Radio Merit Badge

Welcome

HamRadioSchool.com is happy to help you earn your *Radio Merit Badge*! Radio is a fascinating science, hobby, and career choice. Learning to use radios for two-way communication can help you be prepared for emergencies by providing reliable communications when telephone systems fail or where they do not reach. You can even use radio to communicate from remote areas when backpacking or camping, and participate in many other fun and valuable activities in your community!

The Radio Merit Badge was first offered way back in 1919. Radio technology and use has grown quite a lot since those days, and this site will help you to learn all about it. This site will help you get a good introduction to radio while earning your merit badge, but don't stop there! With just a little more study you can earn your FCC Amateur Radio Technician License and become a ham radio operator, able to talk around the world with other operators. It's a lot of fun, so let's get going!

Let's Get Going!

Here's how to get started with your Radio Merit Badge:

1. You should get a copy of the newest Radio Merit Badge pamphlet, the 2008 color edition. It has very good information about radio and the merit badge requirements. Use it along with this web site to really understand radio!

2. Be sure that your troop or your Scoutmaster has connected you with a Radio Merit Badge Counselor in your area. Frequently the merit badge counselor will be a licensed amateur (ham) radio operator who is affiliated with your troop or with the local council. You or your Scoutmaster may contact a local amateur radio club to find a volunteer counselor for you if one is not already available.

3. Also be sure that you print a copy of the Radio Merit Badge workbook that provides an outline of the requirements and space to write about the requirements as you learn from this web site and the Radio Merit Badge pamphlet. Here is a link to the Radio Merit Badge workbook.

4. This web site has some links to other web sites that we do not control. Make sure that your parents approve of you going to those other internet sites before starting. We link to those other sites because they provide excellent explanations and additional learning materials that will help you to better understand radio.

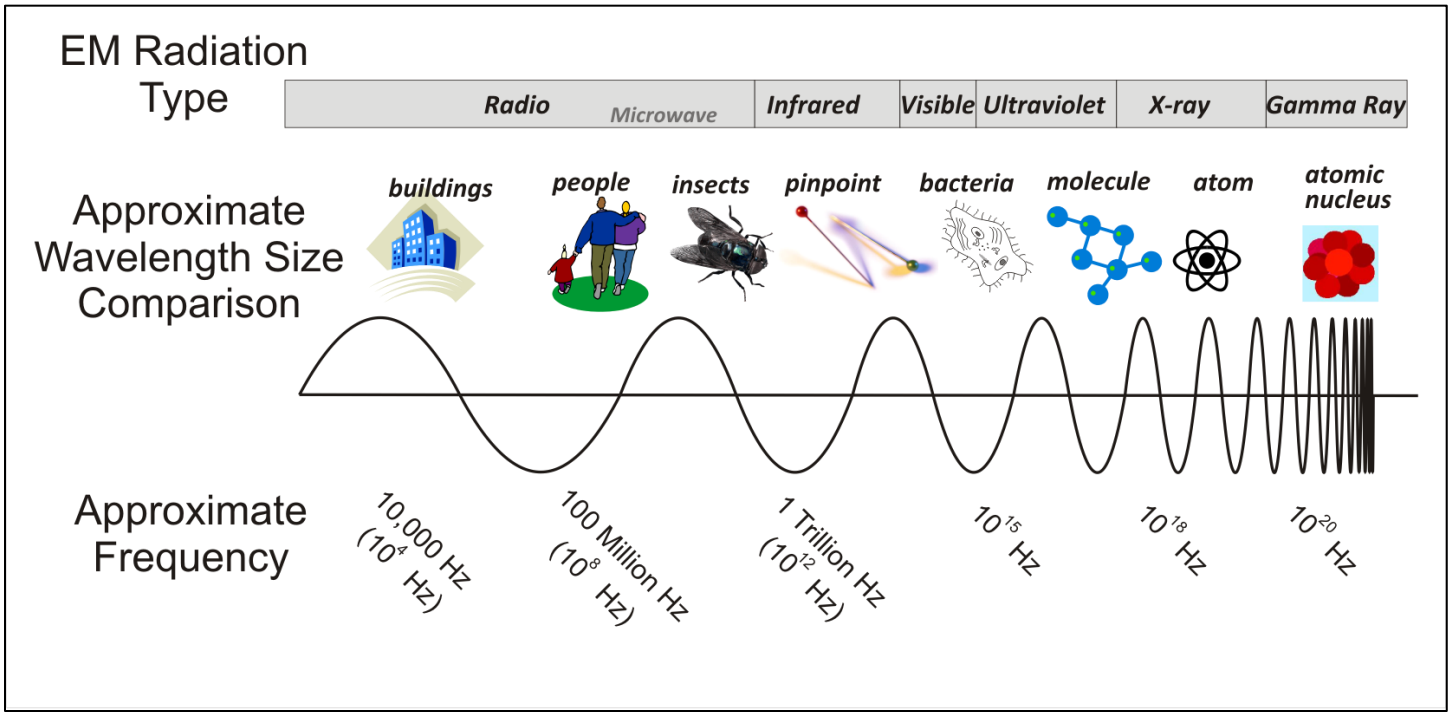
Ready? Get your materials together and *let's get going!*

Requirement 1

1. Explain what radio is. Then discuss the following:

- **a. The differences between broadcast radio and hobby radio.**
- **b. The differences between broadcasting and two-way communications.**
- **c. Radio station call signs and how they are used in broadcast radio and amateur radio.**
- **d. The phonetic alphabet and how it is used to communicate clearly.**

Radio uses electromagnetic waves that are sent through the air to communicate and send messages between stations. Radio waves are much like light waves, only the radio "waves" are much longer than the waves we can see as visible light. Radio waves are emitted from an antenna whenever an electric current is sent back-and-forth through the antenna at a very fast rate, usually many thousands or many millions of back-and-forth cycles each second! The rate, or frequency, of the electric current cycles through the antenna determines the frequency of the radio wave cycles.



A Comparison of the Electromagnetic Spectrum of Waves, from Radio Waves to Visible Light to Gamma Rays

Related fun Links from *HamRadioSchool.com*:

Video: Radio Wave Polarization with a Light Bulb!

Video: See a Radio Antenna's Power with a Light Bulb!

Text: Read more about radio wavelength and frequency!

Radio waves can carry messages in different ways. The radio waves can be turned on and off in patterns, such as Morse Code patterns. The on-off patterns of Morse Code represent letters, numbers, and punctuation, so that a message can be sent. Radio waves can also change in power (amplitude) or frequency to encode the sounds picked up by a microphone. A voice or music may be transmitted by radio waves in this way. The way that a message is encoded into a radio wave is called the *modulation* method, or the *mode* of transmission.

Audio: Hear sounds of different *modes* of transmission! [*From HamRadioSchool.com*]

Broadcasting is the one-way transmission of radio signals for many people to receive and hear all at once, without a radio message coming back from any of those people. The AM and FM radio stations that you may listen to in a car are broadcast stations. **Hobby radio is usually two-way communication between people and using much lower power levels than broadcast radio stations.** Amateur radio, or "ham radio," is hobby radio that people use to communicate with one another in back-and-forth, two-way conversation. Police and fire officers also use two-way communication by radio to stay in touch with one another, and airplanes, boats, and spacecraft also use two-way radio communications.

A call sign is a special name for a radio station that is used to identify the station from all others in its radio transmissions. In the US, all radio stations that must have a license must also have a call sign. Broadcast station call signs are usually 3 or 4 letter names, such as WABC or WGN. Ham radio call signs have different formats that include a number that tells the region of the country in which the station was licensed. Ham call signs look like these: K2BSA, WØSTU, W1AW, KF5CLZ, KB4SA.

A phonetic alphabet uses special words to identify a call sign letter. Radio communications are sometimes noisy and unclear. Many letters of the alphabet sound similar, such as C, D, E, G, P, T, and Z. To help receiving stations understand a call sign in noisy conditions, a phonetic alphabet may be used by transmitting operators. So, the call sign K2BSA would be transmitted as "Kilo, Two, Bravo, Sierra, Alpha."

The standard phonetic alphabet used by radio operators is listed below along with a link to a *HamRadioSchool.com* sound recording of the entire phonetic alphabet. Audio: Hear the Phonetic Alphabet [*From HamRadioSchool.com*]

A – Alpha	***J – Juliet***	***S – Sierra***
B – Bravo	***K – Kilo***	***T – Tango***
C – Charlie	***L – Lima***	***U – Uniform***
D – Delta	***M – Mike***	***V – Victor***
E – Echo	***N – November***	***W – Whiskey***
F – Foxtrot	***O – Oscar***	***X – X-Ray***
G – Golf	***P – Papa***	***Y – Yankee***
H – Hotel	***Q – Quebec***	***Z – Zulu***
I – India	***R – Romeo***	

The International Telecommunications Union
Standard Phonetic Alphabet

You can learn more about amateur radio, on-air procedures, phonetics, and more in the HamRadioSchool.com Technician License Course book and web site!

Requirement 2

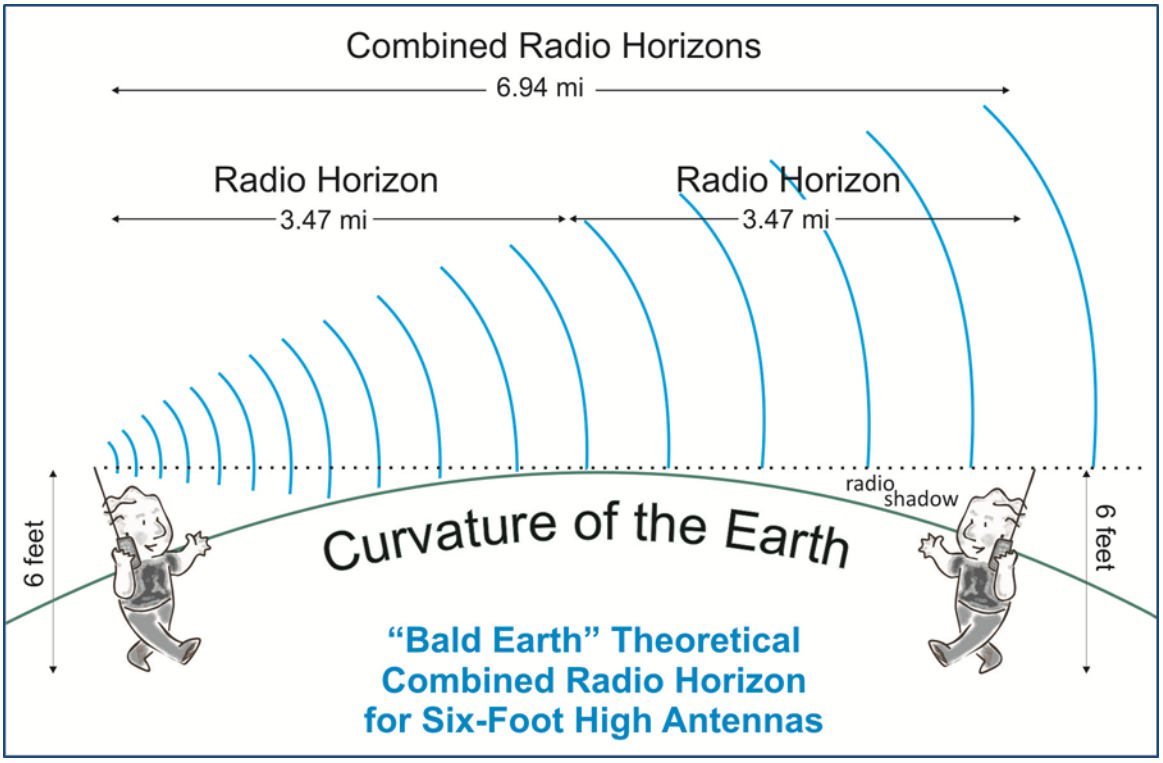
2. Do the following:

a. Sketch a diagram showing how radio waves travel locally and around the world. Explain how the broadcast radio stations WWV and WWVH can be used to help determine what you will hear when you listen to a shortwave radio.

b. Explain the difference between a DX and a local station. Discuss what the Federal Communications Commission (FCC) does and how it is different from the International Telecommunications Union.

Radio waves travel by three main methods: 1) Line of sight, 2) Sky wave reflection, and 3) Ground wave. The method of travel, or *propagation,* is determined mostly by the frequency of the radio wave.

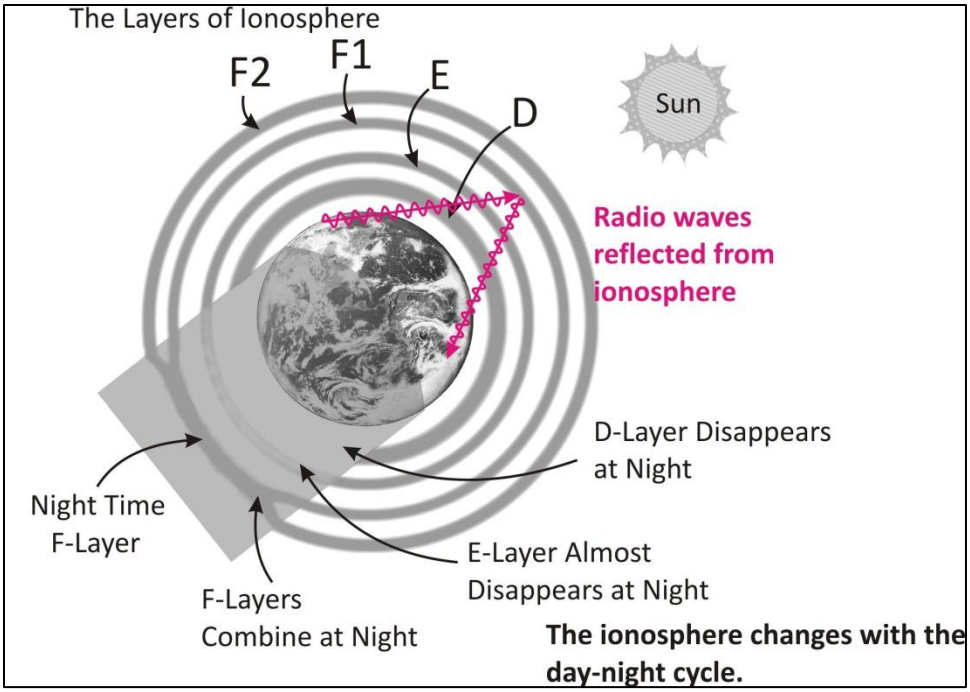
1. **Line of Sight:** Some radio frequencies that have very high wave cycle rates, or frequency, tend to travel in straight lines without being affected much by the atmosphere. We say these radio frequencies travel "line of sight" because they travel approximately the same straight line distances as we can see around us. These radio frequencies will travel in straight lines toward the horizon until they are blocked by the curvature of the earth or by buildings, rocks, mountains, or other obstacles in their path. These frequencies will also travel upward through the atmosphere and into space, never to return to earth! So, usually these frequencies cannot be used very well to communicate long distances over the horizon without some kind of relay radio station to repeat the signals a greater distance. These *Very High Frequency*, or *VHF* signals and their higher frequency cousins *Ultra High Frequency (UHF)* and even higher *Microwave Frequencies*, cycle 30 million times per second (30 million *hertz, or 30 MHz*) or greater! So, VHF and higher frequencies usually travel *line of sight*. Click for more about **line of site radio communications** from HamRadioSchool.com.



Line of Sight Travel Limit: Any further and the radio waves are blocked by the earth's curvature!

2. **Sky Wave Reflection:** Some radio frequencies that are referred to simply as *High Frequency (HF)* can be reflected by special layers of the high atmosphere. These signals are also sometimes called *shortwave* radio frequencies. The sun's energy creates electrically charged particles called *ions* in various layers up to 250 miles above the earth! These layers of charged particles are called the *ionosphere*. The ionosphere can act like a mirror to HF radio signals, bending them back toward the earth. The earth itself may reflect the signals back into the sky where the ionosphere can again bend them earthward! With one or more of these signal bounces or "skips" between sky and earth, HF signals can travel over the horizon hundreds or thousands of miles, even propagating all the way around the world when conditions are right! These kinds of signals become very weak as they travel and bounce, so this is sometimes called *weak signal propagation*. Ham radio operators often use HF frequencies to make radio contacts around the world by sky wave reflection.

   The HF region of radio frequencies is from 3 to 30 million hertz (3-30 MHz). Radio frequencies lower than the HF region (less than 3 MHz) are also commonly reflected by the ionosphere, and the commercial broadcast AM radio band in the US falls into this category, extending to as low as 550 thousand hertz (550kHz, or 0.55 MHz). This is why you can sometimes receive AM stations from great distances.



3. **Ground Wave:** Radio waves with frequencies lower than 3 MHz can travel along the earth's surface for hundreds of miles, hugging the curvature of the earth. These are called *ground waves*. The commercial AM broadcast frequencies may propagate by ground wave as well as sky wave reflection.

Stations WWV and WWVH are US government radio stations that broadcast precise time and frequency information 24 hours per day, 7 days per week, on several HF (and lower) frequencies. WWV is located in Fort Collins, Colorado. WWVH is located in Hawaii. These stations broadcast time signals on 2.5, 5.0, 10.0, 15.0, and 20.0 MHz, so radio operators can tune into these HF frequencies to see how well those frequencies are being reflected by the ionosphere. If the signals from WWV and WWVH are strong, the ionosphere is likely reflecting well and shortwave signals may be easily heard from those locations and perhaps many others.

Link: More information about WWV

Link: More information about WWVH

Hear what the WWV transmission sounds like: **WWV**

DX and Local Stations: A DX station is a station at a far distance, usually in another country from your own. Local stations are close by, and certainly inside the US. The term "DX" is a Morse Code shortcut for the word *distance*. Ham radio operators are commonly interested in making contact with DX stations, outside of the US.

The FCC is the Federal Communications Commission, the branch of the US government that administers the use of radio frequencies and that issues radio licenses inside the United States. The ITU is the *International Telecommunications Union*, an agency of the United Nations that helps coordinate radio communications and the use of frequencies among the world's nations and territories.

You can learn more about radio waves in Chapter 4 of the HamRadioSchool.com Technician License Course book!

You can learn more about radio signal propagation in Chapter 5 of the HamRadioSchool.com Technician License Course book!

You can learn more about the FCC and the ITU in Chapter 2 of the HamRadioSchool.com Technician License Course book!

Requirement 3

3. Do the following:

a. Draw a chart of the electromagnetic spectrum covering 100 kilohertz (kHz) to 1,000 megahertz (MHz).
b. Label the MF, HF, VHF, UHF, and microwave portions of the spectrum on your diagram.
c. Locate on your chart at least eight radio services, such as AM and FM commercial broadcast, citizens band (CB), television, amateur radio (at least four amateur radio bands), and public service (police and fire).

Let's chart the spectrum by frequency regions mentioned in requirement 2. We'll look at the following:

Medium Frequencies (MF) – 300 kHz to 3 MHz

High Frequencies (HF) – 3 MHz to 30 MHz

Very High Frequencies (VHF) – 30 MHz to 300 MHz

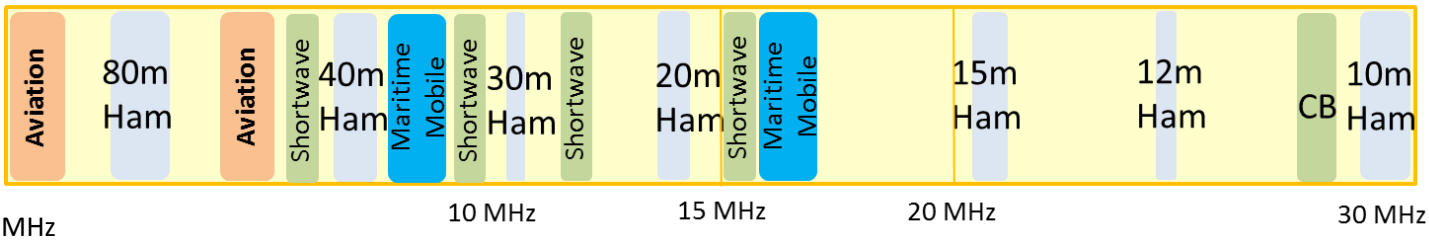
Ultra High Frequencies (UHF) – 300 MHz to 3000 MHz

Medium Frequencies (MF) of 300 kHz to 3 MHz tend to follow the earth's surface as ground waves for hundreds of miles, but they may also be reflected from the ionosphere as sky waves. Commercial AM broadcast frequencies and one ham frequency band are found in the MF region of the radio spectrum.

Medium Frequency Region of Radio Spectrum

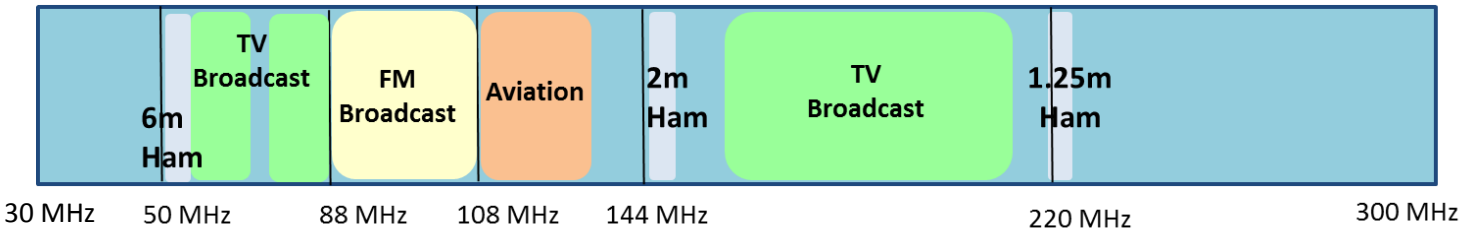
High Frequencies (HF) of 3 MHz to 30 MHz tend to be reflected by the ionosphere as sky waves and may travels thousands of miles around the globe. Many of the shortwave and ham frequency bands are in the HF region of the radio spectrum, as well as the citizen band (CB) radio frequencies.

High Frequency (HF) Region of Radio Spectrum



Very High Frequencies (VHF) of 30 MHz to 300 MHz travel "line of sight" as described in requirement 2. The FM radio and television commercial broadcast frequencies are in the VHF region, along with three popular ham frequency bands. Police, Fire, and aviation frequencies are also found in the VHF region.

Very High Frequency (VHF) Region of Radio Spectrum



Ultra High Frequencies (UHF) of 300 MHz to 3000 MHz also travel "line of sight." Like VHF, these frequencies do not bounce from the ionosphere and are very good for communicating with spacecraft and satellites. The UHF region also includes a broad television band and some public service radio frequencies for Police and Fire. Some cellular telephone frequencies are UHF, and a popular ham radio band (440 MHz / 70 cm band) is in the UHF region of the spectrum.

Ultra High Frequency (UHF) Region of Radio Spectrum

See the full United States Frequency Allocations chart of radio spectrum.

See the ARRL Amateur Radio Band Allocations chart.

You can learn more about radio frequencies in the HamRadioSchool.com Technician License Course book, Chapter 4 and Chapter 5.

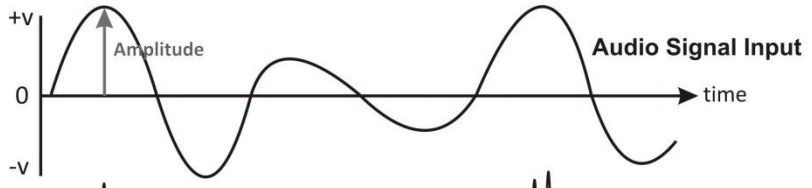
Requirement 4

4. Explain how radio waves carry information. Include in your explanation: transceiver, transmitter, receiver, amplifier, and antenna.

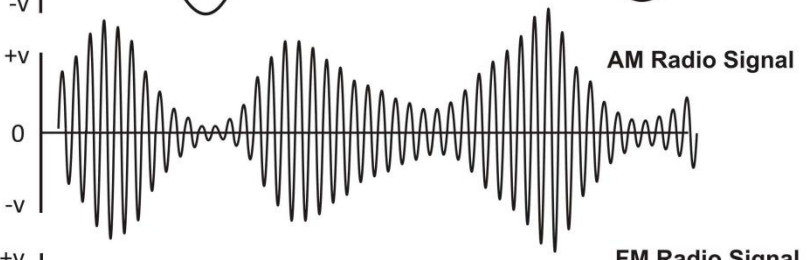
Radio waves can carry information, such as words, sounds, or even pictures, between a sending station and a receiving station. Requirement 1 described some of the different modes by which information may be encoded into radio waves. Two different modes you may have heard of before include *amplitude modulation, or AM*, and *frequency modulation, or FM*.

No matter which mode is chosen, a radio signal must be generated by a ***transmitter***. A transmitter is a device that produces very rapid back-and-forth electric currents, called *alternating currents or AC*, within an electronic circuit called an *oscillator*. The transmitter combines the oscillator's alternating currents with other electrical signals, such as signals from a microphone, to *modulate* the oscillating currents. When *modulation* occurs, the signals from the microphone are encoded into the alternating currents by changing some characteristic of those currents. For instance, with amplitude modulation the *power* of the alternating current is changed to encode the microphone's signals. With frequency modulation the *frequency* of the alternating current is changed to encode the microphone's signals. Either way, the sounds detected by the microphone are carried within the transmitter's electrical alternating currents.

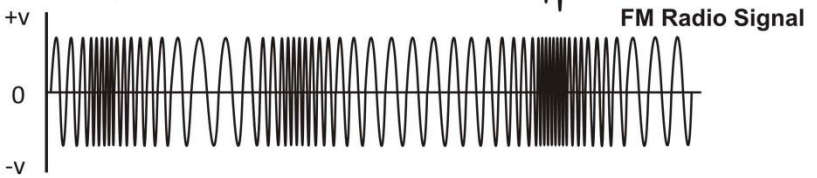
Example Microphone Signal



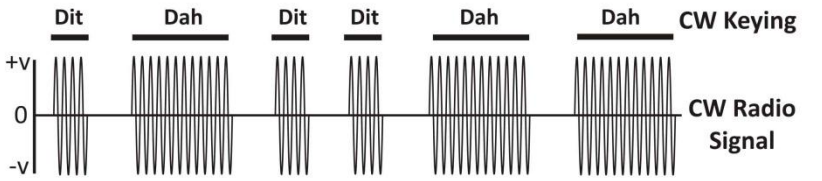
Example Amplitude Modulation



Example Frequency Modulation



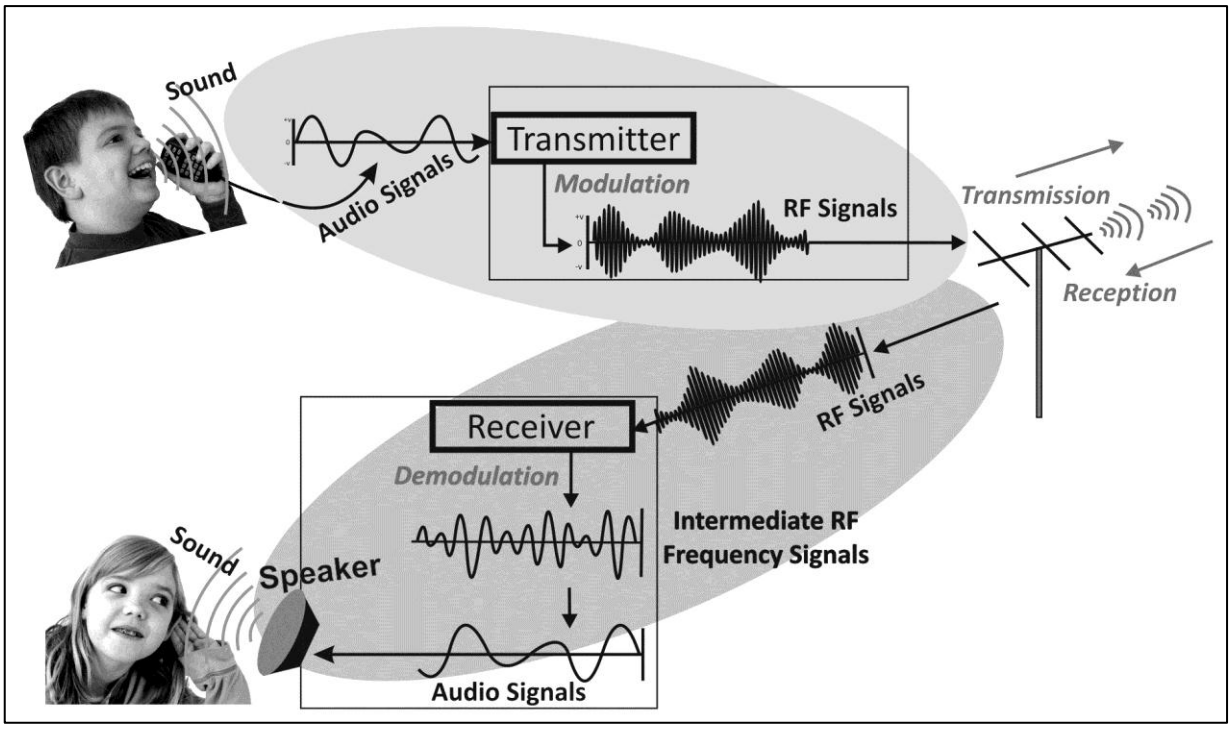
Example Morse Code Radio Signals in a Continuous Wave (CW) transmission



The modulated oscillator currents are sent to an ***amplifier*** that boosts the power of the currents. These more powerful alternating currents are sent to an ***antenna*** through a *feedline*, or wire cable. The antenna transforms the electrical currents into radio waves that are radiated out into the air and space at the speed of light!

A radio ***receiver*** is a device that detects the transmitted radio waves and turns the signals back into sound. The receiver uses an **antenna** to pick up the radio waves from the air. With a receiver, the antenna turns any detected radio waves back into alternating electrical currents that flow back-and-forth in the antenna and into the receiver device through the feedline. The antenna's newly created currents are very weak, so another ***amplifier*** (also called a radio frequency *pre-amplifier*) is used to boost their power for the receiver. The receiver has special electronic circuits that reverse the modulation process of the transmitter, and it ***demodulates*** the signal, getting the original microphone's electrical signals back out of the rapidly alternating currents. These *audio* electrical signals are sent to a speaker to recreate the sound that went into the microphone of the transmitter!

Most modern two-way radios are ***transceivers***, meaning they contain both a ***transmitter*** and a ***receiver*** together in one package. That way a single radio is able to both send and receive radio signals at the push of a button! It's almost like magic, but it's really just cool science and engineering!



A Simple View of Modulated Radio Transmitting and Receiving

You can learn much more about modulation, radio signal transmitting, and radio signal receiving, in the HamRadioSchool.com Technician License Course book Chapter 6!

Requirement 5

5. Do the following:

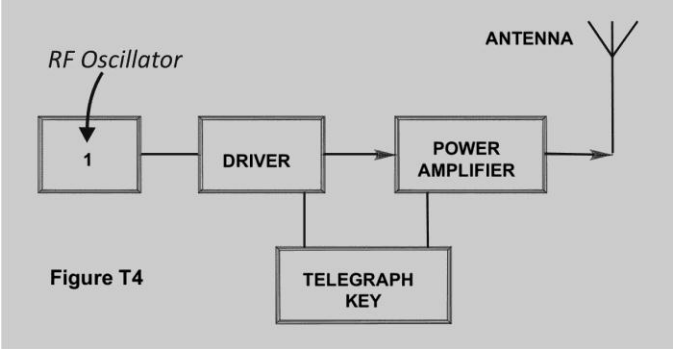
a. Explain the differences between a block diagram and a schematic diagram.

b. Draw a block diagram for a radio station that includes a transceiver, amplifier, microphone, antenna, and feed line.

c. Explain the differences between an open circuit, a closed circuit, and a short circuit.

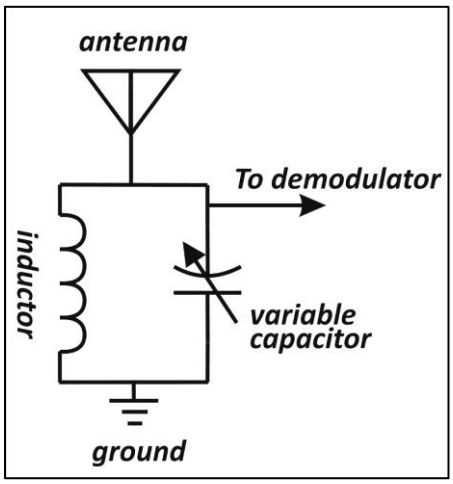
d. Draw eight schematic symbols. Explain what three of the represented parts do. Find three electrical components to match to three of these symbols.

A block diagram, like the one below for a simple transmitter, shows the main parts of an electronic device like a transmitter, a receiver, or a transceiver. The main parts are represented by simple rectangles or "blocks," so it is called a block diagram. For example, one block in the example is an *oscillator,* the transmitter part that creates the very fast back-and-forth alternating electrical currents as described in requirement 4. Usually the blocks in a block diagram will be connected with lines to show how the blocks are related to one another.

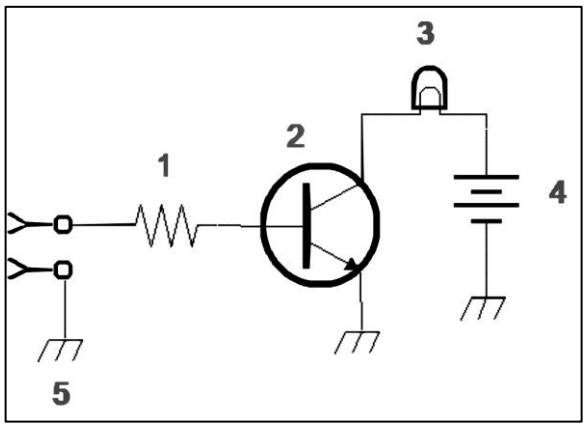


A Simple Block Diagram of a Continuous Wave Transmitter for Sending Morse Code

Schematic Diagram: Each block in a block diagram can usually be described in much more detail by a **schematic diagram**. A schematic diagram will show symbols of all of the individual electronic components that are connected together to build a part of the radio, or even the entire radio. The schematic diagram will show exactly how the electronic components are connected together. For example, the oscillator circuit that is represented by a block in the block diagram above is shown below in a simple schematic diagram. Another schematic diagram is also shown for a lamp dimmer control circuit. Schematic diagrams of complex devices, such as a whole transceiver, can appear very crowded and very complex!

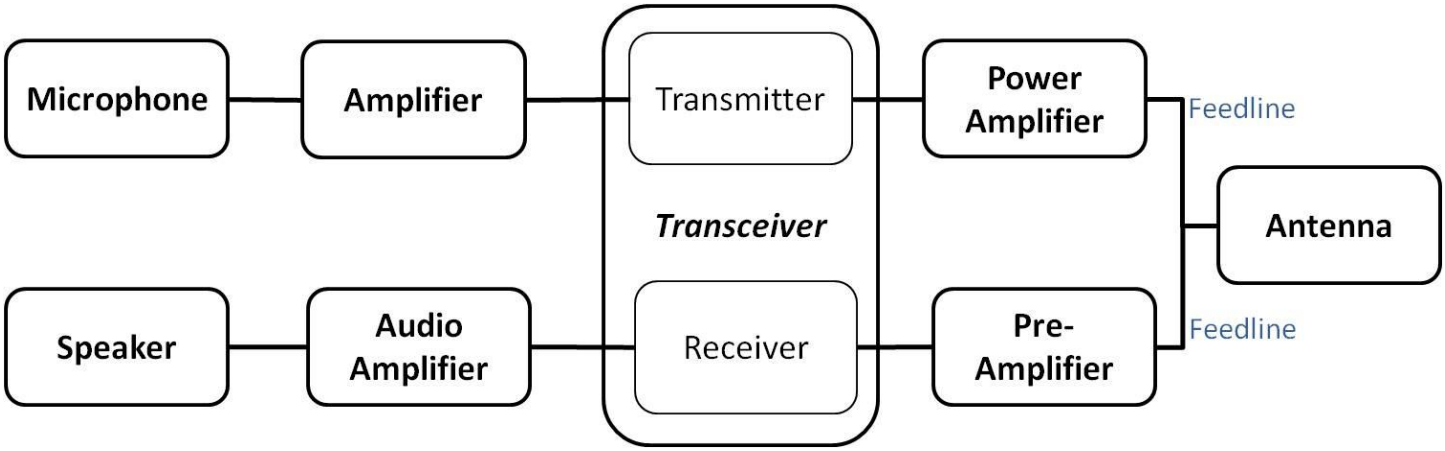


Simple Oscillator Circuit Schematic

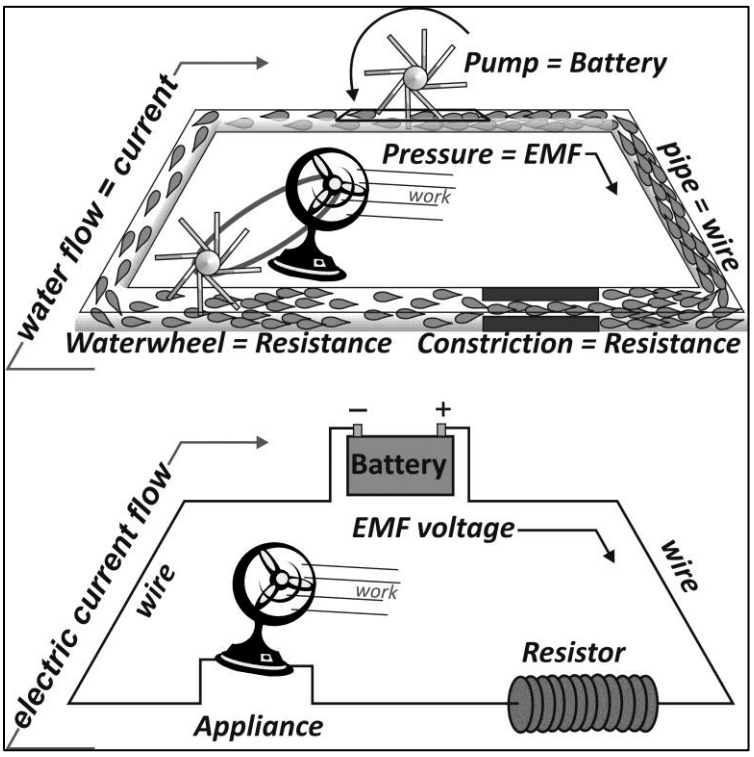


Lamp Dimmer Control Circuit Schematic

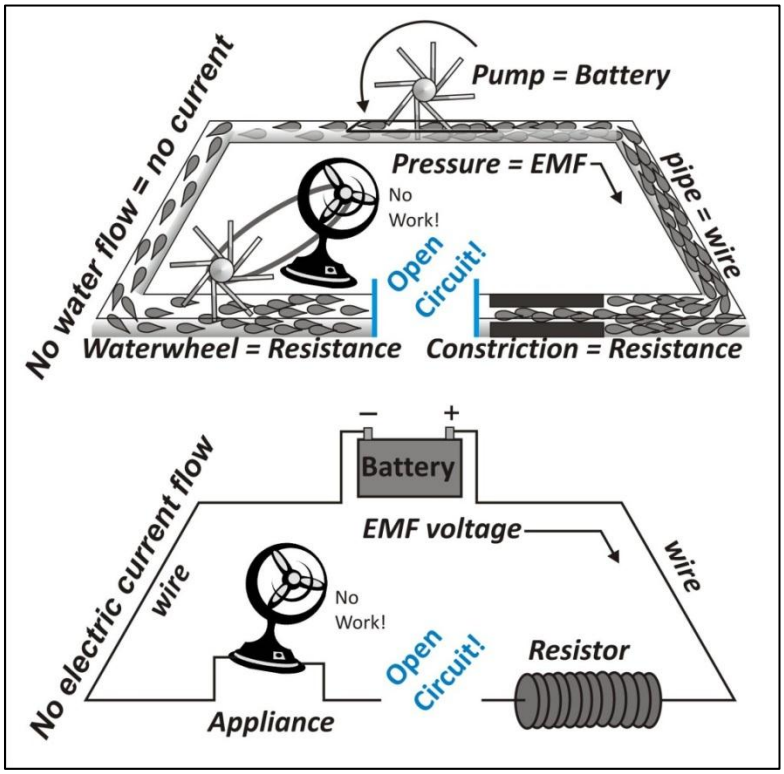
Radio Station: Here is one way to show the parts of an entire radio station with a block diagram. In many modern integrated transceivers, all of the block parts shown here may be together in one unit that is generally called the "transceiver."



A closed circuit: Electricity flows through wires much like water flows through pipes. In a *circuit* the flow of electricity (or water) must travel around a closed path, like the picture below. This is called a closed circuit because the flow of current is closed within the path of the circuit.

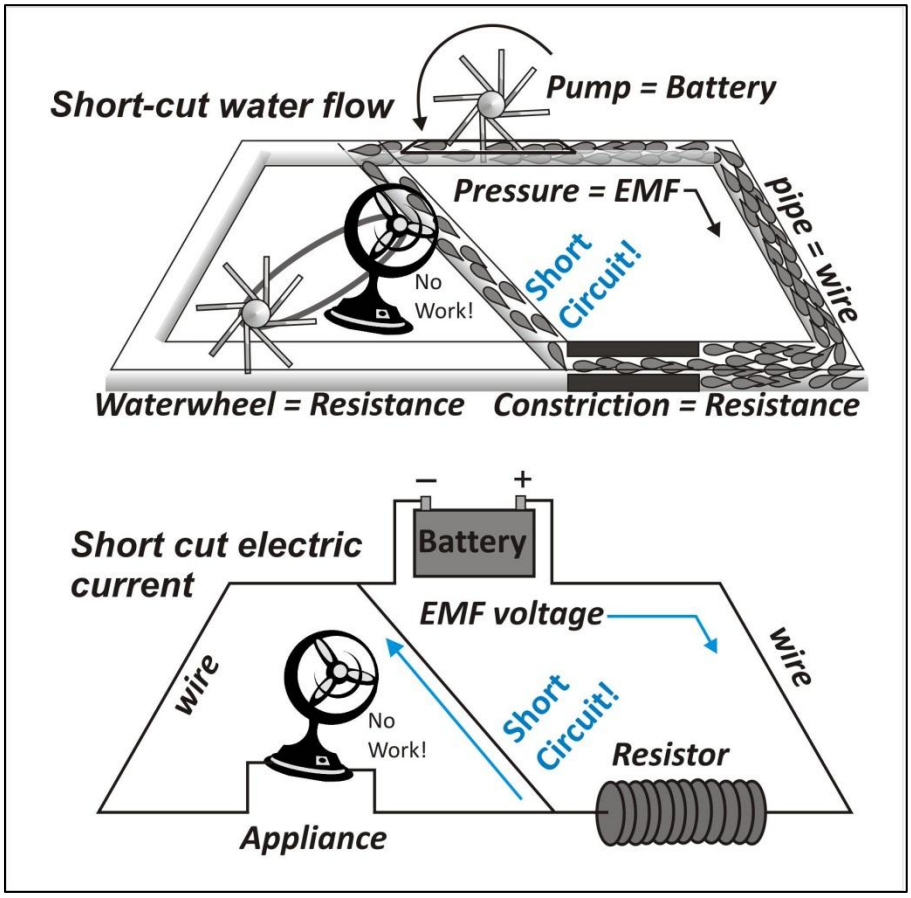


A Closed Circuit – Electricity is like water flow!

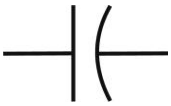


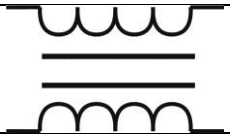
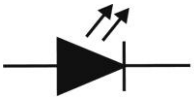
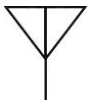
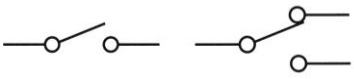
An open circuit is one that has a gap or a break in it, such as when a switch is turned off. In an open circuit the flow cannot continue around the path because the path is interrupted by a gap, like this.

A short circuit is where the current flows in an undesired way. This may occur if two wires touch in an electric circuit when they should not touch at all. This may occur is an electrical conductor, such as a wire or other piece of metal, accidentally crosses over the circuit and creates a sort of "short cut" for the electric current to flow a different way, like below. With a short circuit, think "short cut."



Schematic Symbols are simple pictures that represent real electronic components in a schematic diagram. Here is a list of several of the most common electronic components in a radio, the **schematic symbol** of each**,** and a brief description of what each component does in an electronic circuit. You will recognize some of these symbols from the simple schematic diagrams above.

Resistor		Resists the flow of electric current in a circuit. It is much like a blockage or narrowing of the water pipe!
Diode		Allow electric current to flow only one direction in a circuit. It is like a one-way water valve, or flap valve.
Capacitor		Stores energy in an electric field that builds up between the two sides of the capacitor when current flows.

Inductor		Stores energy in a magnetic field that builds up among coils of wire when current flows.
Battery		Stores energy in chemical form and produces direct current voltage for a circuit. Like a water pump!
Transformer		Changes the voltage of electric current from one value to another, using magnetic induction between two coils of wire in the transformer.
Transistor		Acts like a switch or an amplifier. A little electric signal on one wire into the transistor controls the flow of a much larger current through the other two wires. Like a water valve that can vary a strong flow of water in a pipe!
Lamp		An electric light that uses a filament to glow when current flows through it.
Light Emitting Diode (LED)		A semiconductor material that emits light when current flows through it.
Antenna		Used to emit radio waves when alternating current flows in it, or used to receive radio signals when radio waves create an electric current in it.
Switch		Used to open or close an electrical circuit, in order to turn on or off a device or appliance.

You can learn more about electric circuits and electronics in the HamRadioSchool.com Technician License Course book Chapters 8 and 9!

Requirement 6

5. Explain the safety precautions for working with radio gear, including the concept of grounding for direct current circuits, power outlets, and antenna systems.

Electrical Safety Summary

- Electric shock can kill if enough current flows through a person's body! Lower amounts of electric current can injure a person and be very painful. Be sure to disconnect the power from a radio or any other electronic device before doing any work on it.
- After a radio is unpowered, the *capacitors* inside can still store a strong electric charge, as described in requirement 5. Be sure that capacitors have plenty of time to discharge before doing any work on the radio, or get help in discharging them properly.
- Grounding a circuit means that a path to electrically neutral "ground voltage" or zero voltage is provided. The earth provides a good electric ground for radio stations since it can absorb large amounts of electricity. Radio stations will usually have a large wire or metal strap path to a metal rod driven deeply into the earth in order to provide an easy path for electric currents to go to ground (0) voltage.
- Alternating current power outlets should be used with a three-prong plug that includes a safety ground wire on the third prong of the plug. The safety ground wire of such a plug is usually attached to a grounding point on the radio chassis, or housing enclosure. This third part of the power outlet is usually connected to the earth ground of your home's electrical system, so the radio housing is grounded through the 3-pronged power cable to earth ground when the radio is plugged in. Any accidental or stray currents that flow to the radio housing have a direct route into the earth to reduce electrical shock hazards.
- Make sure that any radio antennas cannot come close to overhead power lines, even if they fall accidentally. Keep antennas far away from power lines! If your antenna touches a power line while you are in contact with it or with the radio to which it is connected, you could receive a deadly electric shock.

Tower and Antenna Safety Summary

- If you climb an antenna tower, always wear proper safety equipment including a climbing harness properly attached to the tower, safety glasses, and a hardhat.
- Never climb an antenna tower without another person to help and to observe for safety problems. This second person on the ground should also have a hardhat and safety glasses in case objects are accidentally dropped from above.
- Lightning can directly hit, or indirectly flow into antennas and feedlines. Do not operate your radio with an external antenna during lightning activity in your area or you could receive a severe or deadly shock.
- Make sure that your external antenna is well grounded to an earth grounding rod. If lightning energy surges into the antenna system, the ground connection will help to send much of the lightning energy directly into the earth instead of into your house and radio.

Radio Emission Safety Summary

- Never touch a radio antenna when the radio is transmitting. Strong radio signals can cause deep and painful burns if you are touching an antenna while it transmits.
- Radio frequencies are absorbed by the human body where they are turned into heat. Strong radio emissions can cause dangerous heating of your body tissues. Do not remain close to a powerful transmitting antenna.

You can learn more about safety related to radio operations in the HamRadioSchool.com Technician License Course book Chapter 13!

Requirement 7

7. Visit a radio installation (an amateur radio station, broadcast station, or public service communications center, for example) approved in advance by your counselor. Discuss what types of equipment you saw in use, how it was used, what types of license is required to operate and maintain the equipment, and the purpose of the station.

Be sure that your counselor approves the visit that you make.

Read ahead to requirement 9. You have the option of learning about amateur radio, broadcast radio, or shortwave radio listening. The amateur radio option is very popular with scouts because that option allows you to conduct two-way communication and actually transmit your voice over the radio waves! If you elect option 9a, we recommend that your visit be to an amateur radio (ham radio) installation. You may be able to complete some of the 9a requirements, such as the on air communication of requirement 9a2, along with the visit of requirement 7.

Questions to ask during your radio installation visit:

1. What do the different pieces of equipment do and how are they used?
    a. What kind of transmitter is used?
    b. What kind of receiver is used?
    c. What kind of microphone or other sending device is used?
    d. What kind of antenna is used?
2. What kind of license is needed to operate the station?
3. What kind of license is needed to work on, or maintain, the equipment?
4. What is the main purpose of this radio station?

Requirement 8

8. Find out about three career opportunities in radio. Pick one and find out the education, training and experience required for this profession. Discuss this with your counselor, and explain why this profession might interest you.

The *US Department of Labor's Bureau of Labor Statistics* (BLS) has an excellent web site describing various careers and occupations. Here are a few career opportunities related to radio along with a BLS web site link for more information:

A radio broadcast announcer or on-the-air personality may present music, news, sports, weather, commercials, and other information to the broadcast audience! The announcer may sometimes get to decide what the radio listeners will hear in a radio show or in a commercial. Most broadcast announcers will have a 4-year college degree (although not required) in communications, journalism, or broadcasting. A pleasant voice is a consideration for an announcer career. In high school courses you should seek to excel in English and writing courses, and get as much public speaking experience as possible.

More about **Broadcast Announcer**

An electrical engineer may design radio electronic circuits, radio test equipment, and other electronic devices. Electrical engineers will use computers to draw and design schematic diagrams of circuits or to work on radios and other electronic devices such as radar systems, satellites, or cellular telephones! Electrical engineers must have at least a 4-year college degree in electrical engineering, and many will go on to higher levels of college education. You should take as much mathematics and science in high school as possible for this career, along with computer courses. You should also have good English communications and writing skills to be an engineer, since you will probably write many technical reports about your work!

More about **Electrical Engineer**

A broadcast and sound engineering technician will set up, operate, and work on electrical equipment for radio broadcasts, live concerts, sound recording, or even for movies and films! The engineering technician makes sure the radio transmission is correct and sounds right, and that all of the equipment is operating properly for a broadcast, recording, or live show. Most broadcast and sound engineering technicians will have at least a 2-year college degree or vocational certificate. Science, mathematics, electronics and computer classes in high school will help with this career path.

More about **Broadcast & Sound Engineering Technician**

A Telecommunications Installer & Repairer maintains and repairs devices and equipment that carry radio signals, telephone systems, radar systems, internet communication systems, and more! They may set up and install equipment in offices or buildings under construction. People in this career field will usually have a 4-year college degree in a technical or engineering field or an industry certification.

More about **Telecommunications Installer & Repairer**

Requirement 9

Do ONE of the following, (a OR b OR c):

a. **AMATEUR RADIO** b. BROADCAST RADIO c. SHORTWAVE LISTENING

9a. AMATEUR RADIO

1. Tell why the FCC has an amateur radio service. Describe some of the activities that amateur radio operators can do on the air, once they have earned an amateur radio license.

2. Using proper call signs, Q signals, and abbreviations, carry on a 10 minute real or simulated radio contact using voice, Morse Code, or digital mode. (Licensed amateur radio operators may substitute five QSL cards as evidence of contacts with amateur radio operators from at least three different call districts.) Properly log the real or simulated ham radio contact and record the signal report.

3. Explain at least five Q signals or amateur radio terms you hear while listening.

4. Explain some of the differences between the Technician, General, and Extra Class license requirements and privileges. Explain who administers amateur radio exams.

5. Explain how you would make an emergency call on voice or Morse code.

6. Explain the differences between handheld transceivers and home "base" transceivers. Explain the uses of mobile amateur radio transceivers and amateur radio repeaters.

9.a.1 Amateur radio is also called ham radio. Specific frequencies are set aside by the FCC for amateur radio use, meaning that these frequencies cannot be used for commercial radio purposes like broadcast radio, cell phones services, or other money-making activities. Amateur radio is a fun hobby and a public service for communities where amateur radio may be used to aid firefighters and police during times of emergency.

The FCC established the Amateur Radio Service for:

- **International goodwill:** With some amateur radio frequencies you can talk around the world to people in other countries.
- **Experimentation and Electronics Expertise:** The amateur radio service encourages the home-building of equipment such as antennas and radio circuits, as well as experimentation with new modes of radio communications.

- **Volunteer Service:** Community communications support and emergency preparation. As a scout, you can earn your amateur radio license and *Be Prepared* to serve your community with radio communication skills!
- **Communications Expertise:** Amateur radio builds communications skills, both technical and social.

Amateur radio operators, or *hams*, do many fun and important things, including:

Radio Contests: Ham radio operators compete with one another to make the most radio contacts in a specific time period. See a video about one type of radio contest!

Space Contacts: Hams can make contact with the International Space Station and talk to amateur radio licensed astronauts! Hams can also communicate with other earthbound hams by having signals relayed by satellites in orbit around the earth! These links tell you more about amateur radio and space contacts!

Amateur Radio on the International Space Station

ISS Fan Club

Amateur Radio Satellites (AMSAT)

Portable Communications: Many hams enjoy taking their radio station away from home, perhaps to a mountaintop or on a backpacking trip, to communicate from the backcountry and to be prepared in case of an accident to get help. **<Link to troop 6 summer camp video; link to WGØAT YouTube videos>**

Skywarn: Hams report on severe weather observations to the National Weather Service: Skywarn Site

Hidden Transmitter Hunting: Some hams like to play a game with radio, seeking a hidden transmitter with direction finding equipment. This popular radiosport is called foxhunting, and some hams combine it with the popular geocache activity! Read about scouts competing in a hidden transmitter hunt!

DX Contacts: Hams communicate "DX" or distant out of country radio communications and exchange QSL cards as a record of the contacts. Hams seek awards, such as for contacting 100 different countries and other accomplishments on the air.

Public Service: Hams serve their community with communications for parades and other community events, and by volunteering in special radio organizations that help fire, police, or other emergency response agencies during times of emergency or disaster. RACES Organization ARES Volunteers

Jamboree On The Air (JOTA): Scouting organizations worldwide participate in JOTA each year on the third weekend of October. Scouts and hams team up to communicate with one another over the airwaves around the world. JOTA Web Site

You can learn more about the fun things amateur radio operators do in the HamRadioSchool.com Technician License Course book Chapter 3!

9.a.2. Using proper call signs, Q signals, and abbreviations, carry on a 10 minute real or simulated radio contact using voice, Morse Code, or digital mode. (Licensed amateur radio operators may substitute five QSL cards as evidence of

contacts with amateur radio operators from at least three different call districts.) Properly log the real or simulated ham radio contact and record the signal report.

This requirement will be a blast! This is one reason why selecting option 9a Amateur Radio is so popular with scouts! Discuss with your counselor visiting an amateur radio operator station where you can make a radio contact with another amateur operator. You can talk on the air!

If your merit badge counselor is not familiar with local amateur radio stations, he may be able to request help from an amateur radio club in your area. You can search for an amateur radio organization in your area at this site: ARRL Find a Club. Just enter your zip code in the search box and click to get a listing of clubs in your area, then have your counselor contact the club with a request.

You may also be able to participate in the JOTA program to fulfill this requirement. Ask your local council about JOTA activities scheduled in your area. (See requirement 9.1.a)

For your on-air contact you should record the following information as a "logbook entry:"

- Date and Time
- Frequency
- Contact's Call Sign, Name, & Location
- Signal Report Received (RST)
- Signal Report Given (RST)

Signal reports by phone (voice) modes are issued as "RS:" **R**eadability (1 to 5) and **S**trength (1 to 9). The best signal report is "59."

Signal reports by CW (Morse Code) mode are issued as "RST:" **R**eadability (1 to 5), **S**trength (1 to 9), and **T**one (1 to 9). The best signal report is "599."

NOTE: If you are visiting an amateur radio station, be sure to review **requirement 7** since you will be able to accomplish that requirement at the same time as this one!

You can learn more about call signs and Q signals in the HamRadioSchool.com Technician License Course book Chapter 2!

9.a.3. Explain at least five Q signals or amateur radio terms you hear while listening.

Q signals are three-letter shortcuts used on the air. Each Q signal has a specific meaning. Q signals were originally used with Morse Code transmissions to help reduce the amount of "dits and dahs" transmitted. Q signals are quick, easy, and efficient. They are often used by amateur radio operators with phone mode (voice) communications also.

Here are a few examples of Q signals, and you may reference a complete list here: <HRS Q-signal link>

QSO: An on air conversation
QSL: Acknowledge receipt
QTH: Location
QSY: Change of frequency

QRP: Low power; reduce power
QRN: Noise interference
QRM: Interference from another station (manmade interference)

See a thorough list of other common amateur radio terms from *HamRadioSchool.com*.

9.a.4. Explain some of the differences between the Technician, General, and Extra Class license requirements and privileges. Explain who administers amateur radio exams.

The 3 levels of amateur radio licenses are:

Technician – Entry level license requiring an examination on basic topics of rules, regulations, on-air procedures, and radio theory. The examination is 35 multiple choice questions selected randomly from a pool of almost 400 total questions. The Technician license allows transmitting on all UHF and VHF amateur frequencies and a small portion of the HF frequencies. The technician will be able to communicate locally and on repeaters, and also communicate long distances by ionosphere skip when conditions permit on the 10-meter and 6-meter bands. *You can get your Technician license easily!* (See below.)

General – Mid-level license requiring passing of Technician examination first and another 35-question examination on more advanced rules, procedures, and radio theory. Much of the radio theory focuses on the HF radio bands and long distance communications. The General license allows transmitting on most of the HF amateur bands in addition to all of the privileges earned with Technician. The General operator will be able to talk around the world using the ionosphere skip of the HF radio bands.

Extra – Highest level license requiring first passing of General examination and another 50-question examination from a question pool of about 700 questions on advanced radio theory, the various modes of operation, and other topics. Extra license holders may transmit on all portions of all amateur frequency bands.

All license examinations are administered by Volunteer Examiners, or VEs. VEs are sanctioned by the FCC to issue and evaluate amateur radio license examinations. At least three qualified VEs must be present for any examination. VEs are other licensed amateur radio operators who volunteer their time and services to the amateur radio community.

GET YOUR LICENSE! Once you have completed the radio merit badge, you have learned a lot of what is needed to earn your FCC Technician license! Don't let that effort go to waste! Check out the *HamRadioSchool.com* Technician training system. The book is easy to read, and the web site learning media has videos, sound files, pictures, quizzes and more that are organized for you right along with the book sections! And we have a fantastic mobile app for practicing questions and exams, and it also follows right along the book organization. It's a great way to really learn about ham radio and get your Technician license! Check it out at: HamRadioSchool.com!

9.a.5. Explain how you would make an emergency call on voice or Morse code.

Voice Mode Emergency: With amateur radio, the most practical thing to do if you need to communicate on the air that you have an emergency situation is to simply say "Emergency!" You may want to say it three times in a row to get

attention. Follow up with your call sign, your location, a brief description of the emergency, and the type of help needed. For example, “Emergency, emergency, emergency. WØCOL, hiking accident with injuries on Pikes Peak Barr Trail. Medical help is needed. Over.”

Wait for a reply from another amateur operator, answer questions, and provide more detailed information as necessary to receive the help you need. For instance, in our example above you may need to provide information about exactly where on the 13 mile trail you are located, such as an altitude position or latitude-longitude determined by a GPS receiver or a map.

The voice method above is fine for clear transmission modes, like FM repeaters, particularly in the United States. However, if the radio conditions are poor and the audio is noisy, such as with many single-sideband and HF bands, or if you are in another country where English is not the primary language, you may need to use the term “Mayday” instead of “Emergency.” If you hear someone transmitting “Mayday, mayday, mayday,” that is telling you that person has an emergency situation! Call them back and help in any way you can!

Morse Code Emergency: With Morse Code an emergency is indicated by transmitting “S O S.” This is a shortcut that means “save our ship” or “save our souls.” Again, follow the SOS transmission with your call sign, location, and what help is needed. The Morse Code transmission for SOS is:

... --- ...

That sounds like “di di dit, dah dah dah, di di dit.”

9.a.6. Explain the differences between handheld transceivers and home "base" transceivers. Explain the uses of mobile amateur radio transceivers and amateur radio repeaters.

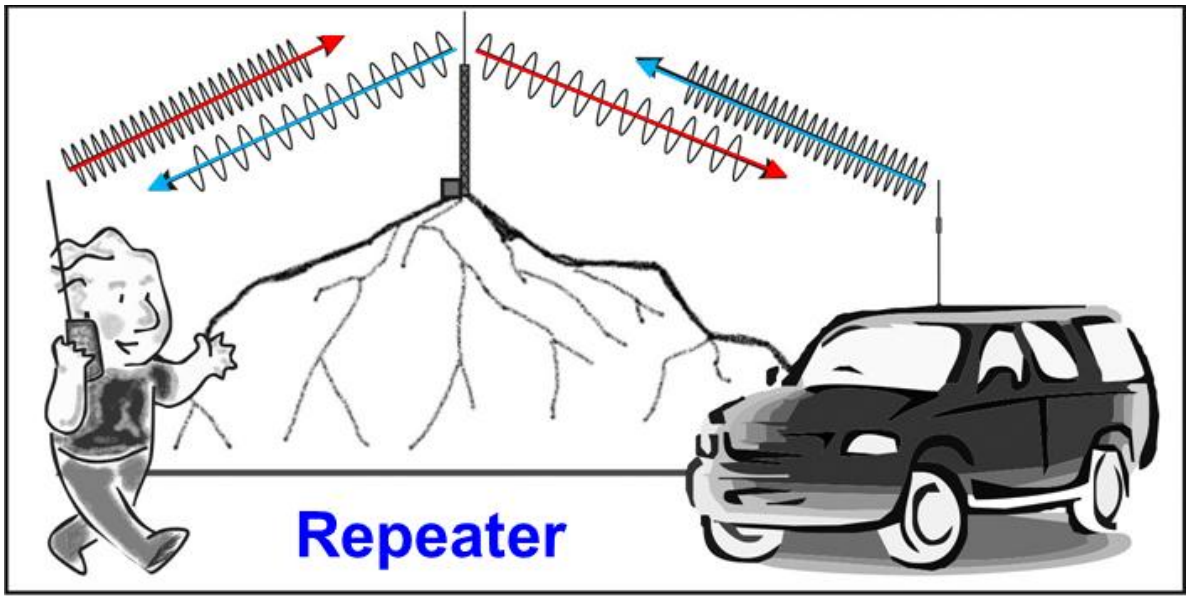
Handheld Transceiver: The “HT” is a small, lightweight radio that fits into your hand. They are great for mobile or portable operations, such as walking around the neighborhood and transmitting across a small town, but they do not transmit with much power and they do not work well from inside a car. However, coupled with a repeater, a handheld transceiver can be very useful and communicate long distances! The HT is usually a voice mode, FM transceiver only.
<Picture of HT>

Base Station Transceiver: A base station is usually a permanently installed station in a home or building. These larger radios provide much more power and usually are connected to large external antennas. The base station may be able to communicate with several different modes, such as FM, AM, Single Sideband (SSB), CW (Morse Code), and digital methods. A base station may have many more features for helping to transmit and receive effectively.
<Picture of base>

Mobile Transceiver: A mobile station is usually installed in a car and can be operated as the car moves around. Usually in between the size of an HT and a base station, the mobile station will provide more power than the HT and it usually will have an antenna mounted outside the car cabin.

<Picture of mobile>

Repeater Station: A repeater station receives your signal and retransmits it on a different frequency, usually with higher power and from a higher antenna position. This lets other operators hear your signal much further away than with your transceiver alone! Repeaters are often located on high hills, mountains, or tall buildings so that their repeated signals travel great distances. Some repeaters are linked together in sets or systems, so that when one repeater in the system receives a call all of the other repeaters will retransmit that call. This can spread your signal across a very wide area! Other repeaters are linked over internet connection, allowing you to contact amateur operators in other countries around the world or in almost any state in the US! You can learn much more about these radio systems by earning your FCC Technician license with HamRadioSchool.com! www.HamRadioSchool.com



A repeater station receives on one frequency and repeats the radio signal on a second frequency.

A repeater can greatly extend the distance your signal travels!

You can learn more about the different kinds of radios and about repeater stations in the HamRadioSchool.com Technician License Course book Chapter 1!

Learn more about amateur radio and getting your Technician license:

HamRadioSchool.com Email the Author of this site

American Radio Relay League (ARRL): New to Ham Radio?

Requirement 9

Do ONE of the following, (a OR b OR c):

a. AMATEUR RADIO **b. BROADCAST RADIO** c. SHORTWAVE LISTENING

9b. BROADCAST RADIO

9.b.1 Prepare a program schedule for radio station "KBSA" of exactly one-half hour, including music, news, commercials, and proper station identification. Record your program on audio tape or in a digital audio format using proper techniques.

A real commercial radio station makes broadcasting radio seem easy! But it takes a lot of work to put together radio broadcasts around the clock. A carefully scheduled script of a day's broadcast must be created to make sure the radio is "always there" for the listeners. A radio station will also usually create many of the commercials that are played on the station, recording them in advance and inserting the commercials into time slots on the station's schedule. Everything must be timed perfectly, to the second, so that all the commercials get played, all the music time is available, and all the news gets covered! It can be a complex and difficult job!

You can get a taste of the radio producer and director jobs with this requirement! When you write your half-hour script consider these things:

- What kind of radio station are you running, and who is the audience that listens?
- What kind of things will you play? Talking conversations? Music? Sports? News? A mixture?
- What kind of products for commercials would be interesting to your station's audience?
- What kind of music, either in broadcasted songs for enjoyment, in commercials, or as background would your audience like?
- How will you introduce the parts of your radio show, including music, news, sports, weather, or other parts that you create?
- What will you use to record your radio show?

If you have access to a computer, you may be able to use it to record your radio show! Many different digital recording software utilities are available, some for free! Get your parents' help and learn to use a simple audio recording application on the computer. With many of these applications you can record different sections of your radio show as separate parts and move the various parts around on a timeline. This way you can experiment with different ordering of your radio show parts and perhaps even use some special sound effects to enhance your radio show, if the audio recording application provides such features.

However, before you start recording, be sure to "prepare a program schedule" as the requirement states. You should have each radio broadcast segment of your show scheduled with a precise time (duration), scripted content (what you'll say or play), and sequence of all the segments. After you have created your schedule, then you can begin to record segments and play with the sequence and effects! Have fun!

Suggested freeware utility, "Audacity:" http://audacity.sourceforge.net/

9.b.2 Listen to and properly log 15 broadcast stations. Determine the program format and target audience for five of these stations.

This one is easy! Just use your family radio to tune across the dial, perhaps both FM and AM stations. Select 15 stations to listen to for a while and evaluate. Record the following for each station you choose:

- Date and Time you listened
- The Station Frequency (on the dial)
- The Station Call Sign
- The Station's Location (City)
- The Station's Format (Talk, Music, News, Sports, etc.)
- The Station's Target Audience (What kind of people does the station wish to reach?)
- Notes About the Broadcast (Topics discussed, music type played, times and sequences of content, etc.)

9.b.3. Explain at least eight terms used in commercial broadcasting, such as segue, cut, fade, continuity, remote, Emergency Alert System, network, cue, dead air, PSA, and playlist.

Seque: A natural flow from one topic or song to another. A smooth transition.

Cut: In recording a broadcast show, the time or point at which the transmission will be terminated; also in recording broadcast material, a single attempt at making a recording, as in "cutting a record."

Fade: To make the volume softer, as to fade to silence.

Continuity: The action of keeping a radio broadcast going, avoiding "dead air." A break in broadcasting continuity results in no content being broadcast.

Remote: A broadcast that originates live on location, outside the studio where the broadcast would normally originate

Emergency Alert System: A government system using commercial broadcast stations to send emergency information.

Network: A group or system of radio stations that broadcast similar or identical shows and content.

Cue: A signal to an on-air announcer or a script position indicator that something is supposed to happen at that point.

Dead Air: A broadcast signal with no sound on it. This is considered very bad!

PSA: A public service announcement.

Playlist: The official list of songs that a radio station will play during a give time period.

You can explore additional broadcasting terms at these fine sites. Remember to get your parents' permission!

http://en.wikipedia.org/wiki/List_of_broadcasting_terms http://radio.about.com/library/blglossary.htm

http://www.radioconnection.com/glossyA.html

Requirement 9

Do ONE of the following, (a OR b OR c):

a. AMATEUR RADIO b. BROADCAST RADIO c. **SHORTWAVE LISTENING**

9c. SHORTWAVE LISTENING

9.c.1 ***Listen across several short-wave bands for four one-hour periods, - at least one period during the daylight hours and at least one period at night. Log the stations properly and locate them geographically on a globe.***

You can use a shortwave receiver coupled with a long wire antenna to hear radio broadcasts from around the world! The broadcasts you receive will change from day to night because the ionosphere from which the shortwave signals are reflected around the world changes with sunlight conditions. Some shortwave stations will be received in the daytime, and others only at night. Experiment and log your results!

You may get better results at night between about 5 MHz and 10 MHz tuning frequencies. You will probably have to tune to 10 MHz or higher during the daylight hours to receive stations. During the "gray line" period of sunrise and sunset, you may get very interesting mixtures of performance!

You will likely hear many different languages on shortwave broadcasts. It may be difficult to identify where the stations are coming from.

When you log a station be sure to record the following information:

- Date & Time of Listening
- Station Frequency
- Station Name / Call Sign
- Station Location
- Notes about the broadcast content (music types, languages, content, etc.)

Also record your evaluation of the station receive quality using SINPO. This signal report means rates the station reception on scales of 1 to 5, with 5 always being the best in each SINPO category. The five SINPO categories stand for the following characteristics that you should rate on the 1 to 5 scale each:

Signal (S)	Interference (I)	Noise (N)	Propagation (P)	Overall (O)
1-Excellent	1-None	1-None	1-None	1-Excellent
2-Good	2-Slight	2-Slight	2-Slight	2-Good
3-Fair	3-Moderate	3-Moderate	3-Moderate	3-Fair
4-Poor	4-Severe	4-Severe	4-Severe	4-Poor
5-Barely audible	5-Extreme	5-Extreme	5-Extreme	5-Unusable

9.c.2 ***For several major foreign stations (BBC in Great Britain or HCJB in Ecuador, for example), list several frequency bands used by each.***

Here is a link to a list of International Shortwave Broadcasters. Each station has a listing of the frequency bands used by each broadcaster. http://www.primetimeshortwave.com/radio.html

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9.c.3 ***Compare your daytime and nighttime logs; note the frequencies on which your selected stations were loudest during each session. Explain differences in the signal strength from one period to the next.***

The key to this requirement is thinking about where the sunlit portion of the earth was during your listening time! You may want to use a globe to help think about this, and examine the radio station's position as well as your own.

Look back at requirement 2 and the discussion of the reflection of radio waves from the ionosphere. Shortwave radio signals travel long distances this way, bouncing from ionosphere to ground and back in many bounces. Think about how far each station in your log traveled to get to your receiver.

Any of the links below show the daytime and nighttime portions of the earth: You can enter a specific date and time of your shortwave listening to see what parts of the earth were in daytime and what parts were in nighttime when you listened, or you can see the present time day-night situation.

http://www.daylightmap.com/

http://www.timeanddate.com/worldclock/sunearth.html

http://www.die.net/earth/

http://aa.usno.navy.mil/data/docs/earthview.php

Learn more about Shortwave Listening at these sites:

http://www.etoncorp.com/shortwavetutorial

http://ac6v.com/swl1.htm

http://www.dxzone.com/catalog/Shortwave_Radio/

http://www.odxa.on.ca/beginnersguide/swintro.html
