THE WEEKEND AMATEUR RADIO COURSE

TECHNICIAN WORKBOOK

Your Name________________________________________________________

THE WEEKEND AMATEUR RADIO COURSE
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ABOUT THIS WORKBOOK

This workbook is intended to give you a head start on your upcoming amateur radio class. *It would be downright tough, if not impossible, to pass the tests in the classroom without a little open-book work ahead of time.*

This workbook was written by your teacher to help you get started in your studies. The workbook supports the Gordon West *Technician Class* book. This book is optional for this course. The supplied On-Line course has all the information you need to prepare for class day. However, some students prefer a book and work book to a computer screen!

The material which you need to know for the test is divided up into 15 sections to make it easy to study. Do one or two sections each evening.

In each section, FIRST read the outline. All of the information you need to know is in this outline. Then, go to the indicated pages in the Technician Class Book and read through each of the questions in the section. Get familiar with the concepts and the correct answers to the questions. Feel free to jot down notes in your book, but do it next to where the answer is given. **Leave the questions and distractors free of marks.** If you do this, you can test yourself on each question later on by covering up the answer with a piece of heavy paper. Next, fill in the answers to the questions in your workbook. The workbook questions are not exactly the questions that will be on your actual exam. They were chosen to help you learn the concepts and to help make you a better ham! You should not have a problem finding the answers to the questions! Don’t worry if you have a couple of questions left blank where you just can’t seem to find the right answer. We will cover them in class. If you don’t have enough time, do as many of the sections as possible – the more, the better. Your goal is to become familiar with the material.

It is normal for you not to understand some of the technical material found in your book. Please continue to read and review it, even if you don’t understand all of it. I will teach EVERYTHING in class, but I’ve found that if you read it first, you will learn it faster in class.

**DON'T stay up nights worrying about the course.** It is supposed to be FUN! Just do the homework and let your teacher worry about teaching it to you!

So, let’s get started! I think you are going to have a lot of fun! See you in class!

Mitch
1. YOUR LICENSE and CALL SIGN

Purpose of Amateur Radio:
- Noncommercial communication, especially in emergencies
- Advancement of the radio art
- Advancing communication and technical skills
- Providing trained operators and technicians
- Enhance international goodwill

Amateur Station is in the Amateur Service using equipment to communicate
Amateur Radio Service is intended for personal use and not pecuniary interest

FCC makes and enforces the radio rules in the U.S. and possessions
- 3 Classes of License: Technician, General Amateur Extra
- You cannot transmit until your license information shows up in the FCC database

License term is 10 years
- After 10 years, license expires and you can no longer transmit
- Within 2 years (grace period) of expiration you can renew license
- You cannot transmit during the grace period until you renew your license
- After the grace period, you will have to take the tests over

Call sign is a unique identifier given to all radio stations

U.S. Call signs always start with W or A or N or K
- Call signs starting with anything else are other countries
- US Amateur Radio Call signs: 1-2 letters, a number, then 1-3 letters
- Special 1x1 Call Sign: 1 letter, a number, 1 letter - for special events
- Call signs not in the above formats are for other services
- U.S. Call signs are issued in sequential order

Vanity call sign – replaces original assigned call sign
- Can be requested by any amateur
- Technician can request a 1x3 call sign (i.e. K1XXX)
- Extra can request even shorter call sign

Club call sign – requested on behalf of an organization of at least 4 members
- Only the Club call sign trustee can request a club vanity call sign

Special Event 1x1 call sign – (i.e. W1A) short call sign issued for a special event

Identify with call sign at end of conversation (sign off) and also every 10 minutes
- Identify by just saying your call sign – nothing else
- Identify in English and use ITU phonetic alphabet to clarify letters

Special rules for transmitting to radio controlled models:
- No on-air identification given
- A label with call sign, name and address is affixed to the transmitter
- Maximum power for radio control is 1 watt

A Tactical Call Sign is a descriptor to identify your function in an event
- There are no rules requiring how a tactical call sign is used
- A tactical call sign must not sound like another U.S. or foreign call sign
- You still MUST give your FCC call sign every 10 minutes
Your License and Call Sign... continued

A **Self-assigned indicator** is a descriptor used after your Call Sign.
You may use a self-assigned indicator to clarify your location or function.
For example KD1XX / KL7 would indicate that you are in Alaska.
You can use “/”, slash, stroke or slant for the indicator.
Indicators of /KT, /AG, /AE during an upgrade are required, others optional.

**ITU** is the **International Telecommunication Union** – a United Nations Agency.
They divide the world into 3 regions to help manage frequencies regionally.
U.S. and North America are in ITU Region 2 – some U.S. territories in other regions.

Communications are permitted to any country who doesn’t object.
Currently there are no restrictions with communicating with hams in other nations.

International Communications are restricted to **comments of a personal nature**.

International Third Party Communications are restricted to specific countries.
Unlicensed person is a **third party** - restricted to countries allowing third party traffic.

Places where your FCC license is valid:
- U.S. and all territories and possessions
- Ships flying the U.S. flag in International Waters

Operation from other countries allowed when reciprocal agreements permit it.
- A ship flying a non-U.S. flag is considered a foreign country.

Communications to U.S. military stations only permitted on **Armed Forces Day**.

**Review the questions and answers on pages 33-50.**

1. Who issues your ham license? ______________________________
2. What age limit to become a ham? ____________________________
3. What has to happen before you transmit? ____________________
4. Licenses are normally issued for how many years? ____________
5. What is a "Grace Period" and how long is it? ________________
6. U.S. call signs begin with which letters? ____________________
7. You must give your call sign when? __________________________
8. What is a tactical call sign? ________________________________
9. Why would you use a self-assigned indicator? ________________
10. What does the ITU do? ________________________________
11. Why is a 1x1 call sign used? ______________________________
12. Where is your FCC license valid?: __________________________
2. CONTROL OPERATORS and THE RULES

*Licensee* holds the license and assures station be operated in accordance with FCC rules.

*Control operator* is designated by the *licensee* to be responsible for its transmissions.

- All transmitting stations require a control operator.
- Control op must have license in FCC database or have a valid reciprocal license.
- Usually the licensee and control operator are the same person.
- *Both* Control Operator and Licensee responsible for transmissions.
- The FCC assumes *the licensee is the control operator* unless the log shows otherwise.

*Control point:* is the location where control operator function takes place.

Three types of control: local, remote, automatic

- **Local control:** simple control of an HT or radio with microphone or key.
- **Remote control:** control from a distant point using radio, telephone or computer.
- **Automatic control:** no control op - a controller makes decisions; i.e. Repeater, APRS.

Operating privileges are determined by the *license class of the control operator*.

- If you operate at a higher class station, you can *only* use your privileges.
- If you operate at a lower class station, sign the station call sign and your call sign.

When using a satellite or repeater, you must have privileges on the uplink/input.

*The originating* station is responsible for his/her transmissions – not the repeater.

Amateur radio operator *may not get paid* to operate an amateur station.

A classroom teacher is permitted to demonstrate amateur radio.

Amateur Radio Regulations found in *Part 97* of the FCC rules.

Normal business communications not permitted on amateur radio.

- Regular business communications should use other services.
- Communications to employer, employees or for own business not allowed.
- FCC rules DO allow communications for bulletins, demos and amateur training.
- List of amateur equipment for sale allowed on air - but not on a regular basis.

*Broadcasting:* transmission intended for the general public.

- Broadcasting only allowed for code practice, bulletins and emergencies.

Amateur radio not permitted to be used for news gathering.

- Unless these communications directly relate to immediate safety.

Music is prohibited, except if incidentally transmitted from a space station.
Control Operators and The Rules... continued

Indecent and obscene language: always prohibited
   Such language is offensive to some and projects a bad image

Codes and ciphers to hide content or meaning prohibited
   Allowed for control of remote systems or spacecraft

Unidentified transmissions prohibited – even quick repeater key ups

*Harmful Interference:* Transmissions which disturb other communications
   Willful Interference: Interference caused knowingly – never allowed!
   Radiolocation service ALWAYS protected from interference

Amateurs must use *minimum power* necessary to maintain communications

Amateurs must make their stations available for FCC inspection by request

Amateurs must answer all FCC correspondence or have license revoked

# Review the questions and answers on pages 51-62.

1. When is a control operator needed? ________________________________
2. If you transmit from another station, who is responsible? ________________
3. What are the three types of control? ________________________________
4. What privileges can you use when you operate at a club station? ________________
5. Who are responsible if you do something bad on a repeater? ________________
6. Can you be paid while operating an amateur station? ________________
7. Where are the amateur radio rules? ________________________________
8. Can you have a QSO with your boss, who is a ham? ________________
9. What is Broadcasting? ________________________________
10. What do you have to do when keying up a repeater for test? ________________
11. In general, how much power is a U.S. ham allowed? ________________
12. What can happen if the FCC cannot sent you mail? ________________
3. FREQUENCIES

Radio Frequencies (RF) composed of Electromagnetic Waves
Radio Waves: Electromagnetic Waves consist of Electric and Magnetic Fields

Radio waves are alternating current; they vibrate back and forth
Frequency: Number of times they vibrate back and forth (in Hertz or cycles/sec)
Speed: waves travel at near the speed of light: 300 million meters per second
Wavelength: length of the wave - distance traveled in one cycle (in meters)

Wavelength describes the basic properties of the wave
Lower-Longer rule: as frequency goes lower, wavelength gets longer
Also, as frequency goes higher, wavelength gets shorter!
Convert frequency to wavelength: 300 divided by frequency \( \text{wl} = \frac{300}{f} \)
Convert wavelength to frequency: 300 divided by wavelength \( f = \frac{300}{\text{wl}} \)

HF is High Frequency = 3-30 MHz
VHF is Very High Frequency = 30-300 MHz
UHF is Ultra High Frequency = 300-3000 MHz

Band Plan is a voluntary guideline for using various activities on amateur radio

On some bands, amateur radio is available on a secondary basis
The primary user has first rights and amateurs must not cause interference

Never operate right on a band edge!
Modulation will extend the width of the signal out of the band
Error in measurement or drift will cause the signal to be out of band

Metric prefixes are used to specify radio waves:
1000 Hz is 1 KHz
1,000,000 Hz or 1000 KHz is 1 MHz
Convert KHz to MHz by changing the comma to a period

To determine approximate frequency, take 300 and divide by wavelength
To determine approximate wavelength, take 300 and divide by frequency

<table>
<thead>
<tr>
<th>Frequency</th>
<th>Approximate Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>6M</td>
<td>( \frac{300}{6} = 50 \text{ MHz} )</td>
</tr>
<tr>
<td>2M</td>
<td>( \frac{300}{2} = 150 \text{ MHz} ) – approximate to 146 MHz</td>
</tr>
<tr>
<td>1.25M</td>
<td>( \frac{300}{1.25} = 240 \text{ MHz} ) – approximate to 222 MHz</td>
</tr>
<tr>
<td>70CM</td>
<td>( \frac{300}{.7} = 428 \text{ MHz} ) – approximate to 440 MHz</td>
</tr>
<tr>
<td>23CM</td>
<td>( \frac{300}{.23} = 1304 \text{ MHz} ) – approximate to 1296 MHz</td>
</tr>
</tbody>
</table>

2M National Calling Frequency: \( 146.52 \text{ MHz} \)
70CM National Calling Frequency: \( 446.00 \text{ MHz} \)

Certain frequencies restricted by allowed modes:
50-50.1: CW only
144-144.1: CW only
219-220: digital message forwarding
NOT 70cm!!
4. YOUR RADIO

Operating a modern radio:
- **Frequencies** are usually selected with a keypad or VFO knob
- **Frequency** can be stepped with up/down buttons
- **Offset** or **shift** is the difference between receive and transmit frequencies
- **Memory**: stores transmit/receive frequency, tone and power
- **Squelch**: control which quiets noise when no signal is being received
- **PTT**: Push to Talk – activates the transmitter

Hand held Radios are supplied with a short Rubber Duck Antenna
- Rubber Duck is **less efficient** than a full size antenna
- Rubber Duck works even more poorly inside of a car
- Most Hand held radios can connect to an external antenna

An **RF Power Amplifier** increases the power of a Hand held Radio

**Modulation** is the method to send information on a radio

**FM** is mostly used on **VHF and UHF** and also for **Repeaters and Packet Radio**
- FM has a **wide bandwidth** – **10-15 KHz** - and **resists** noise interference
- When you talk louder (**more amplitude**), deviation and bandwidth **increase**

**SSB** is used for high performance **weak signal operations**
- SSB has a **narrow bandwidth** - **2-3 KHz** - and is **harder to tune** than FM
- On 10M, VHF and UHF, we use **Upper Sideband (USB)**

**Computers** are often used in amateur radio
- Send and decode CW and other digital signals
- Logging contacts and keeping information
Frequencies... continued

Review the questions and answers on pages 63-78.
1. What are the two components of a radio wave?
2. How fast do radio waves travel?
3. What is the definition of wavelength?
4. What happens to the wavelength when the frequency goes up?
5. What is the wavelength of 50 MHz?
6. What is the nearest frequency of 70 cm?
7. The frequency 420 MHz is what type of frequency?
8. What is the range of VHF frequencies?
9. Why shouldn’t you operate on a band edge?
10. How many kHz is 28 MHz?
11. How many MHz is 7150 KHz?
12. What three bands have special mode restrictions?

Your Radio... continued

Review the questions and answers on pages 79-82.
1. What is an offset?
2. What does a squelch do?
3. What are the pros and cons of a rubber duck antenna?
4. Two ways to improve HT performance:
5. Why must you connect a microphone with care?
6. What do you need to run a mobile radio in the house?
7. What does a transverter do?
8. Most popular mode on VHF:
9. Why is SSB used?
10. What sideband is used on 10, 6 and 2 meters?
5. ON THE AIR - REPEATERS - EMERGENCY

Before transmitting: Listen; is it legal to be there?; ask if anyone is there

To find activity, call CQ (calling any station), followed by your call sign
NEVER do this on a repeater – just give your call sign
To answer a station, give the their call sign followed by your call sign
When testing equipment on air, always properly identify - no exceptions

If you unintentionally cause interference, identify and move change frequency
No one has any more right to a frequency – common courtesy should prevail

If your signal suddenly gets weak, move a few feet to avoid reflections
Picket fencing: rapid fluttering from mobile stations
UHF signals often work better inside of building due to shorter wavelength
When blocked by obstructions, try a different path with directional antenna

QRM means interference from other stations; QSY means changing frequency

Contest is an activity the involves contacting as many stations as possible
Call a contest station with your full call and give the contest exchange

Grid Locator: a letter-number designator assigned to a geographic location

Repeater: retransmits signals to extend range of mobile/portable stations
Auxiliary station: retransmits signals from a remote site to a repeater
Space Station: repeater in space
All of the above receive on one frequency and transmit on another at same time

To use a repeater, you must know the frequency, offset and tone
CTCSS, DCS, Tone Burst: tone used to access some repeaters
Offset: difference in frequency between repeater’s receiver and transmitter
Common offsets: 2m: 600 KHz; 70cm: 5 MHz
Repeaters (all phone stations) identify themselves via voice or CW

Simplex uses one frequency for receive and transmit
Duplex (repeater) uses two separate frequencies
Use simplex whenever you are in range of the other station

Frequency coordinator selects frequencies for repeaters and auxiliary stations
A frequency coordinator is selected by repeater operators in a particular area
Emergency is when there is immediate threat to human life or property
In an emergency amateurs may use any means of communications to get help
Only applies if normal communications not available - Otherwise FCC rules apply

To get attention, use the word emergency or priority before your message
During an emergency net do not transmit unless directed by Net Control

Most important job: Pass messages accurately

RACES: Radio Amateur Civil Emergency Service
Uses amateur stations for government emergency management
ARES: Amateur Radio Emergency Service
Registry of amateurs who support client agencies such as the Red Cross
Both RACES and ARES provide communications during emergencies

Formal Traffic is a structured method to send messages
Preamble is the information needed to track the message
Check is the number of words in the message to check content
Names and unusual words are always spelled out to avoid confusion

Review the questions and answers on pages 83-104

1. Proper way to find activity: ____________________________________________
2. How do you call a station? ____________________________________________
3. What should you do if your HT suddenly gets weak?________________________
4. Best band to use when inside a building:______________________________
5. What is the Q-signal for changing frequency?___________________________
6. What is an auxiliary station?__________________________________________
7. To use a repeater, you must know:___________, ___________ and ___________
8. The standard offset on 2 meters is:___________ and on 70 cm it is:___________
9. What does simplex mean?__________________________________________
10. When does a repeater identify?________________________________________
11. What is the definition of Emergency?________________________________
12. The most important job of an operator during an emergency__________________
13. What should you do during an emergency net?__________________________
14. What is RACES?____________________________________________________
15. What is a preamble and a check?_____________________________________
6. **WEAK SIGNALS - SPACE**

VHF and UHF Signals travel *line of sight* – they do not normally bend
- Because the earth is curved, radio and light will eventually go into space
- To radio signals, the earth seems less curved and will travel 15% further
  
  *Radio Horizon*: the distance which stations can communicate via direct path

Sometimes VHF/UHF signals travel much beyond line of sight

*Ionospheric Propagation*: Signals bent by Ionosphere 50 miles up
- F layer skip on 10/6 meters best during daylight hours - during sunspot peak
- Sporadic E layer skip permits 10/6/2 meter contacts over 1000 miles
- UHF signals *not* affected by Ionospheric propagation
- Changing of signal path causes signal fading and change of polarization

*Tropospheric Ducting or Scatter*: Signal bent by Troposphere 10 miles up
- Caused by temperature inversions in the atmosphere
- Affects both VHF and UHF to distances up to 300 miles

*Auroral Reflection*: Signals bent by aurora borealis
- These signals exhibit rapid fluctuations and often are distorted

*Meteor Scatter*: Signals bent by meteor trail, usually on 6 meters

*Knife Edge Propagation*: Signals bent over a sharp edged hill

Communications with Space Stations available to *Technician* and higher

*Amateur satellite*: orbiting repeater which greatly extends range of VHF/UHF
- You must know the uplink/downlink frequencies, mode and track of satellite
- Satellites can be high orbit geosynchronous or *Low Earth Orbiting* (LEO)
- Mode indicates the band: V:VHF; U:UHF; U/V:UHF uplink, VHF downlink

Satellite tracking program uses *Keplerian* elements to determine location
- Tracking software determines time, location, azimuth, elevation, frequency shift

Satellites move fast resulting in *Doppler shift* causing their frequency to shift
- Satellites spin rapidly, causing *Spin fading*

*FM Packet* is the most popular digital mode used with satellites

*Satellite Beacons* send information about a satellite

*Telemetry*: One way transmission of measurements from a remote device
*Telecommand*: One way transmission to control a remote device

Amateurs must use *minimum power* to avoid damaging the satellite
7. DIGITAL

*Digital modes:* CW, Packet, PSK31, MFSK, RTTY

CW sent by turning transmitter on and off using Morse code
   CW can be sent with straight key, electronic keyer or computer

*Packet:* Computer ASCII is converted to tones input to a transmitter
   *Terminal Node Controller* (TNC) used between computer and transceiver
   Computer *sound card* can be used in place of TNC to convert packet audio

Packet transmissions includes the text of a message plus:
   *Header* with address information
   *Check sum* for error correction
   *Automatic* Repeat Request (ARQ) used to detect errors and ask for a repeat

Packet radio is superior because it is error correcting
   *Parity Bit:* Extra code element to detect errors
   *Bit Error Rate* (BER): The rate of received errors
   Bit Error Rate goes up as signals propagate over several paths

*Automatic Position Report System* (APRS) used to send location reports on packet
   A Global Positioning System (GPS) receiver necessary

PSK-31: *Phase Shift Keying* - 31 baud is a low rate data mode

*Gateway:* amateur station which connects other stations to the Internet
   Uses *Voice Over Internet Protocol* (VoIP) to convert audio to digital and back
   Several programs use VoIP: IRLP and Echolink
   Lists of VoIP gateways found in Repeater Directory and Internet

*IRLP* is a method to connect repeaters together worldwide via VoIP
   Select an IRLP node by keying in the node ID on radio keypad (DTMF tones)

*NTSC:* Analog modulation for older Fast Scan televisions systems
   Very wide bandwidth: 6 MHz!
Weak Signal - Space... continued

Review the questions and answers on pages 105-118.
1. How do VHF and UHF waves travel?_______________________________________________
2. What is the radio horizon?_______________________________________________________
3. Why do VHF signals sometimes go further than line of sight?________________________
4. What are 4 ways VHF signals go beyond line of sight?______________________________
5. What type of skip affects 10, 6 and 2 meters?______________________________________
6. How far does tropospheric ducting usually go?_____________________________________
7. What is a characteristic of aurora skip?___________________________________________
8. What class of license is required to use satellites?__________________________________
9. What do you need to know to operate through a satellite?____________________________
10. What are the two basic types of satellite orbits?___________________________________
11. What does Doppler Shift cause?__________________________________________________
12. What is Telemetry?_____________________________________________________________

Digital... continued

Review the questions and answers on pages 119-126
1. Name 4 digital modes:______________________________________________________________
2. What 3 things are needed for a packet radio station?________________________________
3. What information is required in a packet transmission?______________________________
4. What information allows packet to correct errors?___________________________________
5. What does an APRS system require?_______________________________________________
6. What is PSK-31?________________________________________________________________
7. What is a gateway?_______________________________________________________________
8. How is voice sent over the Internet?______________________________________________
9. How often is a telecommand transmitter identified?________________________________
10. What is NTSC?_________________________________________________________________
8. EQUIPMENT

A Transceiver combines a transmitter and receiver
Most VHF/UHF Radios operate on FM only
A Multi-mode radio is required for SSB and CW

VHF/UHF Operating Modes:
- **FM:** Wide bandwidth (10-15 kHz), good clarity, shorter distance, most popular
- **SSB:** Narrow bandwidth (2-3 KHz), requires careful tuning, further distance
- **SSB** is a form of AM; **Upper sideband** found on all bands: VHF and UHF
- **CW:** Narrowest bandwidth (150-500 Hz), requires Morse code, furthest distance
A selection of receive bandwidths will result in best receiver noise performance

Receiver components:
- **RF Preamplifier:** Amplifier placed between antenna and receiver
- **Mixer:** Mixes incoming signal with an oscillator to shift it to another frequency

Receiver characteristics:
- **RIT or Clarifier:** Separately tunes receiver to set SSB signal to correct pitch
- **Automatic Gain Control (AGC):** Keeps audio output relatively constant
- **Bandwidth:** width of the received signal -wide for FM, narrow for SSB
- **Sensitivity:** Receiver’s ability to detect the presence of a weak signal
- **Selectivity:** Receiver’s ability to choose between multiple signals
- **Fundamental Overload:** Interference caused by very strong nearby signals

A regulated power supply is used to provide 12-14 volts DC in place of a battery
Regulated means that it prevents voltage fluctuations

**Transverter** produces signals on a higher frequency from a lower frequency

**Modulator:** Mixes speech from microphone with RF carrier to send information
Amplitude modulation (also SSB) changes the amplitude of the signal
Frequency modulation changes the frequency of the signal

A microphone connector often contains voltage to power the microphone

All transmitters start out with an Oscillator, which generates a desired frequency

*proceed to questions on page 19*
9. INTERFERENCE

Microphone gain must be correct or your signal will be distorted
   Too much gain on FM = overdeviation = distortion
   If this is the case, talk farther away from the microphone

Other factors causing a poor signal:
   Transmitter not on correct frequency
   Battery voltage low
   Bad location
   RF Feedback - causes garbled audio

If you are causing interference on nearby frequencies:
   Check for splatter or off-frequency spurious emissions

Automotive ignition systems cause radio interference
   Noise blanker in radio sometimes helps
   Automotive alternators often generate noise which gets transmitted
   Alternator interference sounds like high-pitched whine on transmissions

Shielded wire is used to prevent coupling of unwanted signals into a wire
   RF can also couple into the shield of a wire, causing audio distortion
   A Ferrite Choke is placed around the wire to stop RF coupling
   RF can feed back into a transmitter causing distorted audio
   Make sure antennas and RF are kept away from equipment

Amateur Radio signals can interfere with TV, telephone or other equipment
   Check your station out and make sure it doesn’t bother your TV or equipment
   Make sure all cable TV coaxial connectors are tight

Types of Radio Frequency Interference
   Fundamental Overload: strong nearby transmitter overloading TV or radio
      Block the amateur signal with low or high pass filter on the affected device
   Telephone Interference: strong nearby transmitter heard on telephone
      Block the amateur signal with an RF filter on the telephone
   Harmonics: Transmitter puts out signal on 2, 3, 4 times the frequency
      Block harmonic signals with a low pass filter between the transmitter and antenna
   Spurious Emissions: Transmitter puts out signals on random frequencies
      Shut down transmitter immediately and have it serviced

Part 15 Device: non-licensed device which transmit low level signals
   Interference causing devices must be removed – work with neighbor to find and fix
Review the questions and answers on pages 127-136.

1. Compare FM with SSB: ________________________________
2. What is the typical width of a cw signal? __________________________
3. What does a Mixer do? ________________________________
4. Where is a Discriminator found? ________________________________
5. What circuit is used to separately tune a receiver? __________________________
6. What is Selectivity? ________________________________
7. What is the difference between AM and FM? ________________________________
8. What happens if you talk too loud on a FM transmitter? ________________________________
9. What would a receiver block diagram show? ________________________________
10. Where is a Product Detector found? ________________________________

Equipment... continued

Review the questions and answers on pages 137-144.

1. What is deviation? ________________________________
2. What occurs if you talk too loud into your transmitter? ________________________________
3. Why may you have a bad signal? ________________________________
4. What might cause a whine on your mobile signal? ________________________________
5. Where should a ferrite choke be placed? ________________________________
6. Where should a low-pass filter be placed? ________________________________
7. What do you do if a neighbor complains about interference? ________________________________
8. What is fundamental overload? ________________________________
9. What is it called if you hear your 28 MHz signal on 56 MHz? ________________________________
10. What happens if a Part 15 device causes interference? ________________________________
## 10. VOLTS & AMPS - COMPONENTS

<table>
<thead>
<tr>
<th>What it is?</th>
<th>Voltage</th>
<th>Current</th>
<th>Resistance</th>
<th>Power</th>
</tr>
</thead>
<tbody>
<tr>
<td>Force</td>
<td>Flow</td>
<td>Opposition</td>
<td>Work</td>
<td></td>
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<tr>
<td>Units</td>
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<td>Measured?</td>
<td>Voltmeter</td>
<td>Ammeter</td>
<td>Ohmmeter</td>
<td>Wattmeter</td>
</tr>
</tbody>
</table>

Electricity is the flow of electrons
- **DC** – *Direct Current* - Electricity flows in one direction
- **AC** – *Alternating Current* – Electricity reverses direction regularly
  - **Frequency**: Number of times a second Alternating Current changes direction
  - **Electromotive Force**: another name for Voltage

Good Conductors: Copper, Gold, Silver, Aluminum
Good Insulators: Air, Plastic, Porcelain, Wood

Mobile transceiver requires 12 volts DC
- Connect mobile negative wire directly to battery or ground strap
- For home use, convert 120v AC to 12 volts DC, with a *Power Supply*
- A Power Supply uses a *Rectifier* (diodes) which converts AC to DC
- Nickel-cadmium, Lithium-ion, Lead-acid cells rechargeable; Carbon-Zinc NOT

**Resistor**: Component which opposes the flow of electrons

**Potentiometer**: Resistor which can be varied in value
- Used for a volume control

**Switch**: Component used to disconnect electrical circuits

**Diode**: Component which allows current to flow in only one direction
- Two leads of a diode anode and cathode (marked with a stripe)
- Diodes used to make up a rectifier to convert AC to DC

**Fuse**: Component used to protect other components from overloads

Multimeter: Instrument which measures voltage, current and resistance
- **Voltmeter** measures voltage: always connected *in parallel* with (across) the circuit
- **Ammeter** measures current: always connected *in series* with (through) the circuit
- **Ohmmeter** measures resistance: damaged if used on a powered up circuit
- If Ohmmeter value increases with time, a capacitor is in the circuit
Volts & Amps - Components... continued

Inductor: Coil of wire
   
   Inductor: component used to store energy in a magnetic field
   Inductance: Ability to store energy in a magnetic field
   Henry: Basic unit of Inductance

Capacitor: Two or more surfaces separated by insulator
   
   Capacitor: component used to store energy in an electric field
   Capacitance: Ability to store energy in an electric field
   Farad: Basic unit of Capacitance

Impedance: measure of the opposition to AC current flow in a circuit
   Measured in ohms – similar to resistance

Fuse: disconnects power to protect other components against current overloads
Switch: connects or disconnects circuits

Transistor: Component which can amplify, switch or control current flow
   
   Gain: Amount of amplification provided by a transistor
   Bipolar Transistor is made up of 3 layers of semiconductors
   Bipolar Transistor leads: Emitter, Base, Collector
   Field Effect Transistor (FET) leads: Source, Drain, Gate

Review the questions and answers on pages 145-157.

1. What is Electromotive Force? _________________________________________________

2. How do you connect a voltmeter to a circuit?_____________an ammeter?______________

3. What changes AC to DC? ______________________________________________________

4. A rechargeable battery:_______________a non-rechargeable battery:_________________

5. What component only allows current in one direction?___________________________

6. What are the leads of a diode?___________________________________________________

7. What is a potentiometer?_____________________________________________________

8. How is a capacitor made?_____________________________________________________

9. What is inductance?__________________________________________________________

10. What is the basic unit of inductance?_______________capacitance?_______________

11. Three things a transistor can do?_____________________________________________ 

12. Which component has an emitter?_______________a gate?______________________
11. OHM’S LAW - POWER LAW

Ohm’s Law: Voltage equals Current times Resistance or \( E = I \times R \)
It relates voltage, current and resistance
If you know two measurements, you can calculate the third one!

To Use Ohm’s Law:
Draw a circle, cut it in half, cut bottom in half
Phrase: Eats In Restaurants: E on top, I and R on bottom
Write value for voltage (E) current (I) and resistance (R) in circle
If you go across circle: multiply. If you go up-down, divide
Find the Ohm’s Law by covering up the letter to the left of the = sign

Example: 100-ohm resistor connected to 200 volts. What is the current?
100 ohms is resistance – write 100 where the R is
200 volts is voltage – write 200 where the E is
Current (I) is 200 over 100 – or 200 divided by 100, which is 2 amps

Power Law: Power equals Voltage times Current or \( P = E \times I \)

To Use Power Law:
Draw a circle, cut it in half, cut bottom in half
Phrase: After Eating in Restaurant, what’s for dessert? PIE!!
Write value for power (P), current (I) and voltage (E) in circle
If you go across circle: multiply. If you go up-down, divide
Find the Power Law by covering up the letter to the left of the = sign

Review the questions and answers on pages 158-162.
1. A 3 ohm resistor is connected to 12 volts. What is the current? ________________
2. What is the current of a 60 watt light bulb at 120 volts? ________________
3. What is the formula to calculate resistance in a circuit? ____________________
4. A resistor of 20 ohms has 20 amps through it. What is the voltage? ____________
5. In the above question, what is the power? ________________________________
12. METRIC - MEASUREMENTS

<table>
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<th>milli</th>
<th>no prefix</th>
<th>kilo</th>
<th>Mega</th>
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</thead>
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<td>1/1000</td>
<td>1</td>
<td>1000</td>
<td>1,000,000</td>
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<tr>
<td>6 places</td>
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<td>3 places</td>
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</tbody>
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move decimal to right  <<<  move decimal to left  >>>

Small to large conversions: Answer will always be a smaller number
- Hertz to Kilo hertz: Move decimal 3 places to left
- Milliamps to Amps: Move decimal 3 places to left
- Milliwatts to Watts: Move decimal 3 places to left
- Microvolts to Volts: Move decimal 6 places to left
- Picofarads to microfarads: Move decimal 6 places to left

Large to small conversions: Answer will always be a larger number
- Amps to Milliamps: Move decimal 3 places to right
- Kilovolts to Volts: Move decimal 3 places to right

Decibels use a logarithmic scale
- 3 db is 2x power
- 6 db is 4x power
- 10 db is 10x power
- -3 db means 1/2x power
- -6 db means 1/4x power

Rosin Core Solder used for electronic circuits
- Rosin is a chemical inside the solder which cleans surfaces
- Any other type of cleaner will damage electronics

A cold solder joint has not been heated enough to make a good connection
- Cold solder joint has a grainy dull finish

1. How many milliamps is 2.5 amps? ____________________________

2. How many kilovolts is 2000 volts? ____________________________

3. 100 milliwatts is how many watts? ____________________________

4. Why would an ohmmeter show an increasing value? ______________

5. When you increase power from 5 to 20 watts, how many dB is this? ______________
13. MORE COMPONENTS

Resistor  Variable Resistor  Inductor  Variable Inductor
Transformer  Capacitor  Battery  Antenna
Switch  Lamp  Light Emitting Diode  Transistor

Schematic symbols: Standard representations of components
Schematic diagram shows the way components are interconnected

Tuned Circuit: Made up of an inductor and capacitor

Meter: Measures current or voltage
Used to display signal strength

Relay: Switch controlled by an electromagnet

Transformer: Changes one AC voltage to another

Regulator: Controls the amount of voltage from a power supply

Integrated Circuit: Device combines many semiconductors in one package

Light Emitting Diode (LED): Used as a visual indicator

Review the questions and answers on pages 163-174.

1. An inductor and capacitor hooked together forms a: _____________________________
2. What other component does a transformer symbol look like? _____________________
3. Name two components which are visual indicators:______________________________
4. A power supply consists of a transformer, filter and:________________________________
5. A variable resistor or inductor has how many leads? _____________________________
14. ANTENNAS - COAX - SWR

Polarization is the orientation of the antenna with respect to ground
- Vertical antenna’s Electric field is oriented perpendicular to ground
- Horizontal antenna’s Electric field is oriented parallel to ground
Weak signal communications use horizontal antennas; Repeaters use vertical
Mixing vertical and horizontal might result in signals 100 times weaker!

Size (length) of antenna determines its resonant frequency
- Lower-Longer: lower freq needs longer ant & higher freq needs shorter ant
- Length of 6 meter dipole: 112”
- Length of 2 meter vertical: 19”

Dipole antenna radiates best broadside to antenna (Not off the ends!)

A 5/8 wave antenna radiates lower and has gain over ¼ wave antenna
- Best location for mobile antenna is roof center – offers uniform pattern
- A coil can be inserted into an antenna to make it electrically longer

Beam, yagi, quad and dish all are directional antennas
- These concentrate transmitted and received signal in one direction
- Gain: the increase of signal strength in one direction
- Directional antennas often used in hidden transmitter hunts and finding noise

Coaxial cable (coax) used to carry RF signals between radio and antenna
- Easy to use and it matches the 50 ohm impedance of all amateur transmitters
- Coax usually black to resist ultraviolet radiation from sun which can damage it
- At higher frequencies, power in coaxial cable is lost as heat
- Cables age and loss increases, especially when moisture gets in
- Large diameter cables (RG-8) have lower loss than small diameter cables (RG-58)
- Air Insulated hard-line coax has the lowest loss at VHF
- Air core coax cable requires special handling to keep moisture out

Coax connectors must be sealed to keep moisture out and an increase in loss
- PL-259 connectors used on HF - not good for UHF
- N connectors most suitable for UHF frequencies above 400 MHz

Standing Wave Ratio (SWR) measures how well transmitter is matched to antenna
- SWR must be kept low to keep losses low and insure best power transfer
- Best SWR is 1:1; Acceptable SWR is 2:1; Over that is a major impedance mismatch
- SWR measured with an SWR meter or Directional Wattmeter
- Antenna resonance (also SWR) can be measured with an antenna analyzer
- Erratic SWR usually means a bad connection in antenna or feed line
Antennas... continued

Antenna tuner is used to match antenna impedance to transceiver's impedance
Antenna switch is used to feed an antenna to a receiver or transmitter

Dummy load used to test transmitter without radiating a signal
Consists of non-inductive 50 ohm resistor and heat sink

Review the questions and answers on pages 175-191.

1. What is a vertical antenna? ___________________________________________________
2. What would happen if local stations used mixed polarization? _________________
3. What usually happens when you make a vertical antenna longer? _______________
4. How long is a quarter wave vertical antenna for 2 meters? _________________
5. Name a nondirectional antenna: ________ Name a directional antenna: ________
6. Name 3 types of gain antennas: ____________________________________________
7. As coax cable length increases, what happens? ______________________________
8. Where does cable loss go? _________________________________________________
9. What connectors should be used at UHF frequencies? _________________________
10. What is SWR? ____________________________________________________________
11. Give an example of a good SWR and bad SWR _____________________________
12. What is likely happening if the SWR varies rapidly? _________________________
15. SAFETY

Hazards of electricity

Voltage over 30 volts can kill – Never touch a live circuit!
Voltage can exist on a power supply even when disconnected due to capacitors
Assure your voltmeter and leads are rated for the high voltage you will measure
Currents through the body of 100 milliamperes (0.1A) will kill
Current in the body cause muscle contractions, body heating and disrupts cells
Misused storage batteries of any voltage can short, overheat, cause fire or explode
Touching an antenna while transmitting will result in an RF burn
Being near an antenna while transmitting will result in RF heating of the body

A 12-volt battery can be charged from a car's electrical system
Connect the battery across the vehicle’s battery and run the engine
Batteries must be charged properly or dangerous gas is emitted

Good Electrical Wiring safety tips

Use 3-wire power cords and plugs with ground
Connect chassis of all equipment to common ground
Use ground fault circuit interrupter
Use the correct size fuse in all power leads to stop overloads and fires
Green wire of power cord is Ground

Tower and antenna mounting

Antennas should be mounted in a place where people can’t touch
If a tower falls, it still should be greater than 10’ from a power line
Never put antenna near power lines or utility poles
Gin Pole is used to hoist tower sections or antennas up to top of tower

Tower safety

Ground crew wears always wears hard hat and safety goggles for protection
Climbers always use safety belt and goggles when climbing a tower
Before climbing, inspect tower, check for power lines and have a helper
Never climb an extended crank-up tower

Station Grounding

Use flat copper strap for grounding – NOT wire which acts like an antenna
Grounds must be a short and direct as possible without sharp bends
All grounds come together at one common point
Tower grounded with 8’ ground rods at each tower leg per local electrical code
Radio Wave Safety

Radio Waves are called non-ionizing radiation - does not cause genetic damage

Touching an antenna while transmitting will result in an RF burn

Being near an antenna while transmitting can result in injury due to RF heating

Certain factors can cause excessive RF power to be absorbed into the body

Factors include frequency, power, antenna gain and distance to antenna

Frequency is important because the body absorbs RF most at VHF

Lowest exposure limits (the worst frequencies) found on 50 MHz

Radio Wave Safety Rules

RF Exposure Evaluation is required when running over 50 watts above 30 MHz

Evaluation done using a Field Strength meter, computer modeling or OET 65

Evaluation must be repeated when station configuration is changed

If limits are exceeded, relocate antennas away from people

Duty cycle is the percentage of time spent transmitting

Duty cycle affects the total exposure to RF

50% Duty cycle means you can double the exposure time

Review the questions and answers on pages 193-205.

1. What minimum voltage is considered dangerous? ______________________________

2. What amount of current is considered lethal? ________________________________

3. How far should towers be from power lines? ________________________________

4. Three things to do before climbing a tower: ________________________________

5. How should grounds be run and with what? ________________________________

6. What occurs when you touch a transmitting antenna? ________________________

7. What occurs when you are near a transmitting antenna? _____________________

8. Four factors which control RF exposure: _________________________________

9. When is an RF Exposure Evaluation required? ____________________________

10. Three allowed methods of performing the Exposure Evaluation: _____________

CONGRATULATIONS!

You have gone through all of the questions. Go back and review them again and make notes on what topics and questions you might not understand.
COMING TO CLASS & TAKING THE EXAM

Read chapter 5, pages 207-216.

We’re just a few more days away from the upcoming ham class. Class starts promptly at the time indicated on the course information sheet (usually 8:30).

We will explore the Technician material on Saturday. During the day, there will be discussion, questions and answers, practice quizzes and demonstrations. There will be a 1 hour lunch break at around 1:00 and several shorter “stretch” breaks. The class will typically end at 6:00 PM. At that time exams for the Technician license will be given.

Before coming to class, you will need to bring a few items required for taking your test. The Volunteer Examiners require you to have TWO forms of identification. They also require an exam fee to cover their costs in duplicating the exam materials. Also bring whatever else you need to take an exam like pens, pencils and a calculator.

By Saturday evening, you will have completed your amateur radio study, passed the examination, and will leave with a certificate of successful completion. It will take about a week to process your new ham radio call sign. Under new FCC rules, you will be able to operate as soon as you learn what your call sign is. Your Volunteer Examiners will give you information on how to find out what your call sign is before it actually arrives from the FCC.

If you are continuing with the General class on Sunday, plan to spend a hour or so reviewing the General material and then get a good night’s rest! The General instruction on Sunday will follow the same schedule as the Technician instruction.
SOON YOU WILL BE
A HAM RADIO OPERATOR !!

If you haven't already, review your Technician theory book. Highlight and check off those questions you know cold. Put a red circle around those questions and answers that you have questions about. Our classroom discussion will answer those questions.

Get a good night’s sleep before class. And don’t forget to set your alarm clock!

Per FCC rules, your volunteer examiners must use the questions and answers that are part of the Technician theory book. There will be no surprises. If you know the book, you’ll pass the test!

I look forward to seeing you in class. If you have questions regarding your homework or regarding the class please call me at 802-879-6589 or E-mail me at w1sj@arrl.net. I look forward to hearing from you, and will see you soon in your upcoming Weekend Amateur Radio Course.

Mitch Stern W1SJ