Technician License Course
Chapter 4

Lesson Plan Module 10 –
Practical Antennas

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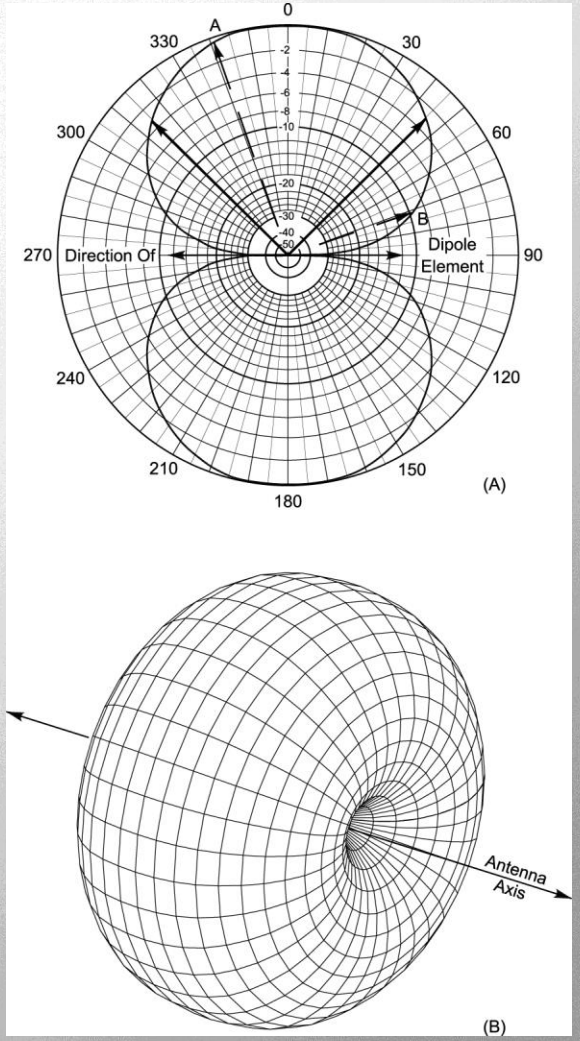
The Dipole

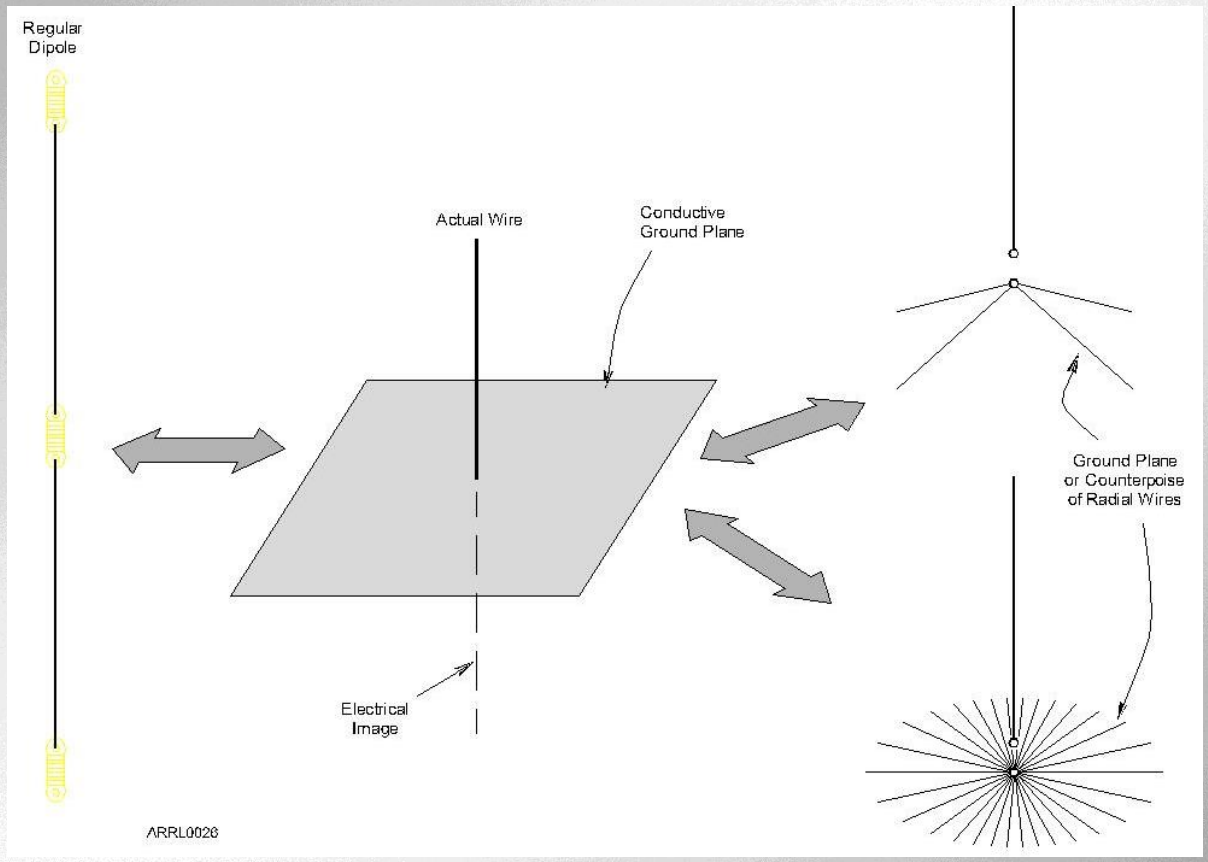
- Most basic antenna
- Total length is ½ wavelength (½ λ)
- Usual construction:
  - Two equal halves of wire, rod, or tubing
  - Feed line connected in the middle
- Length (in feet) usually estimated
  - 468 / frequency (in MHz) – often too short

The Dipole

- Radiates strongest broadside to the dipole, weakest off the ends
- If oriented horizontally, the radiated waves are horizontally polarized
- 3D radiation pattern looks like a donut or bagel
  - This is a *free-space* picture



The Ground-Plane



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The Ground-Plane

- One-half of a dipole (1/4-wavelength long) oriented perpendicularly to a *ground plane* that acts as an "electrical mirror"
  - Replaces the dipole's missing half
- Any conducting surface can act as the ground-plane, including the ground!
  - Car roof or trunk, or other metal surface
  - Radial wires

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The Rubber Duck

- Coiled wire coated in tough plastic
- Convenient size, rugged enough for handheld use
- The radio and operator make up the ground plane
- Small size equals compromise performance
  - Hold vertically to maximize range
- Doesn’t work well inside vehicles due to metal body shielding signal
- For mobile use, replace rubber duck with an external magnet-mount or permanent antenna

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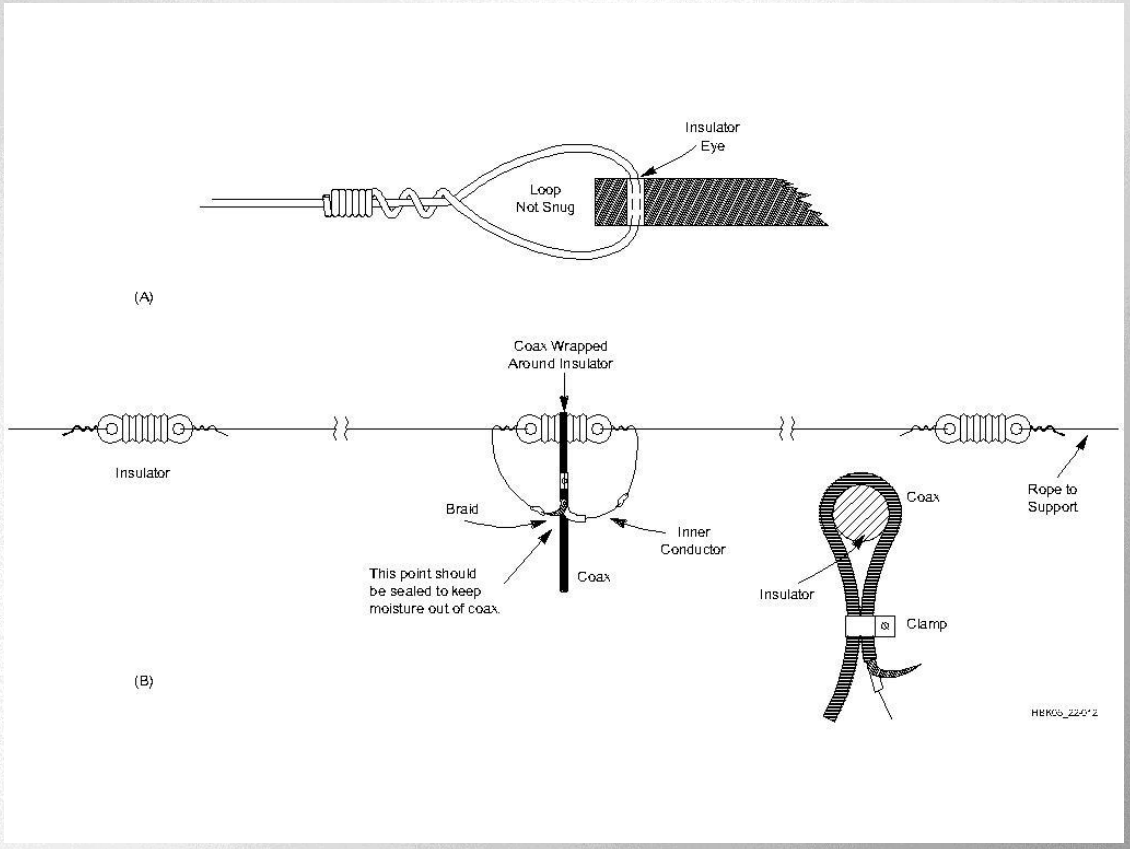
Dipole Construction

- Start with excess length (490 / f) and adjust
- To raise resonant frequency, shorten each half equally



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Ground-Plane Construction

- Length (in feet) usually estimated
  - 234 / frequency (in MHz) – often short, start long and trim to length
  - Thickness of whip or rod also affects calculated length
- Vertical ground-plane antennas are omni-directional
  - Mount mobile whips in center of roof or trunk for best coverage

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Ground-Plane Construction

- Lengthening a ¼-wavelength VHF/UHF ground-plane to 5/8 wavelengths focuses more signal toward the horizon which usually improves range.
- At HF, vertical antenna size is quite large.
  - 40 meter ¼-wavelength whip is about 32 feet
  - Inserting an inductor makes the antenna longer electrically
  - Reduces physical length required

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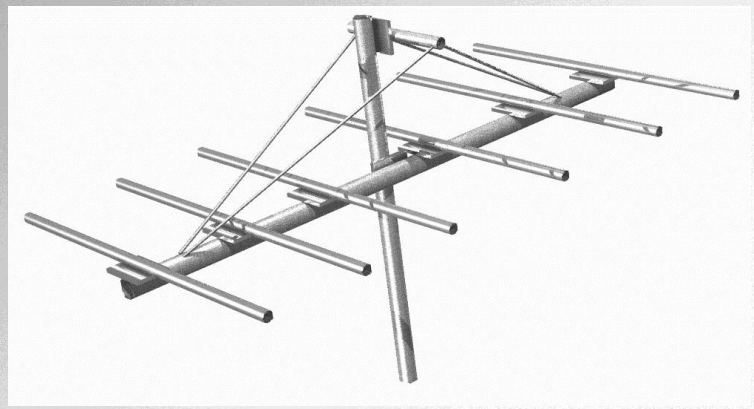
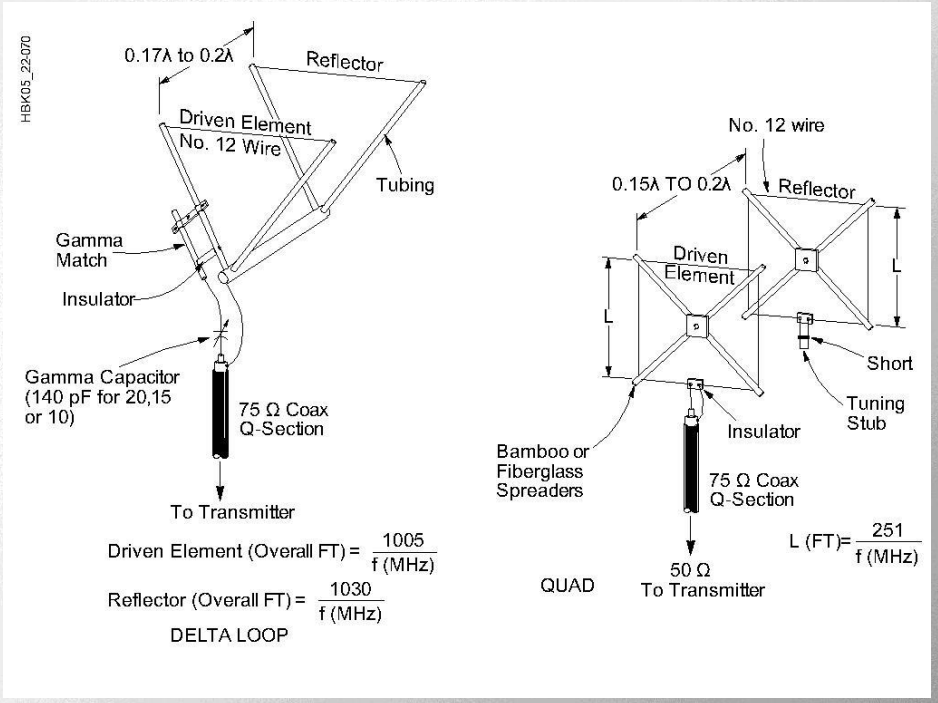
Directional (Beam) Antennas

- Beam antennas focus or direct RF energy in a desired direction.
  - Gain improves range
  - Reduces reception in unwanted directions
  - Reduces interference to and from other stations
- Directional characteristics are the same for receiving as they are for transmitting.

Directional (Beam) Antennas

Yagi





Quads

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Directional (Beam) Antennas

- Used for “DXing” to obtain maximum range for contacts
- Can be used at VHF/UHF to avoid multi-path and bypass obstructions
  - Use vertical elements for repeaters and FM simplex contacts
  - Use horizontal elements for CW and SSB contacts to reduce ground losses

Directional (Beam) Antennas

- At microwave frequencies (above 1 GHz) it becomes practical to use a dish antenna
- Short wavelength
- High gain
- Small size

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Practical Feed Lines

- Coaxial cables
  - Larger diameter cables have lower loss
    - Loss is measured in dB/foot
    - Loss increases with frequency
  - Keep water out! Protect the jacket from cuts and cracks and ultraviolet exposure.
    - Some cable is UV-rated

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Common Coaxial Cables

- RG-174: miniature, short connections only
- RG-58: 0.2" OD, lossy at VHF/UHF
- RG-8X: 0.25" OD, good through low VHF
- RG-8/RG-213; 0.4" OD, used through UHF
- Hard line: ½" to multiple inch OD, used through microwave
- Most coax is 50 Ω or 75 Ω

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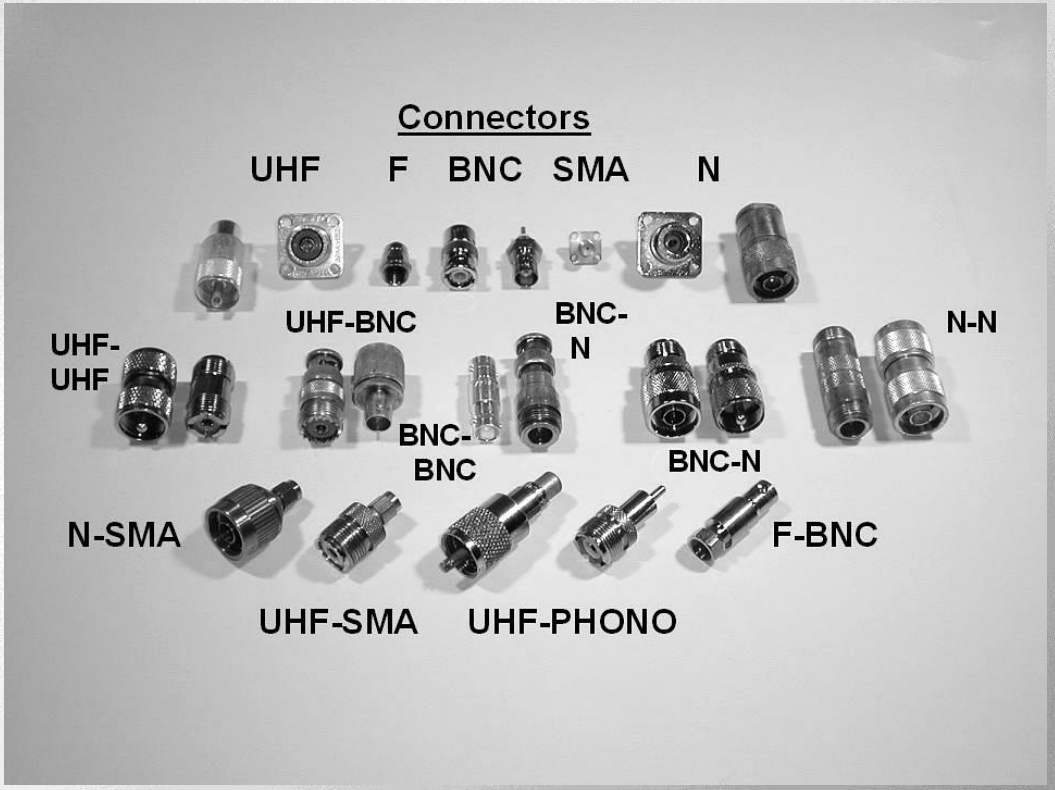
Coaxial Connectors

- UHF
  - SO-239/PL-259
- BNC
- N
- SMA
- F (cable TV)



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Installing Coaxial Connectors

- Soldering is the traditional way
  - Use rosin-core solder and avoid “cold” solder joints
  - See *The Art of Soldering* on the ARRL website
- Crimp connectors are becoming widely used by hams
  - Obtain and learn to use proper crimping tools

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Waterproofing Connectors

- **MUST** be waterproofed for use outdoors
  - Type N are waterproof but still usually protected anyway
- Use good-quality electrical tape first, then a layer of self-vulcanizing tape, then another covering of electrical tape
- Air-core coaxial cable requires special connectors and techniques to waterproof

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Practical Feed Lines

- Open-wire feed lines
  - Flexing will eventually break conductors
  - Vulnerable to abrasion and twisting
  - Rain, snow, and ice do affect the line
  - Lower loss than coax, generally
  - Higher impedance may complicate use

Feed Line Equipment

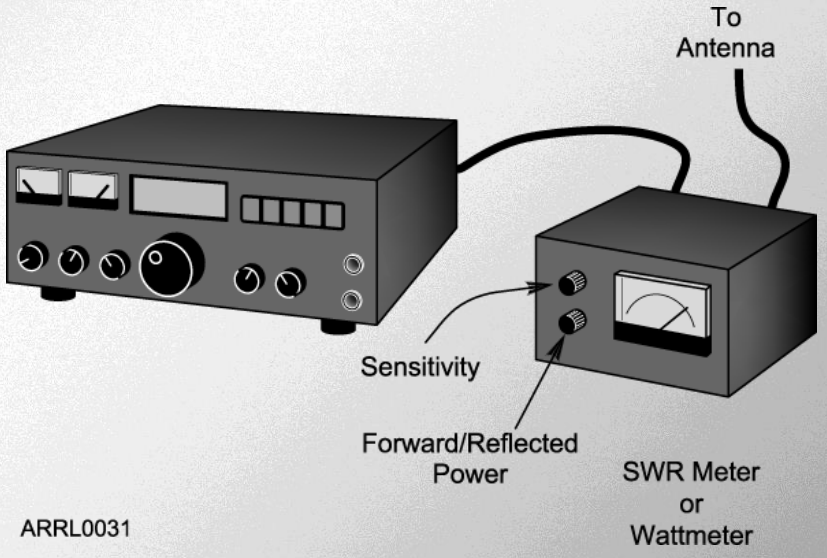
- Wattmeters
- SWR Meters
- Antenna Tuners
- Antenna Analyzers

Wattmeters

- Most wattmeters are *directional*
  - Sensitive to direction of power flow
  - Read forward and reflected power
  - Use a sensing element
- SWR is computed from power values
  - Table or formula

SWR Meters

- Measure SWR directly by sensing power flow in the line
- Usually installed at the transmitter



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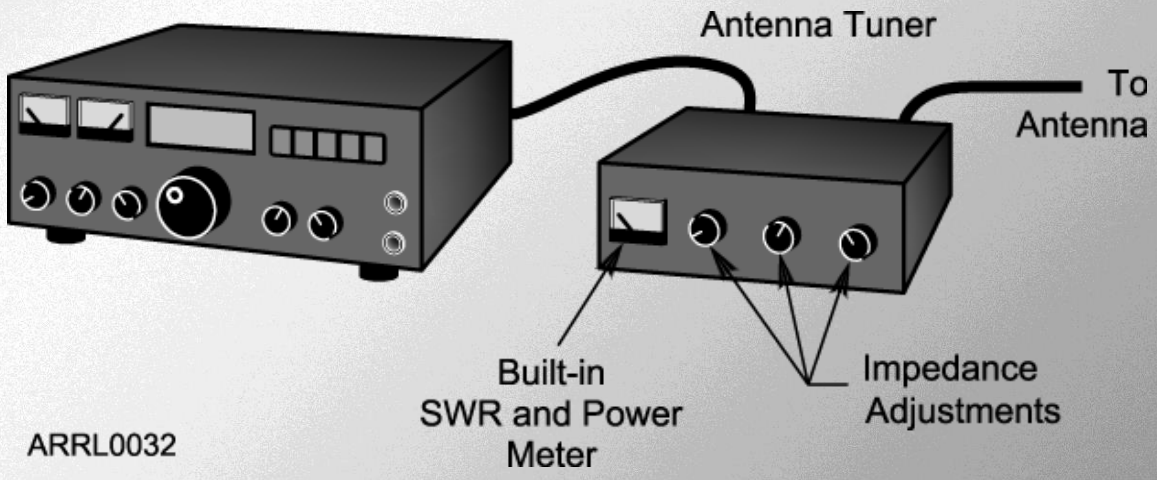
Antenna Tuners

- Don't really "tune the antenna"
- Transform impedances at the end of the feed line to 50 Ω which reduces SWR to 1:1
  - Antenna feed point impedance unchanged
  - Feed line SWR unchanged
- Also called *impedance matchers*, *transmatches*, *matchboxes*, other trade names

How to Use an Antenna Tuner

- Transmit a low-power signal
- Monitor the SWR meter
- Adjust the tuner until minimum SWR is achieved



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Antenna Analyzers

- Low-power signal source, frequency counter, and SWR meter in one package
- Makes antenna and cable measurements without transmitting a full-power signal
- Available for HF through UHF and microwave
- Very handy for adjusting and troubleshooting antennas and feed lines

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Practice Questions

What antenna polarization is normally used for long-distance weak-signal CW and SSB contacts using the VHF and UHF bands?

A. Right-hand circular

B. Left-hand circular

C. Horizontal

D. Vertical

T3A03 HRLM (4-15)

ARRL The national association for AMATEUR RADIO

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T3A03 HRLM (4-15)

ARRL The national association for AMATEUR RADIO

When using a directional antenna, how might your station be able to access a distant repeater if buildings or obstructions are blocking the direct line of sight path?

A. Change from vertical to horizontal polarization

B. Try to find a path that reflects signals to the repeater

C. Try the long path

D. Increase the antenna SWR

T3A05 HRLM (4-14)

ARRL The national association for AMATEUR RADIO

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T3A05 HRLM (4-14)

ARRL The national association for AMATEUR RADIO

Where should an in-line SWR meter be connected to monitor the standing wave ratio of the station antenna system?

A. In series with the feed line, between the transmitter and antenna

B. In series with the stations ground

C. In parallel with the push-to-talk line and the antenna

D. In series with the power cable, as close as possible to the radio

T4A05 HRLM (4-18)

ARRL The national association for AMATEUR RADIO

Where should an in-line SWR meter be connected to monitor the standing wave ratio of the station antenna system?

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T4A05 HRLM (4-18)

ARRL The national association for AMATEUR RADIO

Which of the following instruments can be used to determine if an antenna is resonant at the desired operating frequency?

A. A VTVM

B. An antenna analyzer

C. A Q meter

D. A frequency counter

T7C02 HRLM (4-19)

ARRL The national association for AMATEUR RADIO

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D. A frequency counter

T7C02 HRLM (4-19)

ARRL The national association for AMATEUR RADIO

What instrument other than an SWR meter could you use to determine if a feed line and antenna are properly matched?

A. Voltmeter

B. Ohmmeter

C. Iambic pentameter

D. Directional wattmeter

T7C08 HRLM (4-18)

ARRL The national association for AMATEUR RADIO

What instrument other than an SWR meter could you use to determine if a feed line and antenna are properly matched?

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T7C08 HRLM (4-18)

ARRL The national association for AMATEUR RADIO

Which of the following is the most common cause for failure of coaxial cables?

A. Moisture contamination

B. Gamma rays

C. The velocity factor exceeds 1.0

D. Overloading

T7C09 HRLM (4-16)

ARRL The national association for AMATEUR RADIO

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T7C09 HRLM (4-16)

Why should the outer jacket of coaxial cable be resistant to ultraviolet light?

A. Ultraviolet resistant jackets prevent harmonic radiation

B. Ultraviolet light can increase losses in the cable's jacket

C. Ultraviolet and RF signals can mix together, causing interference

D. Ultraviolet light can damage the jacket and allow water to enter the cable

T7C10 HRLM (4-16)

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T7C10 HRLM (4-16)

ARRL The national association for AMATEUR RADIO

What is a disadvantage of air core coaxial cable when compared to foam or solid dielectric types?

A. It has more loss per foot

B. It cannot be used for VHF or UHF antennas

C. It requires special techniques to prevent water absorption

D. It cannot be used at below freezing temperatures

T7C11 HRLM (4-17)

ARRL The national association for AMATEUR RADIO

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T7C11 HRLM (4-17)

ARRL The national association for AMATEUR RADIO

Which of the following is a common use of coaxial cable?

A. Carrying dc power from a vehicle battery to a mobile radio
B. Carrying RF signals between a radio and antenna
C. C. Securing masts, tubing, and other cylindrical objects on towers
D. D. Connecting data signals from a TNC to a computer

T7C12 HRLM (4-9)

ARRL The national association for AMATEUR RADIO

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T7C12 HRLM (4-9)

ARRL The national association for AMATEUR RADIO

Which of the following types of solder is best for radio and electronic use?

A. Acid-core solder

B. Silver solder

C. Rosin-core solder

D. Aluminum solder

T7D08 HRLM (4-17)

Which of the following types of solder is best for radio and electronic use?

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T7D08 HRLM (4-17)

ARRL The national association for AMATEUR RADIO

What is the characteristic appearance of a cold solder joint?

A. Dark black spots

B. A bright or shiny surface

C. A grainy or dull surface

D. A greenish tint

T7D09 HRLM (4-17)

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T7D09 HRLM (4-17)

ARRL The national association for AMATEUR RADIO

What is a beam antenna?

A. An antenna built from aluminum I-beams

B. An omnidirectional antenna invented by Clarence Beam

C. An antenna that concentrates signals in one direction

D. An antenna that reverses the phase of received signals

T9A01 HRLM (4-14)

ARRL The national association for AMATEUR RADIO

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T9A01 HRLM (4-14)

ARRL The national association for AMATEUR RADIO

Which of the following describes a simple dipole mounted so the conductor is parallel to the Earth's surface?

A. A ground wave antenna

B. A horizontally polarized antenna

C. A rhombic antenna

D. A vertically polarized antenna

T9A03 HRLM (4-11)

ARRL The national association for AMATEUR RADIO

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T9A03 HRLM (4-11)

ARRL The national association for AMATEUR RADIO

What is a disadvantage of the “rubber duck” antenna supplied with most handheld radio transceivers?

A. It does not transmit or receive as effectively as a full-sized antenna

B. It transmits a circularly polarized signal

C. If the rubber end cap is lost it will unravel very quickly

D. All of these choices are correct

T9A04 HRLM (4-13)

ARRL The national association for AMATEUR RADIO

What is a disadvantage of the “rubber duck” antenna supplied with most handheld radio transceivers?

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T9A04 HRLM (4-13)

ARRL The national association for AMATEUR RADIO

How would you change a dipole antenna to make it resonant on a higher frequency?

A. Lengthen it

B. Insert coils in series with radiating wires

C. Shorten it

D. Add capacitive loading to the ends of the radiating wires

T9A05 HRLM (4-12)

ARRL The national association for AMATEUR RADIO

How would you change a dipole antenna to make it resonant on a higher frequency?

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B. Insert coils in series with radiating wires

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T9A05 HRLM (4-12)

ARRL The national association for AMATEUR RADIO

What type of antennas are the quad, Yagi, and dish?

A. Non-resonant antennas

B. Loop antennas

C. Directional antennas

D. Isotropic antennas

T9A06 HRLM (4-15)

What type of antennas are the quad, Yagi, and dish?

A. Non-resonant antennas

B. Loop antennas

C. Directional antennas

D. Isotropic antennas

T9A06 HRLM (4-15)

ARRL The national association for AMATEUR RADIO

What is a good reason not to use a “rubber duck” antenna inside your car?

A. Signals can be significantly weaker than when it is outside of the vehicle

B. It might cause your radio to overheat

C. The SWR might decrease, decreasing the signal strength

D. All of these choices are correct

T9A07 HRLM (4-13)

ARRL The national association for AMATEUR RADIO

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T9A07 HRLM (4-13)

ARRL The national association for AMATEUR RADIO

What is the approximate length, in inches, of a quarter-wavelength vertical antenna for 146 MHz?

A. 112

B. 50

C. 19

D. 12

T9A08 HRLM (4-11)

ARRL The national association for AMATEUR RADIO

What is the approximate length, in inches, of a quarter-wavelength vertical antenna for 146 MHz?

A. 112

B. 50

C. 19

D. 12

T9A08 HRLM (4-11)

What is the approximate length, in inches, of a 6 meter 1/2-wavelength wire dipole antenna?

A. 6

B. 50

C. 112

D. 236

T9A09 HRLM (4-11)

What is the approximate length, in inches, of a 6 meter 1/2-wavelength wire dipole antenna?

A. 6

B. 50

C. 112

D. 236

T9A09 HRLM (4-11)

In which direction is the radiation strongest from a half-wave dipole antenna in free space?

A. Equally in all directions

B. Off the ends of the antenna

C. Broadside to the antenna

D. In the direction of the feed line

T9A10 HRLM (4-11)

In which direction is the radiation strongest from a half-wave dipole antenna in free space?

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T9A10 HRLM (4-11)

ARRL The national association for AMATEUR RADIO

What is a reason to use a properly mounted 5/8 wavelength antenna for VHF or UHF mobile service?

A. It offers a lower angle of radiation than a 1/4 wavelength antenna and usually provides improved coverage

B. It features a very high angle of radiation and is better for communicating via a repeater

C. The 5/8 wavelength antenna completely eliminates distortion caused by reflected signals

D. The 5/8 wavelength antenna offers a 10-times power gain over a 1/4 wavelength design

T9A12 HRLM (4-13)

ARRL The national association for AMATEUR RADIO

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T9A12 HRLM (4-13)

ARRL The national association for AMATEUR RADIO

Why are VHF or UHF mobile antennas often mounted in the center of the vehicle roof?

A. Roof mounts have the lowest possible SWR of any mounting configuration

B. Only roof mounting can guarantee a vertically polarized signal

C. A roof mounted antenna normally provides the most uniform radiation pattern

D. Roof mounted antennas are always the easiest to install

T9A13 HRLM (4-13)

ARRL The national association for AMATEUR RADIO

Why are VHF or UHF mobile antennas often mounted in the center of the vehicle roof?

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T9A13 HRLM (4-13)

ARRL The national association for AMATEUR RADIO

Which of the following terms describes a type of “loading” when referring to an antenna?

A. Inserting an inductor in the radiating portion of the antenna to make it electrically longer

B. Inserting a resistor in the radiating portion of the antenna to make it resonant

C. Installing a spring at the base of the antenna to absorb the effects of collisions with other objects

D. Making the antenna heavier so it will resist wind effects when in motion

T9A14 HRLM (4-13)

ARRL The national association for AMATEUR RADIO

Which of the following terms describes a type of “loading” when referring to an antenna?

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T9A14 HRLM (4-13)

ARRL The national association for AMATEUR RADIO

What does an antenna tuner do?

A. It matches the antenna system impedance to the transceiver's output impedance

B. It helps a receiver automatically tune in weak stations

C. It allows an antenna to be used on both transmit and receive

D. It automatically selects the proper antenna for the frequency band being used

T9B04 HRLM (4-18)

ARRL The national association for AMATEUR RADIO

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T9B04 HRLM (4-18)

ARRL The national association for AMATEUR RADIO

Which of the following connectors is most suitable for frequencies above 400 MHz?

A. A UHF (PL-259/SO-239) connector

B. A Type N connector

C. An RS-213 connector

D. A DB-25 connector

T9B06 HRLM (4-17)

ARRL The national association for AMATEUR RADIO

Which of the following connectors is most suitable for frequencies above 400 MHz?

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B. A Type N connector

C. An RS-213 connector

D. A DB-25 connector

T9B06 HRLM (4-17)

ARRL The national association for AMATEUR RADIO

Which of the following is true of PL-259 type coax connectors?

A. They are preferred for microwave operation

B. They are water tight

C. The are commonly used at HF frequencies

D. They are a bayonet type connector

T9B07 HRLM (4-17)

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Which of the following is true of PL-259 type coax connectors?

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T9B07 HRLM (4-17)

ARRL The national association for AMATEUR RADIO

Why should coax connectors exposed to the weather be sealed against water intrusion?

A. To prevent an increase in feed line loss

B. To prevent interference to telephones

C. To keep the jacket from becoming loose

D. All of these choices are correct

T9B08 HRLM (4-17)

ARRL The national association for AMATEUR RADIO

Why should coax connectors exposed to the weather be sealed against water intrusion?

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B. To prevent interference to telephones

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T9B08 HRLM (4-17)

ARRL The national association for AMATEUR RADIO

What electrical difference exists between the smaller RG-58 and larger RG-8 coaxial cables?

A. There is no significant difference between the two types

B. RG-58 cable has less loss at a given frequency

C. RG-8 cable has less loss at a given frequency

D. RG-58 cable can handle higher power levels

T9B10 HRLM (4-16)

What electrical difference exists between the smaller RG-58 and larger RG-8 coaxial cables?

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T9B10 HRLM (4-16)

ARRL The national association for AMATEUR RADIO