**Requirements for the Radio merit badge:**

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 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.
2. Do the following:
    a. Sketch a diagram showing how radio waves travel locally and around the world.
    b. 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.
    c. Explain the difference between a distant (DX) and a local station.
    d. Discuss what the Federal Communication Commission (FCC) does and how it is different from the International Telecommunication Union.
3. Do the following:
    a. Draw a chart of the electromagnetic spectrum covering 300 kilohertz (kHz) to 3000 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).
4. Explain how radio waves carry information. Include in your explanation: transceiver, transmitter, amplifier, and antenna.
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. Discuss how information is sent when using amplitude modulation (AM), frequency modulation (FM), continuous wave (CW) Morse Code transmission, single sideband (SSB) transmission, and digital transmission.
    d. Explain how NOAA Weather Radio (NWR) can alert you to danger.
    e. Explain how cellular telephones work. Identify their benefits and limitations in an emergency.
6. Explain the safety precautions for working with radio gear, including the concept of grounding for direct current circuits, power outlets, and antenna systems.
7. Visit a radio installation (an amateur radio station, broadcast station, or public 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 licenses are required to operate and maintain the equipment, and the purpose of the station.
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.
9. Do ONE of the following:
    a. Amateur Radio
        a. Tell why the FCC has an amateur radio service. Describe activities that amateur radio operators can do on the air, once they have earned an amateur radio license.
        b. Explain differences between the Technician, General, and Extra Class license requirements and privileges. Explain who administers amateur radio exams.
        c. Explain at least five Q signals or amateur radio terms.
        d. Explain how you would make an emergency call on voice or Morse code.
        e. Explain the differences between handheld transceivers and home "base" transceivers. Explain the uses of mobile amateur radio transceivers and amateur radio repeaters.
        f. Using proper call signs, Q signals, and abbreviations, carry on a 10-minute real or simulated amateur radio contact using voice, Morse code, or digital mode. (Licensed amateur radio operators may substitute five QSL cards as evidence of contacts with five amateur radio operators. Properly log the real or simulated ham radio contact, and record the signal report.) **connects to 7 above**

2017+ current requirements

Answers: #1

**Radio is a way to electronically communicate without wires**. Radio sends information from one location to another using electromagnetic waves. The information could be morse code, your voice, music, or data. Electromagnetic waves are created when we get an electrical circuit to vibrate electrons back and forth thousands or millions a time per second.

You probably already know broadcast radio, but radar, wireless networks, remote car locks, cell phones, microwave ovens, communications satellites, televison, satellite navigation systems, EZ-Pass toll systems and those security tags in stores are all radio too!

**Broadcasting** uses radio to send information to many people at the same time. **Hobby radio** is the use of radio by ordinary people such as ham radio operators to communicate with each other or to control models.

**Broadcasting is a one way transmission** to many receivers at the same time such as a local music station or television station.

**Two way communications are** a back and forth conversation between two stations. Both stations then take turns transmitting and receiving. Two way radio is used by police, fire, ambulances, planes, trains, ships, astronauts, and folks like you every day!

**All radio transmitters must use call signs** to prove that they have been licensed. Some broadcast call signs are WABC or KDKA, WESH, WFTV, WUCF. Amateur Radio Call signs are like K2BSA or wB4SA, with a number in them.

Because some letters such as "C" and "E" might sound alike when transmissions are noisy, standard **Phonetic Alphabet words are often used to make things understood.**

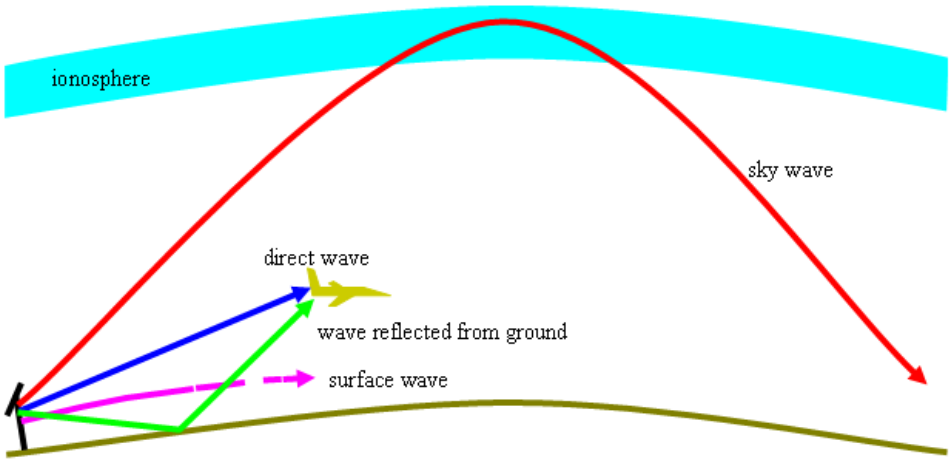
These standard "phonetics" are:

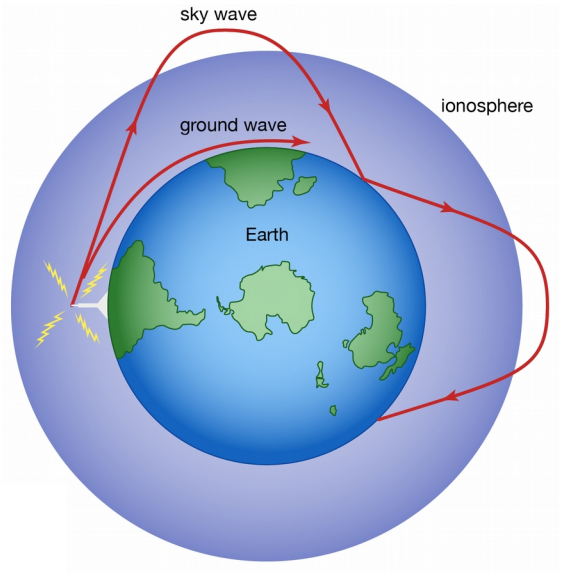
| Letter | Pronunciation | Letter | Pronunciation | Number | Pronunciation |
|---|---|---|---|---|---|
| A | Alfa (AL fah) | N | November (no VEM ber) | 0 | ZEE row |
| B | Bravo (BRAH VOH) | O | Oscar (OSS cah) | 1 | WUN |
| C | Charlie (CHAR lee) | P | Papa (pah PAH) | 2 | TOO |
| D | Delta (DELL tah) | 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) | | |

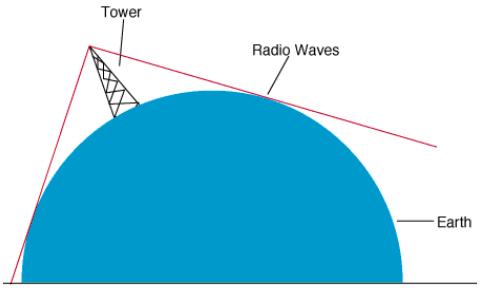
For example, you might say "My name is **Gary**, I spell **Golf Alfa Romeo Yankee**"

Answers: #2

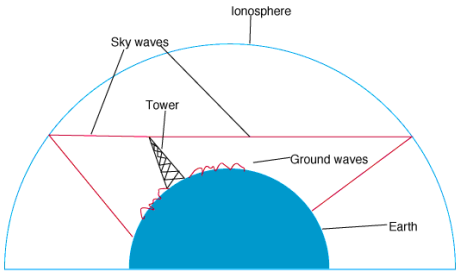
a. Sketch a diagram showing how radio waves travel locally and around the world.




Direct Wave Propogation
FM signals travel no farther than the horizon.




Sky Wave Propogation
Ground waves follow the curvature of the earth. Sky waves are reflected back to the earth due to the ionization of the ionosphere at night.

The most common way for radio waves to travel is in a straight **line of sight** from one antenna to another. This is most common for radio waves using frequencies of 30 MegaHertz (30 MHz or 30 million changes of direction per second) or higher.

Radio **sky waves** between 3 and 30 MHz can also reflect off the electrically charged upper atmosphere, which is called the **Ionosphere,** to then bounce thousands of miles around the earth.

Radio Waves below 3 Mhz can hug the earth's surface to travel hundreds of miles using **ground waves**.

b. 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.

Radio station WWV is located in Fort Collins Colorado and WWVH is located in Hawaii. Both provide **precise time** signals and transmit exactly on the frequencies of 5, 10, 15 and 25 MHz. They also provide infomation on how well the Ionosphere is bouncing radio signals today.
They can be used to **set your clock**, to **calibrate your receiver and transmitter**, and to **see how well radio signals can travel** to and from Colorado and Hawaii.

c. Explain the difference between a distant (DX) and a local station.
**Local vs DX -** Signals from nearby stations are called local, while those from **far away places are called "DX"**. "DX" is the old Morse Code abbreviation for "distance".

d. Discuss what the Federal Communication Commission (FCC) does and how it is different from the International Telecommunication Union.

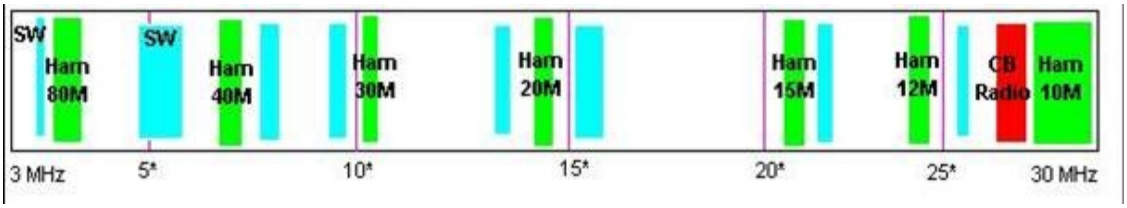
The **FCC** is the **Federal Communications Commission**. It regulates **and issues radio licenses in the United States**. The **ITU** is the **International Telecommunications Union** and the agency of the United Nations that **establishes international standards for radio.**

**Answer: #3**
a. Draw a chart of the electromagnetic spectrum covering 300 kilohertz (kHz) to 3000 megahertz (MHz).

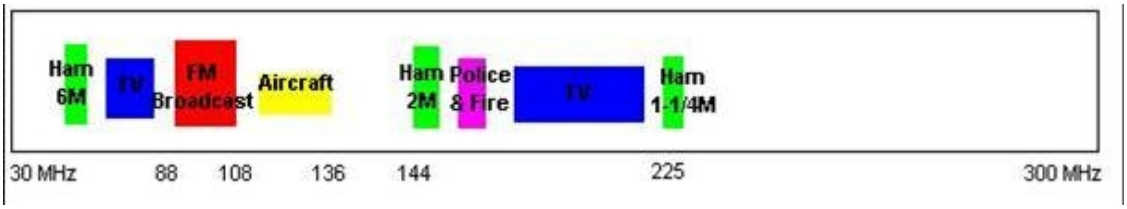
Different frequencies in the Electromagnetic spectrum are used for different purposes and travel a bit differently.

**Medium Frequencies** - The frequencies from 300 KHz to 3 MHz are called the Medium Frequencies. The usually follow the earth's surface using "Ground Waves" and can reach hundreds of miles. AM broadcasters are found here


**High Frequencies** - The frequencies from 3 MHz to 30 MHz are called the High Frequencies or "HF" The usually bounce off the Ionospere using "Sky Waves" and can reach thousands of miles. Shortwave broadcasters and many Ham bands are found here




**Very High Frequencies** - The frequencies from 30 MHz to 300 MHz are called the Very High Frequencies or "VHF" The usually go right through the Ionospere and so are mostly used for line of sight communications on earth. They also can be used to talk to spacecraft. FM Radio and TV broadcasters as well as many Police, Fire and Aircraft radios operate here. The popular 6 meter and 2 meter Ham bands are found here.




**Ultra High Frequencies** - The frequencies from 300 MHz to 3000 MHz are called the Ultra High Frequencies or "UHF" The usually go right through the Ionospere and so are used for line of sight communications on earth. They also can be used to talk to spacecraft. UHF TV broadcasters as well as some Police, Fire radios and cell phones operate here. The 440 MHz Ham band is found here.


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).

Answer: #4

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

Radio waves are created when an **oscillator** circuit gets electrons to vibrate thousands or millions of times per second. An **amplifier** in the **transmitter** makes these **Radio Frequencies (RF)** more powerful.

If the circuit is turned on or off in a pattern using a **telegraph key**, information may be sent using **Morse Code**.You can also talk into a **microphone** and have a circuit then **modulate** the radio waves to have them carry your voice signal.

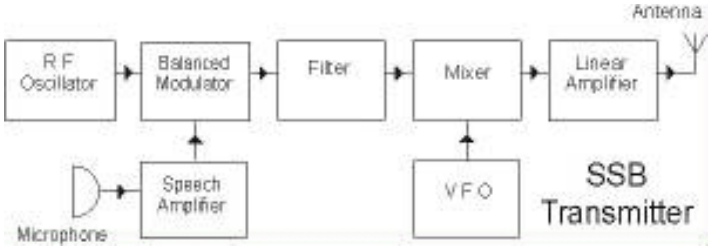
In both cases, these radio waves are then fed to an **antenna** which lets them travel through space. An antenna somewhere else catches the radio waves and feeds them to a **receiver** where they are **demodulated** into **Audio Frequencies (AF)** and played through **headphones** or a **speaker**.

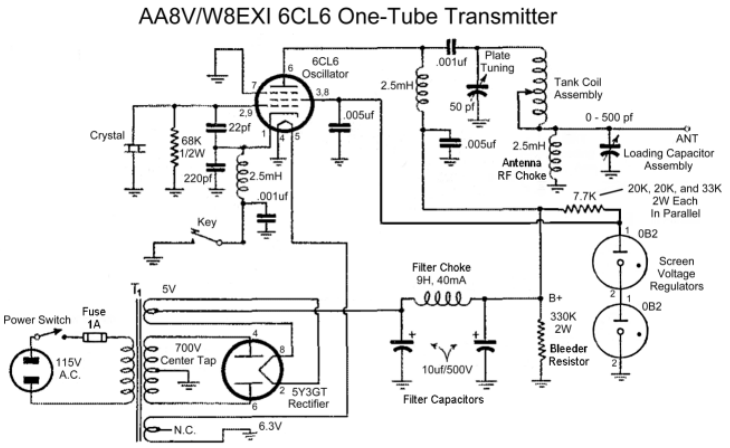
A **transceiver** is a radio that has both a transmitter and receiver in the same case.

Answer: #5

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

A **block diagram shows the different sections** of a transmitter or receiver.




A more detailed **schematic diagram** shows all of the individual electrical components used **to build the radio.** For more information on schematic diagrams and electronic components, you might wish to explore *Electronics Merit Badge.*

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

c. Discuss how information is sent when using amplitude modulation AM), frequency modulation (FM), continuous wave (CW) Morse Code transmission, single sideband (SSB) transmission, and digital transmission.

Transmitters generate "Radio Frequency" (RF) energy. **This RF energy is then modified to convey useful information.**

**The simplest method to send information is to turn the transmitter on and off in recognizable pattern, such as Morse code**. This has the advantage of being simple radios to build, and is very efficient in using both electrical power and "bandwidth". The disadvantage is the both the person transmitting and receiving the signal need to know Morse Code. Morse Code transmissions are **often called "*CW*" for "*Continuous Wave*" which describes how the underlying signal is now generated**.

But how can you send the sound of someone's voice over radio so that an untrained person can hear it?
The first technique to be developed is called ***"Amplitude Modulation*" or *AM***. In this case**, the strength of the RF signaled is varied by the sound of the voice being placed on it**. While simple to do, this requires a bit of power, occupies a bit of bandwidth, and is subject to atmospheric noise, which often similarly AM.

To reduce, the bandwidth and power needed on the HF bands, voice communications are often done using **"*Single SIde Band" (SSB*), which cuts the transmission in half, and suppresses a lot of the carrier signal.** The receiver then adds the carrier back using a "Beat Frequency Oscillator" (BFO) to make the "Donald Duck" sounding signal intelligible. It does require more frequency stability and some skill on the receiving operator, so this is mostly used for point to point communications instead of broadcasting.

For a really good high fidelity sounding signal, which is especially important when transmitting music, **"*Frequency Modulation" (FM*)** is used. In this case **the frequency of the carrier signal is varied by the information, instead of the amplitude**. This provides a very realistic sound, but since it takes lots of power and bandwidth, is restricted to the VHF and higher portions of the spectrum.

**A more modern techniques is *digital* transmission**. In this case**, the audio signal of a voice is sliced up, sampled, measured, and converted to a numerical value for each millisecond.** This data is then sent by microchip computer on the RF as a series of on off pulses, much like an extremely fast Morse Code. The receiving radio's microchip decodes the pattern and numbers to recreate the voice signal in it's speaker. This has the advantage of being less prone to interference as error-correction can be included, and also that computer data can also be sent by radio from one computer to another.

d. Explain how NOAA Weather Radio (NWR) can alert you to danger.

NOAA Weather Radio (NWR) is a series of transmitters operating near 162 MHz across the country sending weather information direct from the National Weather Service. Many Amateur Radio handheld transceivers can receive these broadcasts, making them doubly useful on camping trips. In addition, special NWR receivers can silently monitor the broadcasts and turn themselves on when urgent weather danger threatens. http://www.nws.noaa.gov/nwr/

e. Explain how cellular telephones work. Identify their benefits and limitations in an emergency.

Cellular telephones are radios. They transmit radio signals back and forth to a cell site to make phone calls, send text messages, or data for applications. As you change location, the your radio is transferred to another cell site along your way of travel. For the system to work, the cell sites are connected by landline cables. This makes them vulnerable in disasters, as the these landlines can fail and power can be lost. .

Answers: #6

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

While working on radios is fun, **it's important to be safe**.  Here are some good rules to follow:

- Electrical shock can hurt or kill - **make sure the power is disconnected** before working.
- Even with the power off, some parts inside the radio can hold a dangerous charge. **If you don't know what you are doing, get help**.
- Radio Frequency (RF) can burn - **keep antennas out of reach** .
- Strong RF radiation can be unhealthy - **Don't use a radio when it is not completely assembled**. The case keeps the RF radiation where it should be.
- **Make sure antennas can't touch any power lines** or you could be electrocuted when using the radio.
- **Lightning can hit your antenna** and travel down your lines to the radio. Make sure your antenna and radio are grounded to a good earth ground.
- **Be careful working on towers and roofs** so you don't fall or drop something onto someone on the ground.

Answers: #7

Visit a radio installation (an amateur radio station, broadcast station, or public 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 licenses are required to operate and maintain the equipment, and the purpose of the station.

Note that your counselor must approve the station that you're planning to visit before you go there.  If you're following Option 9a, "Amateur Radio" then you'll probably be visiting a permanent or portable ham radio station when you make your on the air contact.  If not, then ask your counselor to recommend a station to visit.

Ask the following of the operator:

- What type transceiver is he using?
- What type of antenna is he using?
- What does he use his station for?
- What type of License does he have?

Answers: #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.

If you're interested in radio broadcasting as a career, talk to your high school guidance counselor. You'll need to study communications and public speaking in college. Try to find a local non-profit radio station where you can volunteer and get valuable experience. Many colleges and schools have them.

If you're interested in radio engineering, you'll want to take a good college prep curriculum in high school, with a full load of math and sciences. Some colleges well known for electrical engineering include MIT, Lehigh University and RPI.

Many community colleges offer electronic technology courses which can lead to career as an electronic technician working in the cellular telephone, computer networking, or radio repair industries.

Additionally, the US Armed Forces and Coast Guard all make extensive use of radio and offer many jobs and training courses in using and maintaining radio equipment.

Answsers: #9

a. Amateur Radio

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

**Amateur Radio is a hobby where people help others, learn about radio and have fun.** It's called Amateur Radio because the frequencies can't be used for commercial (money-making) purposes. It's also called "Ham Radio"

**The FCC has an Amateur Radio Service for**:

- **Volunteer service** - (community service and disaster help). A Scout does a good turn daily - here's another way.
- **International goodwill** - A great way to talk to people in far away lands.
- **Experimentation** - If you want, you can build your own radio equipment, and many hams build their own antennas. Some hams have come up with new inventions, such as FM, SSB, Packet Radio, Automatic Position Reporting Systems.
- **Communication skills** - Because only one person can talk at a time, you learn how to listen!
- **Self-training** - You can learn by doing.

Hams do lots of things! A few are:

**Jamboree On The Air (JOTA)** is the third weekend every October when Scouts all over the world talk to each other on ham radio.

**DX -** Lots of hams like to talk to other hams around the world and collect postcards called QSL cards to prove they did it. It's a great way to have fun and learn about geography.

**Contests** are held many weekends when you try to contact as many people from a certain place or in a certain way.

**Public Service** at parades & special events - Ham radio operators are often the best people to help with communication at large community events, from small carnivals all the way up to the Boston and New York City Marathons.

**Disasters** - Hams are often called on to help during fires, floods, earthquakes, and other disasters. At these times, telephone lines and cell phone sites are often damaged or overloaded, and ham radio is the only reliable communication.

**Skywarn** - National Weather Service uses Hams to report severe weather.

**Digital Communications** - Some hams hook their computers to their radios so they can send electronic messages, sort of like wireless e-mail.

**Camping** communications are easy even in the backcountry when you need to get help or just let the folks back home know how things are going.

**Parks on the air (POTA)** is portable amateur radio operations that promote emergency awareness and communications from national and state/province level parks.

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

**The Technician Class license is the entry level Amateur Radio license**.

- There is just **one 35 question multiple choice** test on radio theory, rules, and procedures.
- This license gives **full VHF & UHF use** so you can **communicate around town and use repeaters**, but you cannot use some of the HF bands which are used for world-wide contacts.
- The exams are given by **local Volunteer Examiners**.

**By getting this merit badge, you already know about half of what's on the Technician license test! Books are available with all the possible questions and answers!**

**The General Class license is the mid level Amateur Radio license**.

- **You must pass the Technician Class test** first or at the same time..
- There is just **one 35 question multiple choice** test on HF radio theory, rules, and procedures.
- This license adds most **HF band privileges** used for world-wide contacts to the VHF & UHF priledges previously earned.
- The exams are given by **local Volunteer Examiners**.

**The Extra Class license is the highest level Amateur Radio license**.

- **You must pass the Technician Class test** and the **General Class test** first or at the same time.
- There is just **one 50 question multiple choice** test on advanced radio theory and modes of operation.
- This license adds all **privileges** on all amateur bands.
- The exams are given by **local Volunteer Examiners**

c. Explain at least five Q signals or amateur radio terms.

**Q Signals are three letter shortcuts** used in Morse Code and useful when radio operators don't speak the same language. Here are the most common:

**QTH**: location
**QSO**: a Conversation
**QSL**: I acknowlege receipt
**QSY**: Change frequency
**QRM**; Manmade Interference
**QRN**: Noise
**QRP**: Low Power
**QRT**: Stopping Transmitting

Other common terms are

**CW: Morse Code (comes from Continuous Wave)**
**DX**: Long distance
**Ham**: An Amateur Radio Operator
**Phone**: Voice transmissions
**RTTY**: Radio Teletype
**Rig**: My radio
**Shack**: my radio room
**YL**: Young Lady

**Signal reports on Morse Code** are given as:
**RST** (**R**eadabilty, **S**trength, **T**one); **599** is the best.

**Signal Reports on Voice** are given as:
**RS** (**R**eadability, **S**trength); **59** is the best.

**Readability**
1 – Unreadable
2 – Barely readable, occasional words distinguishable.
3 – Readable with considerable difficulty.
4 – Readable with practically no difficulty.
5 – Perfectly readable.

**Signal Strength**
1- Faint signals, barely perceptible.
2- Very weak signals.
3- Weak signals.
4- Fair signals.
5- Fairly good signals.
6- Good signals.
7- Moderately strong signals.
8- Strong signals.
9- Extremely strong signals.

**Tone**
1- Sixty cycle a.c or less, very rough and broad.
2- Very rough a.c., very harsh and broad.
3- Rough a.c. tone, rectified but not filtered.
4- Rough note, some trace of filtering.
5- Filtered rectified a.c. but strongly ripple-modulated.
6- Filtered tone, definite trace of ripple modulation.
7- Near pure tone, trace of ripple modulation.
8- Near perfect tone, slight trace of modulation.
9- Perfect tone, no trace of ripple or modulation of any kind.

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

**On voice, say**

- **Mayday, Mayday, Mayday**
- **Your callsign**
- **Your location**
- **What help you need**
- **Over**

**On Morse Code, send**

- **SOS SOS SOS**
- **Your callsign**
- **Your location**
- **What help you need**
- **AR**

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

**Handheld transceiver (HT): Small, light, portable**, but not much power. Some can fit in your pocket. With repeaters they can be quite useful, and they can go on your hike easily.

Handheld Radios ("HT's")

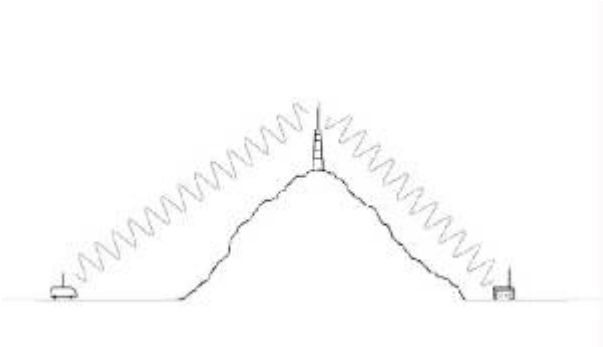
**Base station transceiver**: **Permanent station** in a building. More power, easier to use, more features.

Base Station Radio

**Mobile transceiver**: Permanent station **in a vehicle**. More power. That HT antenna doesn't work well inside a metal car.

Mobile Radio

**Repeaters**: Located on high points (Mountains, tall buildings, satellites) to **automatically relay signals**. Some have connections to the telephone system.



Repeaters listen on one frequency and retransmit on another

**Which kind of radio is best?** It depends on what you want to do. You wouldn't backpack with a heavy base radio, but that base radio will let you talk farther when you are at home.

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

When you make a contact on the air, record the following information for your log:

Date:

Time:

Frequency:

His Callsign:

His Name:

His Location:

His Signal Report (RST):

My Signal Report (RST):

Record this information in your Logbook.  You can buy one or make your own in a notebook by adding columns like this:

| Date / Time | Frequency | Callsign | Name | Location | His RST | My RST | Notes |
|---|---|---|---|---|---|---|---|
| | | | | | | | |

Also, don't forget to make notes about the station you are visiting, so you can also complete Requirement 7 at the same time!