, will also have basic – and sometimes, very advanced – knowledge of electronics and other technology topics you might explore with your troop.

Adults should consult with Volunteer Essentials, Safety Activity Checkpoints, and Risk Management at Girl Scout Councils to ensure Girl Scout safety guidelines are followed when working with girls.

PATCH COMPLETION REQUIREMENTS

READ and DISCUSS background information provided on all topics. Then DO the activities required to complete the patch program at your grade level.

When you have completed the requirements, please complete the program report to provide feedback about the program. You may purchase the official ARRL Radio and Wireless Technology Patch from the ARRL store after completing the report on your patch completion activities. You'll find the report form online at www.arrl.org/girl-scouts-radio-patch. The report includes an order form for patches. After submitting your report you will receive an email with the link to order patches. You may contact us at ead@arrl.org with any questions.

Please feel free to share your experiences and report on your accomplishments through appropriate social media channels!

SECTION 1: DISCOVER COMMUNICATION (6 Topics, 11 activities)

Brownies — Complete one activity from each of three topics.
Juniors — Complete any six activities, choosing at least one from each topic.
Cadettes, Seniors, and Ambassadors — Complete any nine activities, choosing at least one from each topic.

SECTION 2: CONNECT WITH RADIO OPERATORS AND WIRELESS TECHNOLOGY (3 Topics, 10 activities)

Brownies — Complete any two activities, but each must be from a different topic.
Juniors — Complete three activities, choosing at least one from each topic.
All other levels — Complete any four activities, choosing at least one from each topic.

SECTION 3: FIND OUT ABOUT WIRELESS CAREERS AND TAKE ACTION TO HELP IN YOUR COMMUNITY (3 Topics, 8 activities)

Brownies — Complete one activity.
Juniors — Complete two activities, choosing each from a different topic.
Cadettes — Complete two activities, choosing each from a different topic.
Seniors and Ambassadors — Complete three activities, choosing each from a different topic. One must be from the "Helping in the troop" topic.

BACKGROUND

Have you seen kids in a television show or movie who use two cans on a string to make a telephone? Have you been in a house that has a “land line” telephone that plugs into the telephone jack on the wall? Those two telephones (the tin can telephone and the traditional telephone) allow people to communicate by sending information along a wire.

What kinds of devices do you know of that communicate wirelessly, that is, they are not physically connected to each other as they are in the above example? Maybe you thought of cell phones, but do all wireless devices have to be telephones? What about a Wi-Fi system? You may use a Wi-Fi device to communicate with others using the Internet via video, e-mail, or text message. Using Wi-Fi enabled devices to communicate, you could have a conversation with anyone, anywhere, about anything. You could give instructions or directions, or someone else could tell you how to do something. Some wireless systems even use Bluetooth to allow short-distance communication between two different devices.

How about a radio or television broadcast? You could listen to music, get the news, or be entertained.

Wait... did you use a remote to give instructions to the TV or radio, like what channel to be on or how loud the volume should be? The remote control is a type of wireless communication, too. Remotes give commands to other appliances, too. Hmm... What about the remote for the garage door opener? Does your house have a motion sensor or alarm system? Those devices monitor the house and send safety information to concerned adults. Someone might have set up a weather station, thermometer, thermostat, or barometer for the house. Those devices communicate weather-related information to a display. Some houses even have digital electric meters so that remote devices can be used by the electric company to record electricity usage.

How about a GPS navigation system for the car or on the cell phone? The GPS satellites communicate wirelessly with your devices so that you can tell where you are.

Amateur Radio is a very special hobby that uses wireless communications. Radio amateurs, or “hams,” talk to other hams all over the world. This promotes international goodwill, but that’s not all there is to the hobby. Hams perform countless acts of public service. They also experiment with wireless technology — to learn and to invent.

This Radio and Wireless Communication Fun Patch will guide you to learn about how wireless works and who uses it. Ask your friends to join you in discovering how important communication is and how wireless devices work.

Wait a second; there’s another form of wireless communication. It is probably the oldest wireless communication form on earth! People have been trying for years to find ways to increase the distance that they can use it to communicate. It is your voice. So let’s start there!

SECTION 1: DISCOVER COMMUNICATION

You communicate. You tell a story or ask a question, you do something to make your intentions known. What do you need or want? Who can help you? What idea do you want to tell someone? That is an important part of communication: someone else. In order to communicate, you must have an idea of who you want to talk with, and then you must figure out how to "send" your "message." You might use your voice in a conversation with another person. You might give instructions. You might give information.

Brainstorm ways voices might communicate information.

Did your list include news or music broadcast on the radio? How about using a cell phone, Wi-Fi, or Bluetooth device? Did you consider a weather station or an electric meter as ways to communicate information? How about GPS and navigation systems?

Could you give a command to a machine? Consider what you are doing when you use a remote control. Wouldn't that be communicating with the TV, garage door opener, or another appliance?

There are many different ways that people communicate. People communicate casually, like texting, and formally, for their jobs. What job interests you? Figure out what types of information you would need to communicate and what devices you might need to use to convey those messages.

Topic 1. What kind of information do you communicate and how do you do it?

We talk a lot, don't we? But what do we say and how do we do it? That's what communications is! Every time you communicate with someone you are passing information that might be valuable to you and that person. But communicating doesn't have to be just talking. We can write, play act, and signal also. We can send letters, sounds, and pictures. Communication is both useful and wonderful. Let's find out more about it.

Discover Activity 1:

◊ At a Girl Scout meeting, make a poster or have a contest to see who can identify the most types of communication. Identify which are wireless.

OR

◊ Keep a record of which types of communication you use during the course of a day. This could include: social media, texting, newspapers, conversations, phone calls, etc. Discuss with your troop which methods you used the most and why.

OR

◊ Think of two things you enjoy in Girl Scouts. Use two different types of communication (for example, sending an e-mail, speaking in a foreign language, making a video diary, drawing a cartoon, signing, miming, writing in Braille, sending a text message) to describe those things to your troop.

Discover Activity 2:

There are various ways that you can communicate over a distance: sending a card or letter by post; telephone; digital communication such as websites, e-mail, and social media.

◊ Explain which would be the best way to communicate each of the following types of information:

- Arrangements for a troop meeting away from your usual meeting place
- World Thinking Day greetings to friends abroad
- Thanking a speaker or guest at a unit meeting
- Details of an upcoming camping trip or holiday
- An invitation to a friend who lives in a neighboring town to go to a movie
- A conversation with a pen pal who lives in Australia

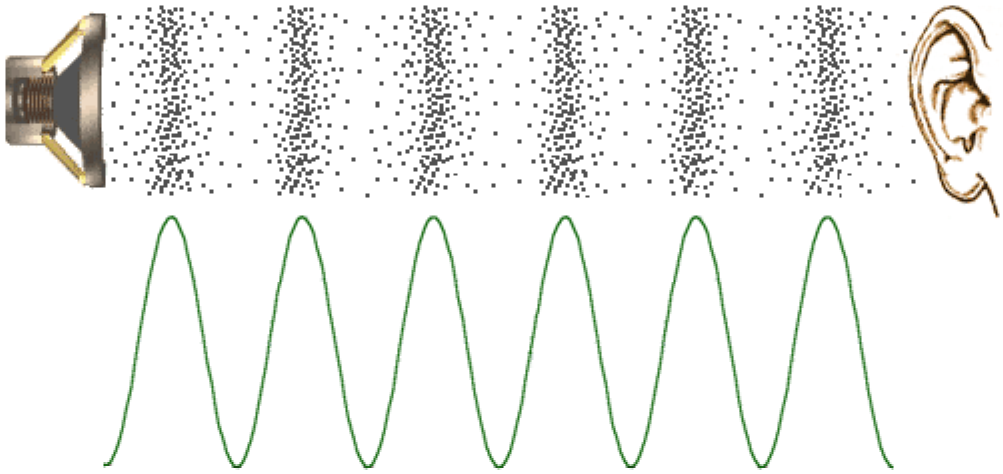
AND

◊ Share your answers with your troop.

Topic 2. What is a sound wave?

We communicate by talking. Speech is sound produced by air passing through your vocal cords in your neck.

You may be familiar with the concept that vibrations make sound. That concept is evident when you listen to music using speakers — have you ever taken the front cover off of a speaker to watch it vibrate? The electrical impulses are transferred to the speaker cone, which pushes the air to form the sound waves you hear. The same system works in the earpiece of a telephone receiver. In fact, if you took apart the handset you'd see a tiny speaker.



Frequency is a term used to describe how fast an object is vibrating. If something is low pitched it has low frequency. If something is high pitched it has a high frequency.

“Amplitude” is a term used to describe how strong the vibrations are. Think about the speaker again. Loud sounds make strong vibrations, which have large amplitude. Quiet sounds make weak vibrations, which have small amplitude. Turning up the volume increases the amplitude of the sound wave.

The graphic illustration shows the sound wave traveling from the speaker to your ear. Now, how does that happen? The speaker has compressed or vibrated the air in front of it. Fast or slow, depending on frequency. And strong or weak depending on amplitude. Your ears react to this and you hear a sound.

Microphones do the opposite of speakers. They convert sound into electrical signals.

Now think about what you see and hear around you in terms of frequency and wavelength. Objects have pitches or frequencies associated with their size and what they are made from — if you strike them they will vibrate or “resonate” At this natural frequency. Musical instruments like pianos and guitars have strings or wires with specific lengths and thicknesses. Drums have heads of specific size and stretch. Large drums and long strings resonate at lower frequencies or pitches (bass) and small drums and short strings resonate at higher frequencies or pitches (treble). Vocal chords are the same, but the size of a person does not necessarily indicate the size of her vocal chords and how high- or low-pitched her voice will be!

Let’s think about waves at the beach. Close your eyes and listen to the waves hitting the shore. The time between the waves hitting is the frequency — how frequently do the waves hit the shore? Is the frequency high, meaning do they hit the shore quickly, or is the frequency low because there is a long time between each wave hitting the beach? The amplitude of the wave is how high it is from its trough to its crest.

Imagine for a moment that you can see a set of ten waves coming toward the shore and that you can cut a pathway into the water so that you can stand beside the waves as they roll in. Walk out to the crest of a wave. Put a marker down and walk to the crest of the next wave so you can set out the next marker. The distance between the two markers is the length of the wave, which we call the wavelength.

High frequency waves (many waves passing per second) have a short wavelength. There is not much space between crests and they hit the beach quickly, one after the other. Low frequency waves have a long wavelength.

Wow, we’ve looked at sound waves from a speaker, which are made of air, and waves at the beach, which are made of water. Radio waves are similar, but they are made of something called electromagnetism. Stay tuned!

Resonance is another important feature of waves. One vibrating body or wave can induce vibration in another. Let’s investigate.

<u>Discover Activity 3:</u>
Show one of the following to your troop:

◊ Make a resonator. Cut the neck off a 12-inch balloon and discard it. Stretch the remaining “balloon” over the opening of a small coffee can. Use two thick rubber bands to hold the balloon tight over the opening. Place the can on a table and sprinkle a dozen pieces of puffed rice over the “drum” you have created. Sing the word “low.” Sing the word “high.” What do you know about their frequency and amplitude? Sing your favorite camp song while your mouth is about 6 inches away from the can.

OR

◊ Make a Singing Glass. Place an empty glass on a table. Touch the table with the handle of a fork. Click the tines of the fork with your fingernail (as you would drag your nail across a comb). Press the handle of the fork against the table top as you click the tines. Move the fork closer to the glass as you click the tines. You should hear the glass resonate as the table and fork vibrate. The sound may be faint or loud. If you're not sure if you can hear it, lean your ear toward the opening of glass (but make sure you or your hair does not touch it). Compare a serving fork, table fork, salad fork, and pickle fork. Explore using glasses of different thickness. What do you know about the frequency and amplitude of the sounds you hear? What did you notice as you changed glasses? What changes did you notice when you moved a glass closer or farther from the fork?

OR

◊ Bing-bong. Tie a spoon to the center of a 3 – 4 foot piece of string with a single knot. Stand close to the edge of a table so that the spoon will bounce against the edge of the table. Bend your neck to look down at the table edge and wrap the string around your fingers. Put your fingers in your ears so that the string and spoon extends to the table. Swing the spoon toward the table. Listen to the bell bong. Describe the frequency and amplitude of the sounds you hear.

Find more explanation here http://lafayettepubliclibrary.org/wp-content/uploads/2015/05/Week-4-spoon-gong-activity.pdf and here https://www.youtube.com/watch?v=PY7HPflnU6k.

Topic 3. How is information carried by a sound wave?

Did you really take a good look at the graphic in the last section? You need to understand it so that you can understand how sound waves work. Go back and take a quick look…do you see the tiny dots in the top half? Those represent particles, or molecules, in the air. The particles are bunched together, or compressed, by the speaker. Our ears react to the change in the air pressure and we hear sound. If the sound we hear (like a dog's bark or a friend's "hello!") makes sense to our brains, we understand the information and react accordingly.

Think a bit. We can only hear a sound if the air particles are compressed and then uncompressed. If there are no air particles where we are, then we cannot hear a sound. Think of astronauts in space. They need to be in spacesuits because there is no air, no atmosphere. So sound can't travel in the space between the astronauts. How do they communicate? We'll solve that problem later.

Take another quick look at the graphic, but look at the bottom section this time. The wavy line has a series of ups and downs, like the troughs and crests of the waves in the ocean. The ups, or crests, represent the most compressed air and the downs, or troughs, represent the least compressed air. Remember frequency is how many waves occur per second. If a sound is low-pitched it will have a low frequency, meaning the wave will be stretched out and there will be fewer waves per second. A high-pitched sound will have waves that are all scrunched up so there will be many more waves per second.

The easiest way for us to communicate specific information through the ear is to change the frequency of the sound wave we send. Ears can sense different frequencies, even at different volumes, fairly easily. You can still hear what someone is saying even if they whisper! If you tried to communicate only by changing the volume of the sound wave (I mean by changing the amplitude) parts of your information might be so soft that the communication gets lost. Then the important message you were communicating might not get through. A wave that has just one frequency and amplitude doesn't tell us much.

Discover Activity 4:

◊ Make a String Telephone. Get a piece of string and two empty cans. Punch a hole at the bottom of each can just small enough for string to fit through. Pass the string through the hole and into the bottom of one can. Tie a knot in the end of the string that is inside the cup. Pass the untied end of the string through the bottom of the other can and knot it. Place the open end of one can over your ear, pull the string tight, and have your partner speak into the open end of the other can. (There are videos and helpful hints about this at http://www.wikihow.com/Make-a-Play-Telephone.

AND

◊ At your next troop meeting try this experiment. Write some questions that have yes or no answers. Make up a code for the answers. Your code could be a high pitch for a yes and a low pitch for a no, or a loud voice for a yes and a soft voice for a no. Without the string telephone, stand across the room (about as far as the string would have stretched on your telephone) and try asking and answering the questions. How did you do? Next, try the experiment again using your string telephone. Did your technology help?

Topic 4. How do we communicate over distance?

One person talking is not communication. Someone has to be listening to the message that another person is sending. In previous sections you have explored talking to another person as a type of communication. What if you were trying to talk to another person over a long distance? How could you make yourself understood? You could write it on paper and mail it, but that takes time and money for each message to be sent.

Using technology to send information, or a message, over a distance is called telecommunication. Telecommunication didn't happen until people began to use electricity to send messages. Messages began being sent over great distances when technologies such as Morse code and the telegraph were invented in the 1830s. Other technologies include the electromagnetic telephone, still in use today, from the 1870s, and now the Internet and cellphones. Can you think of any others?

If you had to send text over long distances, what would you do? In the 1800s, many scientists and engineers thought of inventions that would make a clicking noise in an office in a distant city. But just clicking isn't much information, is it? So a man named Samuel Morse invented a code — a series of short and long clicks — to represent the letters of the alphabet. Now he could send text from city to city without writing letters and waiting for the postman to deliver them! For example, the letter 'e' is given by one short click (called a dit), and the letter 't' is given by one long click (called a dah). An 's' is three short clicks (dit-dit-dit) and an 'o' is three long clicks (dah-dah-dah). Now can you send 'sos' in Morse code? Morse code has been used for sound, wired, and wireless communications. (You'll find a Morse code dictionary in the Appendix at the end of this document.)

You can find out more about the history of communication on Wikipedia if you're interested.

Nowadays people are comfortable using technology to send messages across distances that are too great for speech to be understood. Most of today's technology is computer-based. Digital computers represent information using devices that can be in one of two "states," like a light switch that is either on or off. Computers use what is called a binary digit to tell the state of the device. For the switch, we could use a '1' to mean it's on, and a '0' to mean it is off. A line of switches or devices can be represented by a string of binary digits that represent a letter or number in a digital computer. These binary digits are also called "bits" and combinations of binary digits make up the "words" that computers use. Girl Scouts from the '80s learned about binary code for a badge called Computer Fun. You'll notice that badge (shown in the image here) has two rows of zeroes and ones.

Sometimes people want to send messages across a distance that is smaller. Security tags at stores mark the items with information that essentially says "this is mine." As long as the item and tag stay within the boundaries of the store nothing happens, but when the tag moves close to the sensors at the store entrances the message on the tag causes the alarms to sound. Those messages from the tag are read by the sensor with radio frequencies. The tag must be deactivated or removed at the counter to "delete" the message.

Now, here are a few challenging questions for you. If you had to send your voice over long distances, what would you do? If you had to send other types of information over long distances, what would you do? (Data, pictures, and commands are examples of other types of information.) Are you a budding Girl Scout inventor?

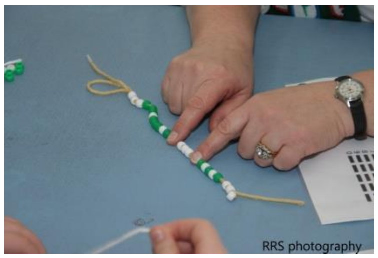
<u>Discover Activity 5:</u>

◊ Try sending your voice by using a megaphone, a telephone, or a radio. Show on a map how far you could send your voice for the method you chose.



Discover Activity 6:

◊ Use Morse code to "spell" your name by making a Morse code bracelet. There is a Morse code chart at the end of this pamphlet.



OR

◊ Borrow or make a code practice oscillator to send Morse code messages. Practice sending messages by Morse code with someone who already knows the code.

Some communication doesn't occur between people. It is the passing of data or instructions between tools. Sometimes this is called telemetry and many times it only happens in one direction. Remote controls pass codes in one direction to instruct a device. A person might design a device to be used to read a code and display the name of a product, or to translate electrical voltages collected by a sensor that will provide information about the weather that is occurring outside.

Discover Activity 7:

◊ Investigate how other kinds of codes are used. Which of the devices in the list below involve communications between a transmitter and a receiver? Which are one-way and which are two-way communications? Choose five items from the following list and describe their function, the way they communicate, and an example of how they are used in a chart. Explain what you found to your sister Scouts.

• UPC barcodes and inventory http://smallbusiness.chron.com/barcode-lettering-defined-78114.html	• Remote sensor on personal weather station http://www.wunderground.com/weatherstation/whatispws.asp
• RFID tags https://en.wikipedia.org/wiki/Radio-frequency_identification	• Garage door opener http://auto.howstuffworks.com/remote-entry1.htm
• QR code https://en.wikipedia.org/wiki/QR_code	• Bluetooth hands-free phone https://www.youtube.com/watch?v=8H7oa7BK2es
• Television remote control http://electronics.howstuffworks.com/remote-control2.htm	• GPS http://spaceplace.nasa.gov/gps/en/

• Remotely controlled car, airplane, or helicopter https://www.youtube.com/watch?v=UaheQsvZK8g	• Mobile payment systems (pay-by-cellphone) http://electronics.howstuffworks.com/cellular-electronic-payment1.htm

OR

◊ Explore how remote controls are programmed. How does a remotely controlled car, airplane, or helicopter work? What kinds of issues affect how well a remote control works? Bring a remotely controlled toy to your next Scout meeting. Demonstrate how to make it work, and then explain how you can use the remote controller to communicate with the toy.

Topic 5. What kinds of techniques are used to improve the quality or accuracy of communications?

Because the information you want to communicate is important, you want to make sure your message is received correctly. It doesn't matter what your message is, it is important to you and you need to make sure that the recipient gets it.

You and your partner could develop or use a code, like semaphore flags if you could see each other but not hear each other, or Morse code if you were so far apart that you couldn't see or hear each other (or radio or a cell phone if you were really far apart). Remember, the code is only going to work well if you both know what the code is and if what is sent can be received and decoded. It would be hard to see a semaphore flag in fog. It would be hard to receive a Morse code signal with lots of background noise.

But what if the sun were in your eyes while you were using semaphore, or there were loud noises while you were using Morse code or your voice?

Discover Activity 8:

◊ Discover interference and noise. Play a "telephone game." Whisper a word around a circle of girls.

- Compare the word received by the last girl in the chain to the original word.
- Play the game again. This time introduce a name or word that will be unfamiliar to most, or a word in another language. Compare the outcome.
- Play the game again. This time use a complete sentence. Compare the outcome.
- Play the game again with a sentence. Introduce noise, such as a background music. Compare the outcome.
- Play the game again. Introduce interference, such as someone carrying on a conversation with you while you are trying to pass a message. Compare the outcome.

AND

◊ When you are done, discuss the importance of accuracy in communication.

Discover Activity 9:

◊ Explore some techniques for improving the accuracy of communication. Find out about the phonetic alphabet. There is a Phonetic Alphabet Chart in the Appendix for your reference. (Who uses the phonetic alphabet as a feature of regular communication? Why?) Use the phonetic alphabet to spell your name and the name of your town.

AND

◊ Play the telephone game using the phonetic alphabet. Divide into two equal groups and initiate a message with an unknown name or word. Have one group pass the message using the phonetic alphabet, the other just speaking the phrase. Time how long it takes each group to pass the message. Compare the accuracy and speed of the two groups. Discuss how the accuracy of the messages you have communicated in other activities might have improved if you had used a common code like the phonetic alphabet.

Topic 6. How do radio waves help us communicate?

What is a radio wave?
When we spoke about sound waves, we were also describing the flow of energy carried by changes in air pressure. The speaker exerts a force on the air to compress it. That requires energy and the wave carries that energy to your ear. Later, when we spoke of waves on a beach, we were describing the flow of energy carried by the motion of the water. Gravity and wind, and earthquakes, apply forces to the water that forms waves. Radio waves are a flow of energy from an antenna that is carried through space by changes in electric and magnetic energy.

A wave that has just one frequency and amplitude doesn't tell us much. How do radio waves carry information?

A microphone turns a person's voice into electrical impulses, which travel through wires inside a radio transmitter. The radio transmitter and its antenna change the electrical signal to a radio wave carrying the voice information. The radio signals traveling away from the antenna have a specific frequency and wavelength. Another antenna receives the radio signals, turns them into electrical impulses which travel to a radio receiver (properly tuned to the transmitter's frequency) where they are finally turned into sound waves by a speaker or headphone.

There are actually several ways to use the radio wave to carry the information. The simplest is just to turn a transmitter on and off using Morse code for your message. Or, you could change the "amplitude" (the strength) of the wave to follow the strength and pitch of your voice. This is called Amplitude Modulation, abbreviated as AM. Or, you could change the frequency of the radio wave. This is called Frequency Modulation, abbreviated as FM.

Once you start modulating frequency or amplitude you can send information. It just takes another person who is using the same modulation method to decode your message and receive the information.

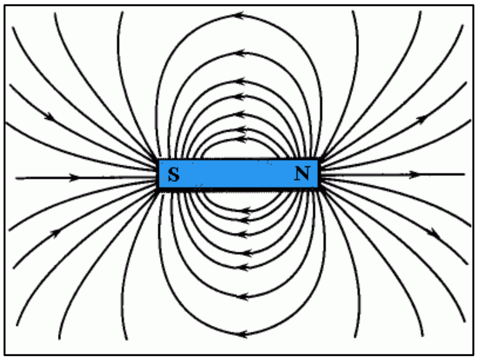
Radio waves move electrical energy instead of air particles. Remember that from the first paragraph above? That is so important I need to write it again. Radio waves move electrical energy! That means that they do not transfer air particle vibrations like sound waves do, because they don't need air particles! They can go into space! The information you send on a radio wave can go all the way out into deepest, darkest, distances of space! Or from astronaut to astronaut.

Like sound waves, radio waves have frequency and amplitude. But radio waves are very special. They work with electric and magnetic fields and move at the speed of light. In fact, light is a high frequency radio wave that our eyes can detect and our brain can understand.

Have you felt the pull of two magnets held close to each other just before they touch? They'll touch if you hold them with a north pole near a south pole. Have you tried to hold them "backwards," with a north near a north, and felt the push from the magnets? What you are feeling is the force of the magnetic field.

But what is a magnetic field? Centuries ago, scientists who were investigating magnets could understand how objects that touch each other can exert forces on each other, but not how magnets could exert forces on other magnets without touching. They defined a quantity called the *field* that could be used to calculate the force on one magnet if placed near a second magnet. It is similar to the gravitational field that describes the force of gravity that an object responds to if placed near another object.

The magnetic force is shown on a diagram by "magnetic field lines." The lines have arrows on them (scientists call them vectors) that come out of the North Pole and point toward the South Pole.



Permanent magnets are made using special metals, like iron, that can "hold" a magnetic charge. All the magnetic fields of the molecules inside the piece of metal are aligned to make the whole piece of metal attract or repel other magnets. If you are interested in making a magnet, you might make your own compass. You'll find a link for instructions in the Resource section.

Temporary magnets can be made, too. Temporary magnets are often called electromagnets. Their magnetism comes from an electric current. When electricity flows through a wire it creates its own magnetic field. If you wrap a wire around a piece of iron, magnetism will be made (induced) while the electricity flows. You'll find instructions for making a simple electromagnet in the Resource section.

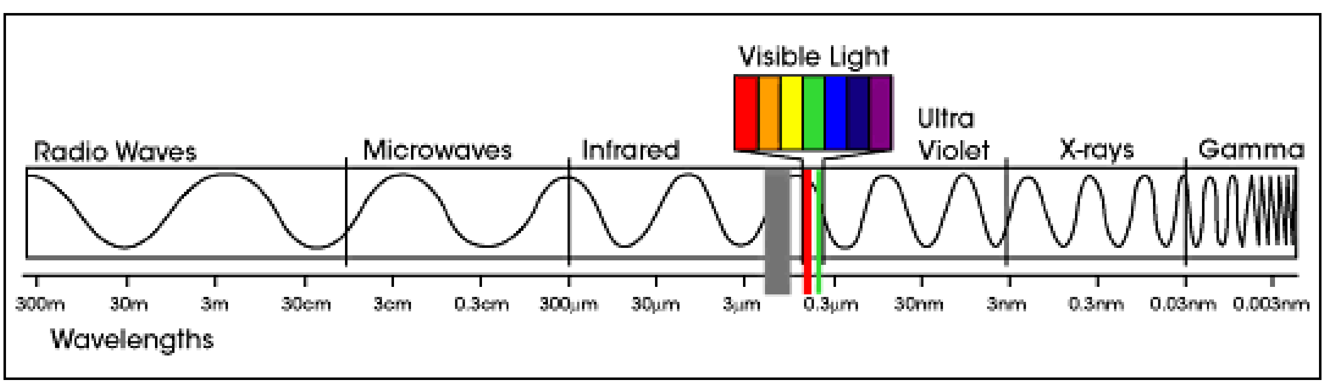
Just like the way electricity can induce a magnetic field, the reverse can happen. A moving magnet can make electrons flow. A scientist named Michael Faraday studied the relationship between magnetic fields and flowing electricity that causes them to change something he called "electromotive force." It is

Faraday's idea of electromotive force that explains how motors and generators work. Faraday's ideas explain magnetism and electricity in a loop of wire. Another person, Heinrich Lenz, looked at the experiment from the opposite point of view. He studied magnetic objects falling through metal tubes and the electric fields that were made

An electric current is the flow of charged particles or electrons. You have seen the effect of charged particles if you have ever had two pieces of clothing cling to each other when you take them out of the dryer, or if you have ever been shocked by touching something after walking across a carpeted room or after getting out of the car. It happens especially when the humidity is low. An electric charge exerts a force on other charges. If the two charges are alike, they attract or pull towards each other, and if they are the opposite, they repel or push away from each other. The force is similar to that of the magnet, but an electric charge has no north and south poles. Scientists define the electric field around it as a way to keep track of the forces it would produce on another charge placed nearby.

When the clothes are sticking together, the charges are opposite and are attracted to each other. In the photo below, a Girl Scout is touching a static charge generator at a STEM Expo. The generator produces charges that are conducted to her hand and through her body. Since all the charges are the same, they repel each other. They try to get away from each other by spreading out as far as they can on her skin and hair. See how her hair is being forced away from her head and each strand is forced away from other strands. Science can be fun!Wait! Remember that we are talking about radio waves! Radio waves are special. They combine electric fields and magnetic fields. The signal that comes out of a radio's antenna causes both an electrical and a magnetic field — an "electromagnetic field." Check out the animation at https://en.wikipedia.org/wiki/Radio_wave. This field is what makes radio waves move through space without needing to vibrate air particles!

Did you know that radio waves and light are related? They are both electromagnetic waves. Radio waves are just a low frequency "sister" of light waves.



What other kinds of electromagnetic waves can you find in the picture? Where are the waves from your TV's infra-red (IR) remote control? They are higher in frequency (shorter in wavelength) than radio waves. Are x-rays longer or shorter in wavelength than visible light? If you have trouble reading this chart you'll find a chart at https://en.wikipedia.org/wiki/Electromagnetic_spectrum.

You find the communication that someone is sending by tuning your radio receiver to the transmitter's frequency. Frequency? You know what that is; it is the number on the radio dial where you find each radio station. It's the *place in the spectrum* where your radio communication is happening.

In electronics and radio, frequency is measured in hertz (the symbol is Hz), and is defined as one cycle per second. It is named for Heinrich Rudolf Hertz, the first person to provide conclusive proof of the existence of electromagnetic waves.

Discover Activity 10:

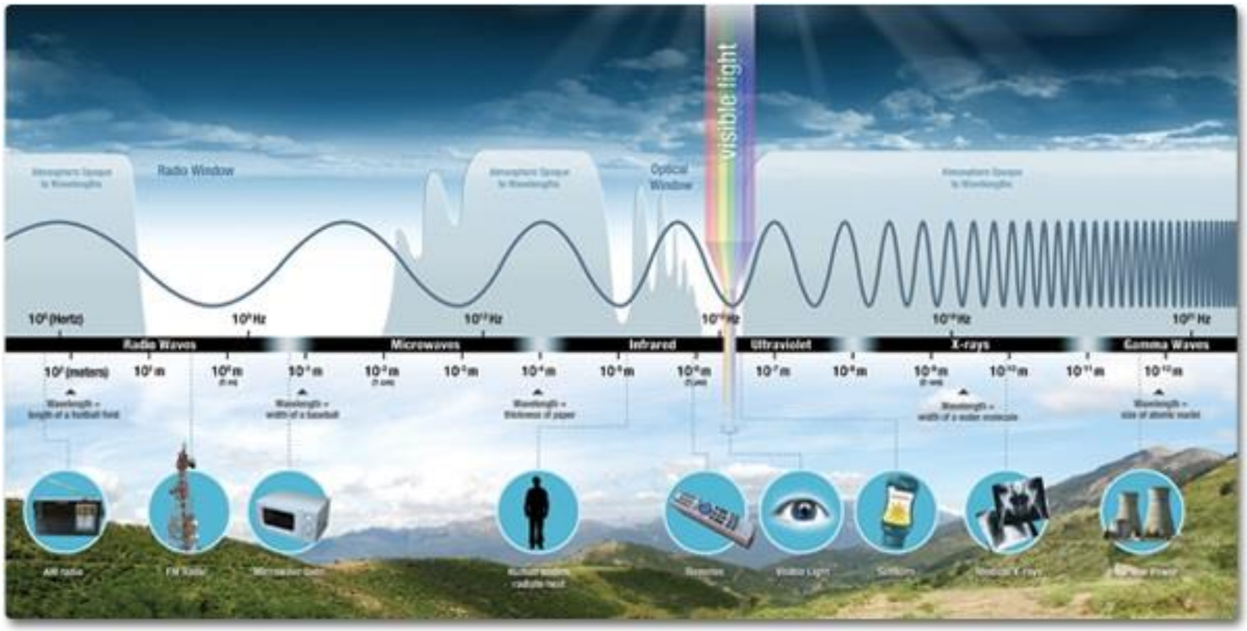
◊ Try mapping a magnetic field with a compass and a bar magnet. Place your magnet on the center of a piece of paper. Bring the compass near the magnet and watch how the compass needle moves as you move it in a circle around the magnet. Discuss why this happens with your troop. Figure out where the compass points north at the magnet. Mark an arrow on the paper that corresponds with the direction of the arrow. Do the same thing where the compass points south at the magnet. Keep repeating the measurement and arrow drawing so that you have at least five arrows pointing toward the North Pole and five arrows pointing toward the South Pole. Then draw lines connecting the pairs of arrows. You should see a diagram similar to the one in the text above. The places where the lines are more densely drawn (where they are closer together) are the places where the magnetic field is strongest. Did you test out the magnetic field above or below your magnet? The coolest thing about magnetic fields is that they go all around the magnet in every direction!

OR

◊ Learn about Lenz's Law. Watch a demonstration of a magnet falling through a non-conducting and a conducting tube. Describe to your advisor the relationship between magnetism and electricity that creates these results. (You can get ideas about how to do this experiment at http://www.iflscience.com/physics/what-happens-when-you-drop-magnet-through-copper-tube)

Discover Activity 11:

◊ Identify the parts of the electromagnetic spectrum associated with radio, light, microwave, and x-rays. To continue the discussion, use a resource provided by NASA that explains in more detail how the various parts of the electromagnetic spectrum are used: http://missionscience.nasa.gov/ems/TourOfEMS_Booklet_Web.pdf.



AND

Watch a YouTube video at: http://missionscience.nasa.gov/ems/emsVideo_01intro.html

SECTION 2: CONNECT WITH RADIO OPERATORS AND WIRELESS TECHNOLOGY

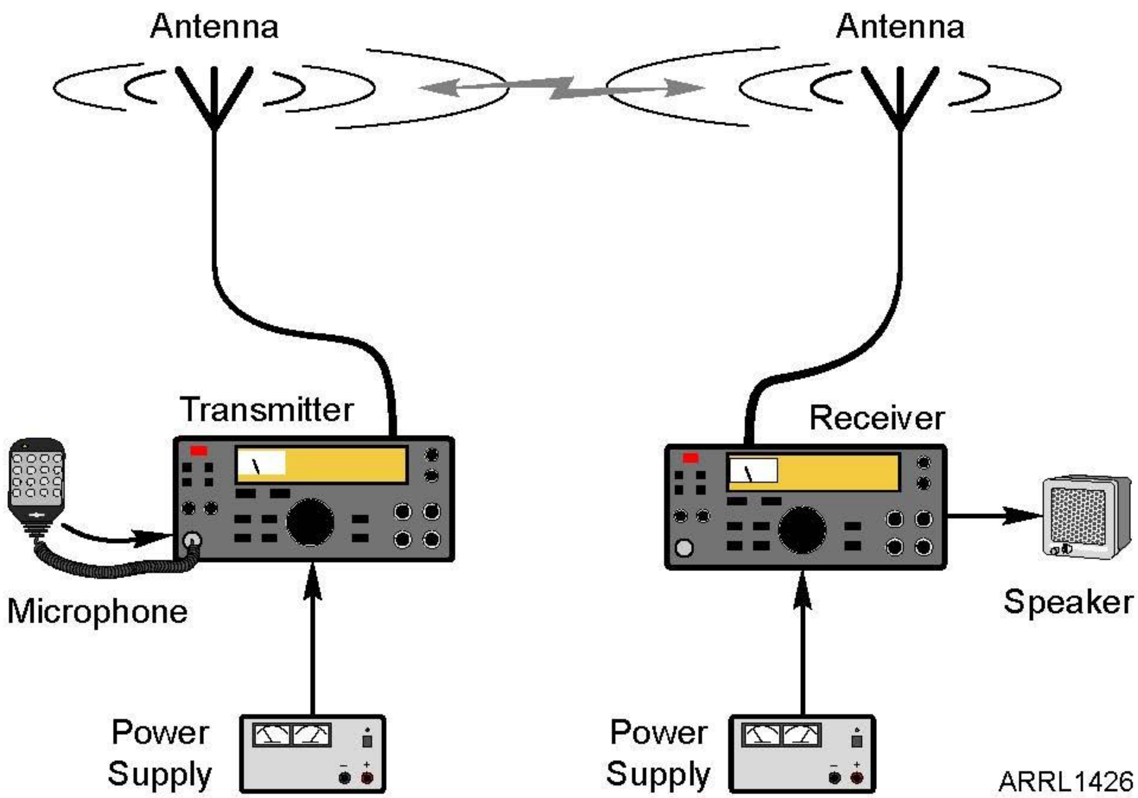
Let's communicate. You've already explored what it is like to communicate with someone relatively nearby. You might have played telephone or made a tin can telephone. Now it is time for even more fun! Let's learn about how people communicate over long distances. Let's find out how a radio really works. What does it need to work? Does it have special parts? Can anyone use it? How do they know what to do? In this section, you'll find out how people send messages via radio and what they might use the radios to do.

Before you leave this section and before you connect with some experts, see if you can list the parts needed for radio communication.

Topic 1. Radio equipment and radio signals

We commonly refer to radios as those boxes with speakers in our home or car that we use to receive local radio station broadcasts of music and news. What makes up a radio? Think about what a radio needs. When you want to use it you have to turn it on, so it must need power. Does your radio use a battery or plug into the wall? Somehow the "message" that was sent must get to your radio. Does your radio have a metal telescoping antenna that you can pull out, or a thin wire antenna? If you can't find one, your radio might have an internal antenna (like a cell phone has), or, in your car, it may be embedded around the windshield. The full name of your radio (the box you can pick up) is radio receiver. It is the part that receives the message that has been broadcast. The last part you'll need is a speaker (external speakers that sit somewhere in the room, small speakers like earphones or ear buds, or an internal speaker that is built into the receiver unit) so that you can listen when you turn on your radio.

But someone sent that message to you, right? That person turned on their power supply and used a microphone to turn their voice into electrical signals in their transmitter. The transmitter and its antenna changed the electrical signal to a radio wave carrying the voice information using a technique called modulation.



As we mentioned previously, there are basically two ways to modulate a radio signal to impose sound (audio) information, voices, and music. You can change the strength of the signal, which is called amplitude modulation or AM. Or you can change the frequency of the signal, which is call frequency modulation or FM. Television is a combination of AM (for the picture) and FM (for the sound). The receiving radio must be set up to receive the same kind of modulated signal that is being sent, and it must be tuned to the same frequency at which the signal is sent in order to receive the signal and extract (demodulate) the information (voice, music, picture) that was sent.

The radio signal carrying the information leaves the transmitter through the antenna. Some antennas send radio signals in all directions. Others are designed to focus the energy of the signal in only one preferred direction. This feature is called directivity. Have you seen an outdoor TV-receiving antenna? It looks a little like an arrow with the “sharp” end pointing toward the TV transmitter.

Radio communication can involve “line of sight” transmission of signals, which means the transmitter and receiver must be able to see each other to communicate. Relay stations, usually located on towers and high elevations, are used to overcome physical obstacles that may block signals (such as a mountain or tall building). They receive and resend signals to reach a wider area.

Environmental conditions at the point of transmission and reception of a radio signal and along its path affect the transmission of radio waves. Conditions in the atmosphere between the locations affect how far radio signals travel and obstacles in their path can block them. Signals at higher and lower frequencies respond differently to these conditions. The ability of radio waves to travel from one place to another is called “propagation.” There are many variables that affect propagation. Knowing how these variables affect transmission of signals at different frequencies is part of the “art” of radio communication.

Some radio waves can bounce off of the ionosphere to follow the contour of the Earth and send signals around the world. The ionosphere is a region of Earth's upper atmosphere, from about 37 miles to 620 miles above the Earth. Particles in this layer are ionized by solar radiation -- which is how it gets its name. Ionization of these particles plays an important part in atmospheric electricity and influences radio propagation to distant places on the Earth. (You can read more about ionization and the importance of the ionosphere to radio communications on Wikipedia.)

Also, other electrical signals can interfere with the signals carrying the message we want to hear and create noise. These are all factors that influence the ability to use radio to communicate in a particular situation, and the quality of the communications that can be achieved.

Connect Activity 1:

◊ Identify different types of radio receivers you see in your house and neighborhood. Make a list and share it with your troop.

AND

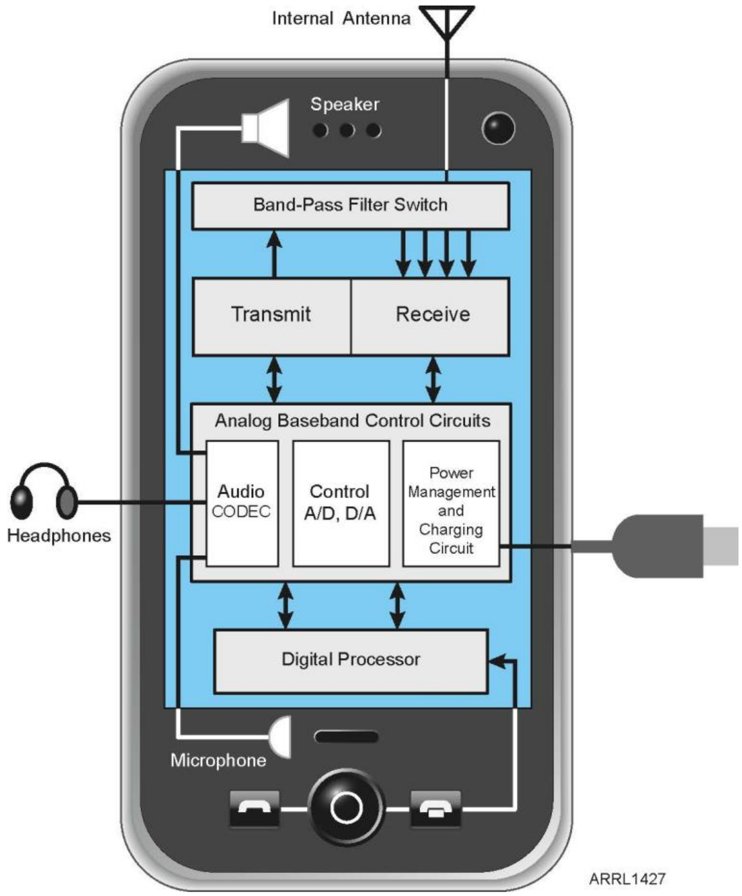
◊ Identify different types of transmitters you see in your environment. (Hint: look for hilltops, tall buildings, and towers.) Mark them on a map and show it to your troop.

AND

◊ Identify different types of antennas you see in your environment. Sketch different types and compare them with other sketches from other troop members.

Connect Activity 2:

◊ Look at this block diagram of a cell phone and identify the parts of a cell phone that identify it as a radio.



AND

Visit this website for an explanation of how a cell phone works:
http://cellphonerepairtutorials.blogspot.com/2010/04/learning-with-block-diagram-on-how.html

AND

Identify cell phone towers in your environment. Based on what you've learned about radio, what is their purpose? Discuss what you have learned with your advisor.

Connect Activity 3:

◊ Watch demonstrations of antenna directivity. You can see interesting demonstrations at http://makezine.com/2010/02/03/seeing-radio-waves-with-a-light-bul/. What kind of antenna is designed to focus radio signal energy in a particular direction? Explain what you saw to your advisor.

Connect Activity 4:

◊ Build a crystal radio/radio receiver. You can get a kit at your local science store or museum, or you might get ideas at http://sci-toys.com/scitoys/scitoys/radio/radio.html.

OR,

◊ You can build your own with instructions from this site: www.youtube.com/watch?v=VqdcU9ULAlA. Watch the related video for a detailed explanation of how the crystal radio works: https://www.youtube.com/watch?annotation_id=annotation_984279&feature=iv&list=PLFsZmHTZL-zlSltC6ELZW9PK4ks7wgPRz&src_vid=VqdcU9ULAlA&v=0-PParSmwtE

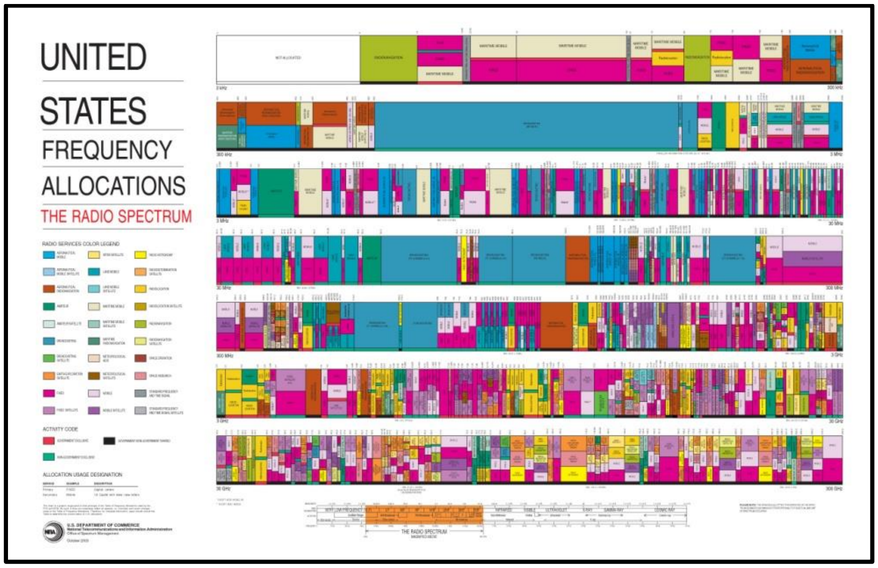
Connect Activity 5:

◊ Listen to broadcast radio station or short wave station at different times of day for several days. Is there a difference in quality of reception? What might explain the difference? Do the exercise that demonstrates the propagation of AM radio signals outlined by the NOAA lesson at http://www.srh.noaa.gov/jetstream/atmos/ll_ampm.htm. Discuss this with your advisor.

Topic 2. Radio activities

Remember, communication cannot happen without a "sender" and a "receiver" of the message. When you listen to your radio you are the receiver. Who is the sender? What do they do that generates information? What kind of information do they want to send? How do they send it? Using which part of the radio spectrum?

Governments all over the world have agreed upon which radio frequencies will be used, who will use them, and how they will be used. In the United States, the Federal Communications Commission (FCC) controls who can use what portion of the radio spectrum for what purpose. The chart below shows these "allocations."



You can view this chart and see all of its incredible detail online at: https://www.ntia.doc.gov/files/ntia/publications/spectrum_wall_chart_aug2011.pdf.

And remember, this is only one small part of the electromagnetic spectrum!

An international organization called the International Telecommunications Union (ITU) coordinates the use of the radio spectrum among countries around the world.

In the United States, the FCC gives authorization to transmit for a particular purpose using portions of the radio spectrum by issuing a license. Licensed transmitters are assigned a name by the FCC when they are issued their license. This name is a combination of letters, or letters and numbers, called a call sign.

Most transmitters are licensed to governments, companies, or organizations. They use them to conduct their business or approved activities.

There is a group of license holders who are not governments, companies, or organizations. They are *people*, just like you and me. They are called Radio Amateurs — and they live all around the world. Sometimes Radio Amateurs are called ham radio operators, or just "hams" for short. In the United States, they get their license to transmit from the FCC.

The FCC has defined some specific purposes for Amateur Radio:

The basis of the Amateur Service is to provide a radio service having a fundamental purpose as expressed in the following principles:	
[This is from the United States law called 47USC, Vol 5, Part 97.1.]	
(a) Recognition and enhancement of the value of the amateur service to the public as a voluntary noncommercial communication service, particularly with respect to providing emergency communications	**Volunteer service** (community service and disaster help). A Scout does a good turn daily — here's another way.
(b) Continuation and extension of the amateur's proven ability to contribute to the advancement of the radio art	**Experimentation**. If you want, you can build your own radio equipment or antennas. Some hams have made important inventions — some have even won Nobel prizes.
(c) Encouragement and improvement of the amateur service through rules which provide for advancing skills in both the communication and technical phases of the art.	**Communication skills**. Sometimes communication can be challenging; you learn to meet the challenge. And because only one person can talk at a time, you learn how to listen! **Technical skills**. A great way to start on a path to science, technology, engineering, or math. Or just to learn new things for the fun of it.
d) Expansion of the existing reservoir within the amateur radio service of trained operators, technicians, and electronics experts.	**Self-training**. You can learn by doing and become more skilled and a better citizen.
(e) Continuation and extension of the amateur's unique ability to enhance international goodwill	**International goodwill**. Make new friends and keep the old. One is silver and the other gold!

Radio amateurs are not permitted to use their license to transmit for commercial purposes. They operate for their own enjoyment and for the challenges of learning and exploring radio technology. They also provide a service to their community.

Radio Amateurs use their radios to talk to other amateurs all over the world, fostering long-distance friendships and international goodwill; amateurs also use their radios to participate in radio contests, such as the Thinking Day on the Air and the Jamboree on the Air; “fox hunts” are fun events where the ham has to find a hidden transmitter. On a more serious note, ham radio operators volunteer their radio skills and equipment to help their communities in times of need. Amateurs provide needed communications to ensure the safety of public events and to help deal with disasters.

Connect Activity 6:

◊ Learn more about the call sign identification system used in the Amateur Radio Service. Investigate the call sign system for identification of radio operators and stations and license classes used in the United States and around the world. What are the current FCC license classes for ham radio operators in the United States? Do you know any ham radio operators in your community? If so, what are their call signs? (If you know their names, you can use the call sign lookup on the ARRL website at www.arrl.org to look them up.) All licensed transmitters (Radio amateurs as well as commercial broadcasters) are required to identify themselves on the air using their assigned call sign. Can you say the call signs of the local hams you found using the phonetic alphabet? How can you tell if a ham is licensed in the United States?

Refer to the FCC and ARRL websites at the online resources for this information:
http://wireless.fcc.gov/services/index.htm?job=about_3&id=amateur

http://wireless.fcc.gov/services/index.htm?job=call_signs_1&id=amateur

http://www.arrl.org/international-call-sign-series

AND

◊ Review an Amateur Radio Band chart that describes the frequencies where hams can operate. http://www.arrl.org/files/file/Regulatory/Band%20Chart/Hambands_color.pdf
Notice the various notches in the radio spectrum where hams with different license privileges can transmit.

Connect Activity 7

◊ Look at a United States Radio Spectrum Allocation chart. (You can find a chart at http://www.ntia.doc.gov/files/ntia/publications/spectrum_wall_chart_aug2011.pdf that will be easy to read.) What are “services” and what do they do? With your advisor, identify some of the radio frequencies where the following services are assigned:

- Aeronautical (aviation and air traffic control)
- Amateur Radio
- Broadcasting (AM and FM radio, TV)
- Cell phone
- Land (public service, police and fire, taxis)
- Maritime
- Radiolocation and Radio navigation (GPS, radar)
- Space operations

Connect Activity 8:

◊ Radio and television broadcasters also have licenses to transmit on parts of the radio spectrum. They may be commercial (money-making) or non-commercial. They have a purpose or format to communicate a particular kind of content, such as music or news, through broadcast (one-way communication) or to target a particular audience of listeners/viewers in a particular coverage area. Visit the offices of a broadcast radio or TV station to learn more about it. What is the station’s FCC license identification? How do they define the station’s format/purpose and their target audience or coverage area? What radio equipment can you identify as you tour the station? What power output do they use for transmission? What frequency? Tell the other members of your troop what you learned.

Connect Activity 9:

◊ Ask a local Amateur Radio operator or Amateur Radio club for a demonstration of a ham radio station. While you are there:

- Identify different types of equipment and what each is used for.
- Ask for an explanation of the different types of equipment and techniques for carrying a voice message, a Morse code message, and a digital message.
- Ask for demonstrations of different types of modulation techniques, such as voice (AM, FM, SSB), Morse code, and digital communications.
- Identify different types of antennas and what they are used for.
- Listen for examples of noise and interference.
- Listen for use of the phonetic alphabet.
- Ask about propagation and other variables that affect communication using Amateur Radio.
- Find out how a ham knows where to operate in the spectrum.
- Get on the air to make contacts using ham radio procedures and customs. Using proper call signs, Q signals, and abbreviations, carry on a real or simulated ham radio contact using voice, Morse code, or digital mode. Properly log the real or simulated ham radio contact and record the signal report.
- Ask to see some of the QSL cards the ham or club has received from contacts made around the world.

Connect Activity 10:

◊ Participate in an Amateur Radio on-the-air operating event such as Girl Scout/Guides Thinking Day on the Air, World Scouting Jamboree on the Air, or the ARRL Kids Day. Report to your troop on it.

Here's where you can find more information about these activities:

http://www.guides-on-the-air.co.uk/

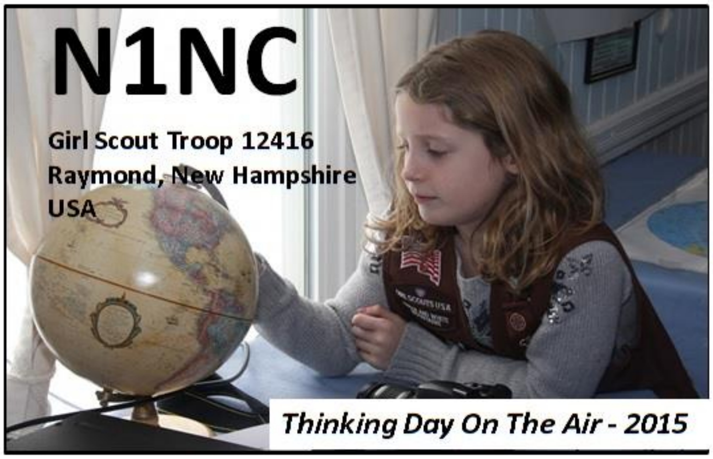
http://jotajoti.info/ and http://www.arrl.org/jamboree-on-the-air-jota

http://www.arrl.org/kids-day

OR

◊ Visit an amateur radio in-the-field operating event such as Field Day. Get on the air if an appropriate opportunity is available, and observe the activity and report to your troop on it.

Find more information about Field Day here: http://www.arrl.org/field-day



OR

◊ Ask a local Amateur Radio club to arrange a foxhunt. Participate in or observe the activity and report to your troop on it.

OR

◊ Ask for a demonstration of an Amateur Radio satellite contact. Ask for an explanation of how the antenna is pointed to communicate with the satellite.

Topic 3. Wireless utilities

How can you find your way in a familiar place? Could you explain to someone else how to find her way? What if you were in an unfamiliar place, like a trail you hadn't hiked before — how would you find your way then?

When you give someone directions to your house, you might say, "Go down the street until you get to the blue house." Or you might mention a store or traffic signal. If you are out in the woods and had to give directions to a site you might not want to say, "Go to the big tree." That could get rather confusing. If you have a GPS receiver you could mark the location of specific landmarks, like the big tree, and then give that GPS list to someone so that they could navigate through the woods. When people use a GPS receiver to navigate they don't look for landmarks but use the GPS receiver to process radio signals from satellites to determine their position.

When people say GPS, they are using initials that mean Global Positioning System. In the US, the Global Positioning System is a group of at least 24 satellites that orbit the earth. They are known as a constellation, just like a group of stars is called a constellation. Each satellite sends a radio signal towards the earth that tells the location of the satellite and the exact time. It also sends its name (a code that allows the receiver to tell which GPS satellite that this radio signal is from). If you have a handheld receiver, or GPS in your vehicle, or in another product you can use it to calculate your location. Your receiver compares the information sent on the radio signals from four satellites to figure out your latitude, longitude, elevation, and local time. (Here's a surprise few people know: a GPS receiver itself only calculates your position. All the other features and maps in your device were included by the people who made the product.)

By learning a few steps from your GPS receiver's instruction book, you can figure out your location. Every manufacturer develops equipment with special features, but just like other devices you have used, there will be some features that you can expect. For instance, there will be an on switch, a screen, an antenna, and probably ways to select the functions you need. Just like any radio, you need to make sure that the antenna can "see" the sky and the satellites from the constellation that is above your horizon. That means you probably won't be able to use the receiver indoors. You'll also have better luck if you are not under trees or deep in valleys.

Receivers have memory functions that allow them to store positions for use later. Yours might be able to store multiple positions. Once the receiver has acquired the signals from four satellites it will display your current position. Shortly, you will be able to use the 3-D navigation function. When you get to a location that you want to remember (that big tree!), you can mark it as a “waypoint” and save it in your receiver’s memory. While you walk, your GPS receiver will keep track of your path and it will show it as a “track” on the screen. You can make a map showing the waypoints you have saved along your track.

Connect Activity 11:

◊ Obtain a GPS receiver and manual. Practice using a GPS Receiver. Learn the functions and features available for that unit. Receive radio signals from the satellites and walk while monitoring your progress on the receiver. Store waypoints and tracks. View a map of your progress, and use GPS to guide you back to each waypoint and back to your “home base.”

AND do one of the following:

> ◊ Nazca Drawings — Use a GPS receiver to make maps similar to the Nazca drawings found in South America or a corn maze. Using the memory function, walk a track and mark waypoints to write a letter, word, or simple picture. Display the “drawing” on your screen.
>
> OR
>
> ◊ GPS Scavenger Hunt — Set a track with a designated number of waypoints to find. Swap receivers with another patrol. Have the other patrol record on paper (or in a “note” function) what they find at each waypoint.
>
> OR
>
> ◊ If you haven’t completed the Geocaching Junior Girl Scout badge, find out about this hobby and try it. Participants use a Global Positioning System receiver or mobile device and other navigational techniques to hide and seek containers, called "geocaches" or "caches," anywhere in the world. You can read about it on Wikipedia or at www.geocaching.com.

SECTION 3: FIND OUT ABOUT WIRELESS CAREERS AND TAKE ACTION TO HELP IN YOUR COMMUNITY

Help communicate. You know much more information today than you did when you began exploring wireless communication. Take a little time to reflect upon what you have discovered about communication and how you connected with radio experts to learn even more. Now it is time to apply your newfound knowledge and skills. Explore careers related to wireless communication; find a way to help in your community, and bring your knowledge back to your troop by teaching others.

Topic 1. Wireless technology in careers

Take Action Activity 1:

◊ Careers in telecommunications (cell phone networks, broadcast engineers, cable and Internet providers) require extensive knowledge of radio technology. Identify people in your community who have careers in the telecommunications industry or whose job it is to provide wireless communications. Take time to find out how these people became interested in their careers. Was it because of a hobby or personal interest? What kind of training did they need? How could they mentor you? (If you took the Junior Muse Journey, use the interview skills that you learned then to explore wireless careers.)

Take Action Activity 2:

◊ Wireless communication is an important tool in many careers. Identify people in your community who use wireless communications to carry out their work tasks and use it to make the world a better place. With other troop members, visit professionals in their work settings to see how they use their wireless communication tools. Which portions of the spectrum do they utilize? How would their job be affected if there wireless communication tools were disabled? Host a panel discussion so that your troop can interview the experts you have found.

Host a career day for your troop (perhaps inviting adult communicators to tell you about their jobs) to show what you learned.

- Utility workers
- Science researchers, astronomers, planetarium docents
- Ozone or habitat health monitoring citizen science groups
- Retailers, warehouse managers/distributors: inventory control
- Medical workers: doctors, radiology technicians, radiation and oncology treatments
- Air traffic controllers and pilots
- Police, fire fighters, and first responders
- Military
- Radio personalities, hosts, or commentators, meteorologists, television newscasters

Topic 2. Radio activities in hobbies and public service

Communication failure is a part of modern disasters that communities try to avoid. Recent storms and other natural disasters have caused communication failures. What disasters affected you recently? What disasters have you heard about? In many large scale disasters that affect neighborhoods, towns, or larger communities people have trouble finding information so they can get medical attention, shelter, and food. Most importantly, they have a hard time communicating with family outside the affected area. Communication plans can help all of these situations.

SKYWARN and CERT are two organizations found in the United States. SKYWARN is part of NOAA, the National Oceanic and Atmospheric Administration. CERT is part of FEMA, the Federal Emergency

Management Agency. Why are these two groups important? Why are they part of their larger associations? Find out online. What groups are organized near you? What do they do to help in emergencies? You can find out information about these groups at http://skywarn.org/ and www.citizencorps.fema.gov/cc/CertIndex.do?submitByState.

Take Action Activity 3:

◊ Recall a personal experience in which cell phone communication failed. What kind of problems did this cause for you and your family? What would happen in your life if your family lost telephone communication and electrical power for a week? Design a communication plan for your family, Scout group, or community (check at your town's Safety Complex to see what the Disaster and Emergency Preparedness Team has devised) that you could put in place when the everyday communications system is down.

Take Action Activity 4:

◊ Contact your local CERT, find out about their activities, and volunteer your services.

OR

◊ Listen to a SKYWARN net or a recording of one. Find out what SKYWARN groups exist in your area and volunteer your services.

Take Action Activity 5:

◊ Attend a high altitude balloon launch. Observe how the balloon is tracked. Check with a local school, university, planetarium, or ham radio club to find out if a launch is scheduled. Help out at the next launch.

OR

◊ Attend a parade, bike or road race for which hams are providing communication. Tag along to find out what they do and see how you can help.

Take Action Activity 6:

◊ Study for a ham radio license. (Better yet, make it a team effort. Find others in your community who might be interested in studying with you!) Report to your troop on what you learned and on your progress after one week, one month, and two months.

Topic 3. Helping in the troop

Communication success… You know all about it now! You need to figure out what message you want to send and the audience to whom you want to send it. Then find a way to send it. If you hold a license from the FCC, you can send that message via Amateur Radio. If you have an account with a telephone company you can use your phone. Maybe you don't have to communicate long distance; you still need to find a way to communicate your message clearly, without interference, to an audience nearby. We've communicated with you by writing this Patch Program. You've communicated with experts when you made arrangements to meet and talk about wireless communication.

Take a few minutes to look back over this pamphlet and see all that you have accomplished. Reflect upon the activities you have completed, the information you have learned, and the fun that you have had. Which topics excited you most? Which activities taught you something that you didn't know before? How could you communicate what you have learned?

Take Action Activity 7:

◊ Choose two or more topics from Section One: Discover Communication and teach them to younger Scouts or another community group.

AND

◊ Write a news article about your workshop to submit to your Council. With your troop and advisors, discuss what forms of communication you should use to publish your article—paper, radio, television, or social media—and do it.

Take Action Activity 8:

◊ Choose a topic from Section Two: Connect with Radio Operators and Their Technology and create a video about that topic. Share what you've done on any social media outlets you decide are appropriate. Share it with ARRL!

AND

◊ Send your video (or a link to your video) to your council and to the American Radio Relay League Education Office (at www.arrl.org).

RESOURCES

American Radio Relay League, Inc. www.arrl.org.

Outreach to Youth: www.arrl.org/outreach-to-youth

Youth Activities: www.arrl.org/youth

Search our database to find local Amateur Radio clubs at www.arrl.org/find-a-club

Find educational resources and lesson ideas at: www.arrl.org/etp-classroom-resources

Call signs and license classes:

http://wireless.fcc.gov/services/index.htm?job=about_3&id=amateur

http://wireless.fcc.gov/services/index.htm?job=call_signs_1&id=amateur
http://www.arrl.org/international-call-sign-series

Amateur Radio Activities

Thinking Day on the Air (TDOTA) is an opportunity for members to talk to other members of the World Association of Girl Guides and Girl Scouts all over the world via Amateur Radio. www.guides-on-the-air.co.uk/.

The Boy Scout Jamboree on the Air (JOTA) is an annual Scouting event that uses amateur radio to link Scouts around the world, around the nation, and in the community. www.scouting.org/jota.aspx.

ARRL Kids Day is designed to give on-the-air experience to young people and hopefully foster interest in getting a license of their own. It is also intended to give older hams a chance to share their station and love for Amateur Radio with their children. www.arrl.org/kids-day.

ARRL Field Day challenges Amateur Radio operators and their clubs to work as many stations as possible to learn to operate in abnormal situations in less than optimal conditions. www.arrl.org/field-day.

What is an Electric Field? Www.physics4kids.com/files/elec_field

More about telecommunication: https://en.wikipedia.org/wiki/Telecommunication

Electromagnetic Spectrum

NASA's description of the Electromagnetic Spectrum and frequency and wavelength:
http://imagine.gsfc.nasa.gov/science/toolbox/emspectrum1.html

Download this document provided by NASA that explains in detail how the various parts of the electromagnetic spectrum are used: http://missionscience.nasa.gov/ems/TourOfEMS_Booklet_Web.pdf.

Watch NASA's video Tour of the Electromagnetic Spectrum (approx. 32 minutes): http://missionscience.nasa.gov/ems/emsVideo_01intro.html

Make a compass http://oceanservice.noaa.gov/education/for_fun/MakeyourownCompass.pdf

Make an electromagnet: http://www.wikihow.com/Make-a-Magnet.

Semaphore signals: https://en.wikipedia.org/wiki/Flag_semaphore

You can practice Morse code by going to http://boyslife.org/games/online-games/575/morse-code-machine/.

How to make a Morse code bracelet: http://makezine.com/2015/01/16/diy-morse-code-bracelets/

There are many online applications for learning and practicing Morse code. You'll find some listed at: http://www.arrl.org/learning-morse-code

The Boy Scouts of America Radio Merit Badge addresses some of the same topics. The Radio Merit Badge curriculum offers additional ideas and more explanation on some topics: http://www.scouting.org/filestore/Merit_Badge_ReqandRes/Radio.pdf

Other resources listed on the BSA Radio Merit Badge Resource page may also be useful http://www.scouting.org/jota/radio_merit_badge.aspx

APPENDIX

The Phonetic Alphabet

Letter	Pronunciation	Letter	Pronunciation	Number	Pronunciation
A	Alfa (AL fah)	N	November (no VEM ber)	0	ZEE row
B	Bravo (BRAH VOH)	O	Oscar (OSS cah)	1	WUN
C	Charlie (CHAR lee)	P	Papa (pah PAH)	2	TOO
D	Delta (DELL tah)	Q	Quebec (keh BECK)	3	TREE
E	Echo (ECK oh)	R	Romeo (ROW me oh)	4	FOW er
F	Foxtrot (FOKS trot)	S	Sierra (see AIR rah)	5	FIFE
G	Golf (GOLF)	T	Tango (TANG go)	6	SIX
H	Hotel (hoh TELL)	U	Uniform (YOU nee form)	7	SEVEN
I	India (IN dee ah)	V	Victor (VIK tah)	8	AIT
J	Juliet (JEW lee ETT)	W	Whiskey (WISS key)	9	NINE er
K	Kilo (KEY loh)	X	X Ray (ECKS RAY)		
L	Lima (LEE mah)	Y	Yankee (YANG key)		
M	Mike (MIKE)	Z	Zulu (ZOO loo)		

The Morse Code

Morse code is a way of sending text information as a series of tones, light flashes, or clicks. We call the short tones or flashes dots and the long ones dashes. A dash is three times as long as a dot. The time between dots and dashes is as long as a dot. The time between letters is as long as three dots.

When we speak Morse code sounds we say the words "dit" for a dot and "dah" for a dash. (We usually leave off the "t" to make a set of dits easier to speak.)

A	• —	dit-dah *or, di-dah*
B	— • • •	dah-di-di-dit
C	— • — •	dah-di-dah-dit
D	— • •	dah-di-dit
E	•	dit
F	• • — •	di-di-dah-dit
G	— — •	dah-dah-dit
H	• • • •	di-di-di-dit
I	• •	di-dit
J	• — — —	di-dah-dah-dah
K	— • —	dah-di-dah
L	• — • •	di-dah-di-dit
M	— —	dah-dah
N	— •	dah-dit
O	— — —	dah-dah-dah
P	• — — •	di-dah-dah-dit
Q	— — • —	dah-dah-di-dah
R	• — •	di-dah-dit
S	• • •	di-di-dit
T	—	dah

U	• • —	di-di-dah
V	• • • —	di-di-di-dah
W	• — —	di-dah-dah
X	— • • —	dah-di-di-dah
Y	— • — —	dah-di-dah-dah
Z	— — • •	dah-dah-di-dit
1	• — — — —	di-dah-dah-dah-dah
2	• • — — —	di-di-dah-dah-dah
3	• • • — —	di-di-di-dah-dah
4	• • • • —	di-di-di-di-dah
5	• • • • •	di-di-di-di-dit
6	— • • • •	dah-di-di-di-dit
7	— — • • •	dah-dah-di-di-dit
8	— — — • •	dah-dah-dah-di-dit
9	— — — — •	dah-dah-dah-dah-dit
0	— — — — —	dah-dah-dah-dah-dah

Mr Morse's code actually had dots, pauses, dashes, long dashes. It was replaced by the International Morse Code that is shown in the chart above.