Lesson 11: Antennas

Preparation for Amateur Radio Technician Class Exam

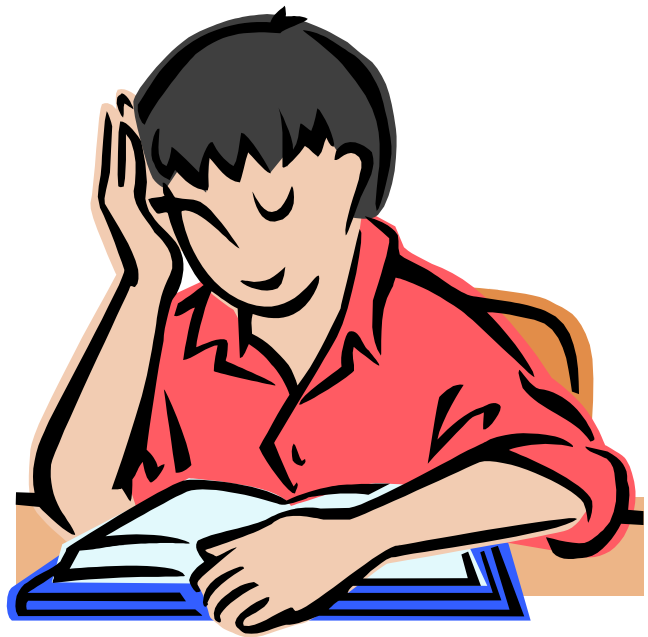
Topics

- Antenna
- ½ wave Dipole antenna
- ¼ wave Vertical antenna
- Antenna polarization
- Antenna location
- Beam antennas
- Test Equipment
- Exam Questions for this section

Reading

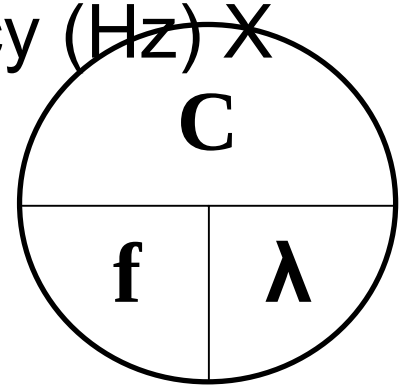
- Chapter 8 – 8.19-8.40

A Quick Review!

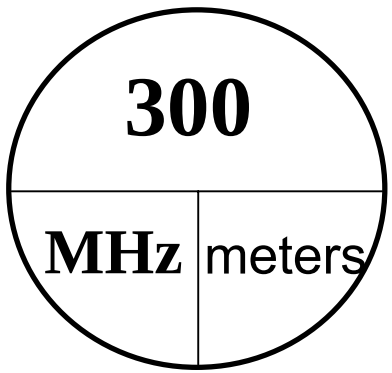


Frequencies and Wavelengths

- Remember: Frequency and wavelength are related by this formula:
  - Speed of light (m/s) = frequency (~~Hz~~) X wavelength (m)
  - C = f λ



- 1 Meter ≅ 37 inches

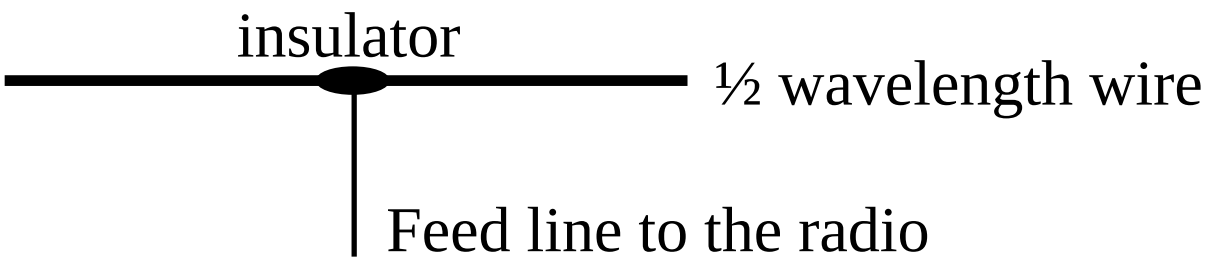


Antennas

- You must have an antenna for your radio to operate
  - The antenna is used by both the transmitter and receiver
- Current travels between the radio and antenna through a transmission line (or feed line)
- Antennas transmit and receive in particular directions, based on the design of the antenna
  - The antenna gain is greatest in the same direction that the antenna puts out the greatest power

½ wave dipole

- Basically, just a wire whose length is ½ of the wavelength of the frequency you are working with
  - Copper or copper clad steel wires are common
  - Most energy from a dipole is sent 90 degrees from the antenna wire
    - If your antenna is strung east to west, your best gain will be north and south of you
  - Gain is OK – certainly better than a “rubber duck”!



½ wave dipole

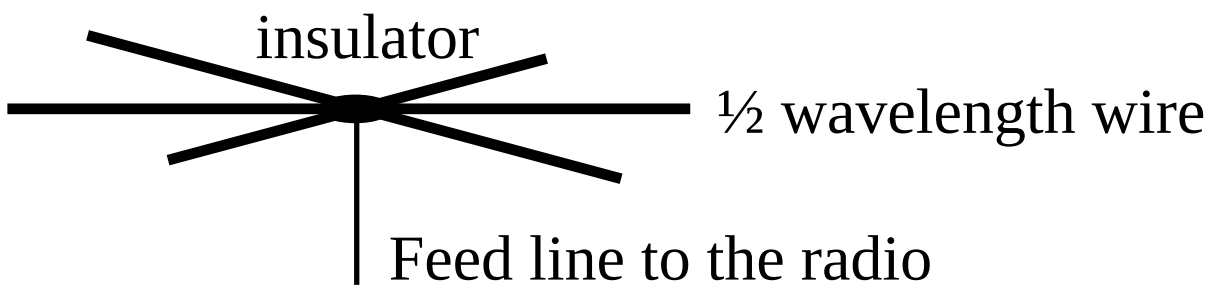
- What would be the length, to the nearest inch, of a half-wavelength dipole antenna that is resonant at 147 MHz?
  - 300/147 = 2.04 meter wavelength
  - 2.04 / 2 = 1.02 meter ½ wavelength
  - 1.02 * 37 ≅ 37 inches

½ wave dipole

- How long should you make a half-wavelength dipole antenna for 223 MHz (measured to the nearest inch)?
  - 300/223 = 1.35 meter wavelength
  - 1.35 / 2 = 0.67 meter ½ wavelength
  - 0.67 * 37 ≅ 25 inches

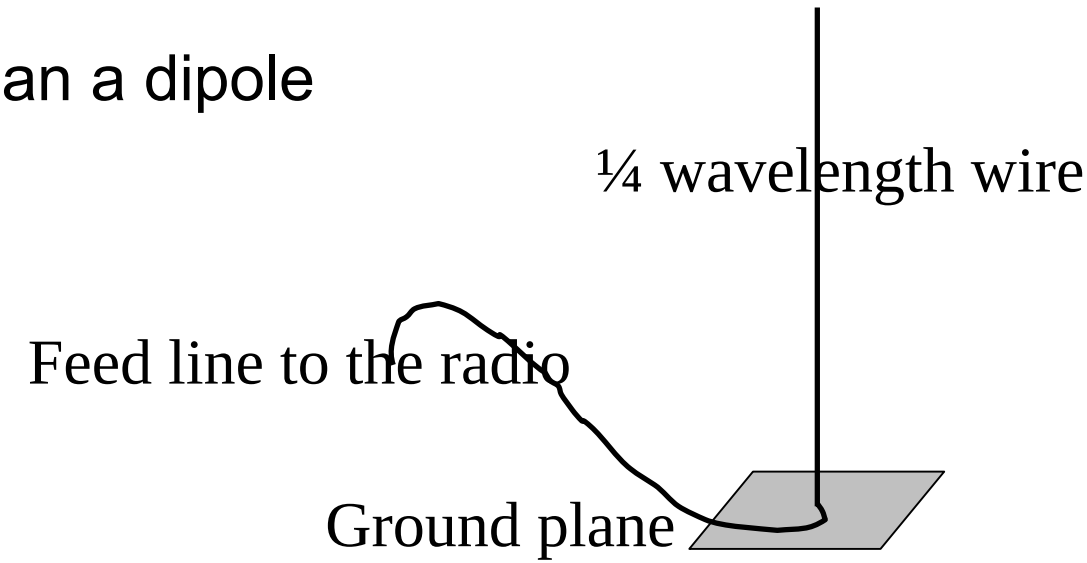
Multi-band dipole

- A dipole with additional wires for additional frequencies
  - There is just one feed line



¼ wave vertical

- Basically, just a wire whose length is ¼ of the wavelength of the frequency you are working with, attached to ground radials or a ground plane
  - Most energy from a dipole is sent 90 degrees from the antenna wire
  - Gain is better than a dipole



¼ wave vertical

- Popular car antennas for HTs because the car body serves as the ground plane
  - To avoid RF to the passengers, mount the antenna on the roof of the car if possible
- The small antenna that comes with the radio is fondly called the “rubber duck”
  - It is fairly inefficient, so many hams replace it with a ¼ wave vertical telescoping or flexible antenna

¼ wave vertical

- How long should you make a quarter-wavelength vertical antenna for 146 MHz (measured to the nearest inch)?
  - 300/146 = 2.05 meter wavelength
  - 2.05 / 4 = 0.5 meter ¼ wavelength
  - 0.5 * 37 ≅ 19 inches

¼ wave vertical

- How long should you make a quarter-wavelength vertical antenna for 440 MHz (measured to the nearest inch)?
  - 300/440 = 0.68 meter wavelength
  - 0.68 / 4 = 0.17 meter ¼ wavelength
  - 0.17 * 37 ≅ 6 inches

Loading Coil

- If you are working a frequencies with long wavelengths, your antenna may get too long to handle
  - You can reduce the length of the antenna without changing its frequency by adding a loading coil to the antenna

Antenna Polarization

- Polarization is the direction of the electrical lines of force from an antenna
  - An antenna parallel to the Earth's surface is horizontally polarized
    - So a ½ wave dipole is ??? polarized
  - An antenna perpendicular to the Earth's surface is vertically polarized
    - So a ¼ wave vertical is ??? polarized

Antenna Polarization

- For best communication, the transmitting and receiving antennas should have the same polarization
  - Because vertical antennas are so popular (handhelds, car mount) most repeater antennas are vertically polarized
  - Most weak-signal SSB and CW work is done with horizontal polarization
  - Satellites use circular polarization

Antenna Location

- Because higher antennas have better range, many people locate their antennas on top of a tower, on a roof top, or up in a tree

Installation Safety Tips

- Tower safety
  - Wear a hard hat and safety glasses if you are on the ground helping someone work on an antenna tower to protect your head from something dropped from the tower
  - The person climbing the tower should wear a safety belt and safety glasses
  - Be careful of using a leather climbing belt, because if the leather is old, it may be brittle and could break unexpectedly

Installation Safety Tips

- Before climbing a tower:
  - Tell someone that you will be up on the tower
  - Bring a variety of tools with you to minimize your trips up and down the tower
  - Inspect the tower before climbing to become aware of any antennas or other obstacles that you may need to step around

Installation Safety Tips

- Before climbing a guyed tower:
  - Tell someone that you will be up on the tower
  - Inspect the tower for cracks or loose bolts
  - Inspect the guy wires for frayed cable, loose cable clamps, loose turnbuckles or loose guy anchors

Installation Safety Tips

- When using a bow and arrow or slingshot and weight to shoot an antenna-support line over a tree, ensure that:
  - The line is strong enough to withstand the shock of shooting the weight
  - The arrow or weight has a safe flight path if the line breaks
  - The bow and arrow or slingshot is in good working condition

Installation Safety Tips

- Watch out for power lines!
  - Be sure your antenna and feed line are well clear of any power lines
  - Make sure your antenna tower is well away from overhead power lines

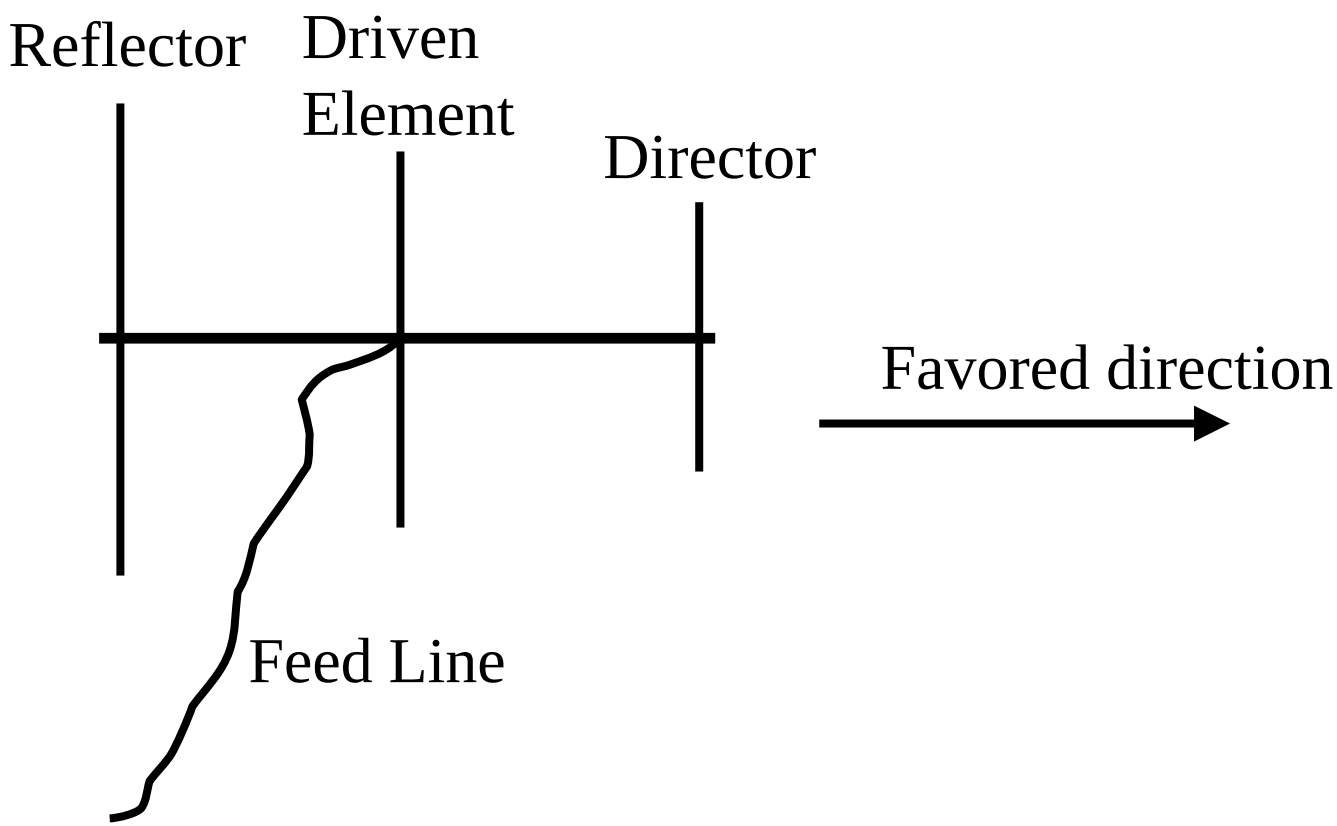
Beam Antennas

- Beam antennas are directional, and are frequently used on higher frequency bands
- Beam antennas provide gain in the direction they are pointed, and reduce interference from other directions
  - If a beam antenna has a 3 dB gain over a dipole antenna, it means that the beam antenna has double the radiated power of the dipole
- Two popular kinds of beam antennas are:
  - Yagi
  - Cubical Quad

Yagi

- Is combed of 3 or more elements connected to a boom
  - At a minimum you will have one of each:
    - Reflector
    - Driven element
    - Director
  - Some people add more directors to their Yagis, but still have one reflector and one driven element
  - The length of the boom determines the gain you get from your antenna

Yagi

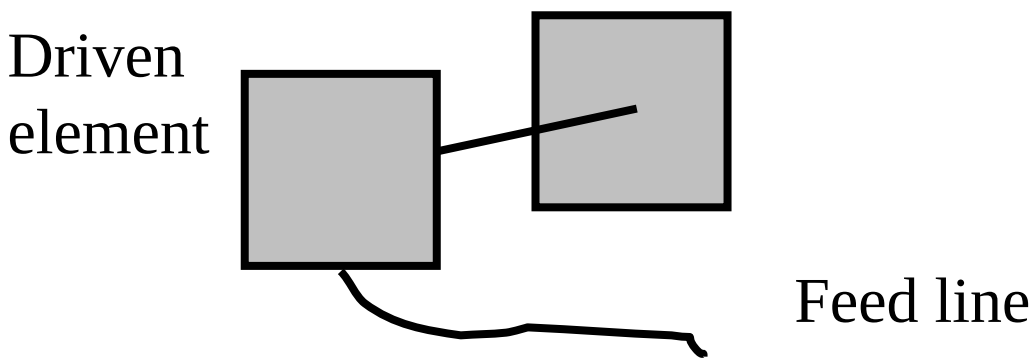


Yagi

- The driven element is typically ½ wavelength
- The director is slightly shorter than the driven element
- The reflector is slightly longer than the driven element
- Only the driven element is connected to the feed line

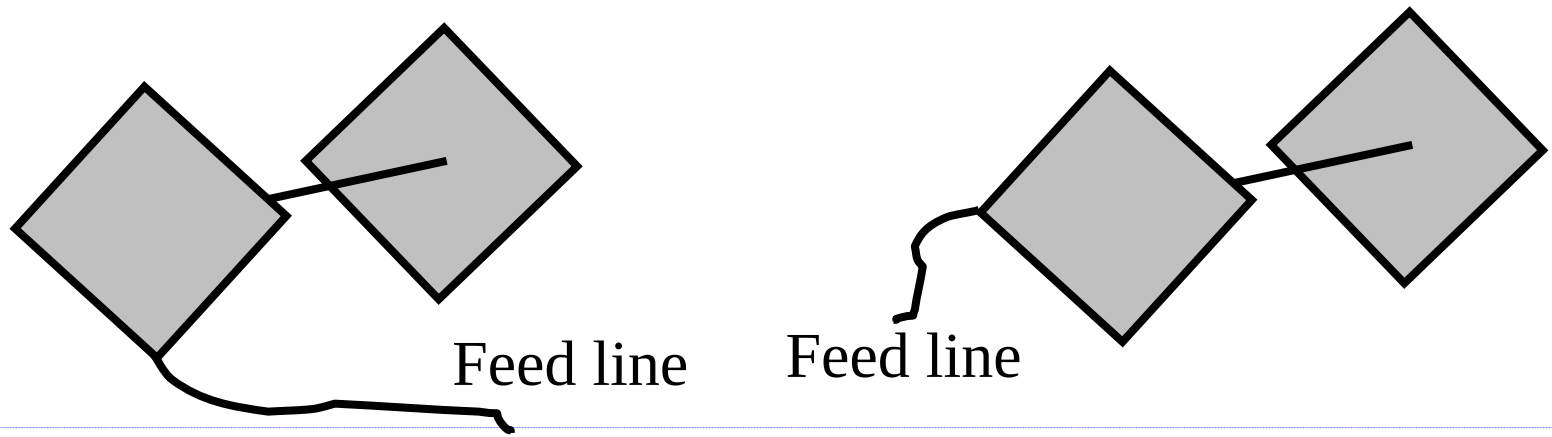
Cubical Quad

- A cubical quad antenna has 2 or more elements in the shape of loops
- Each loop is a square of wire with a total length of about one wavelength
  - So each side of the square is about ¼ wavelength
- One element is the driven element, the other can be either a reflector or director



Cubical Quad

- When the feed line is connected to a horizontal side of the driven element loop, the antenna is horizontally polarized
- When the feed line is connected to a vertical side of the driven element loop, the antenna is vertically polarized



Test Equipment

- Avoiding current
  - Handling electrical equipment one handed helps prevent you from becoming a path for current
- Soldering
  - Wear safety glasses
  - Work in a well-ventilated area
  - Make sure no one can touch the soldering iron tip for at least 10 minutes after it is turned off

Test Equipment

- Voltmeter
  - Measures voltage, the electro-motive force
  - It is a meter with resistors in series
  - When you switch to higher voltage, more resistance is added to the series
  - Connect in parallel to the circuit under test

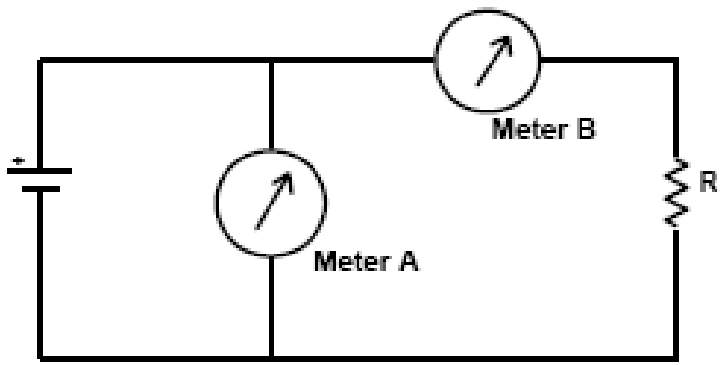


Figure T8-9

Meter A is measuring voltage

Test Equipment

- Ammeter or Ampmeter
  - Measures current
  - It is a meter with resistors in parallel
  - When you switch to higher current, more resistors are added in parallel to give the current more paths to follow
  - Connect in series to the circuit under test

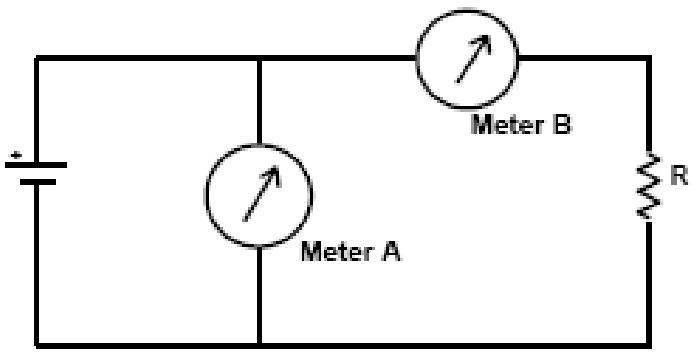


Figure T8-9

Meter B is measuring current

One way to find power used by resistor R is multiply the value of R by the square of the current reading on meter B

Test Equipment

- Ohmmeter
  - Measures resistance
  - Connect in across the circuit under test
  - Do not measure resistance in a circuit that has power applied to it

Test Equipment

- Multimeters
  - Combines a voltmeter, ammeter, and ohmmeter
  - Be careful as to which setting you use and how you connect the meter to the circuit
    - For example, if you connect the meter to a circuit that has power to measure voltage, then switch it to the ohmmeter, you could burn out the moving-needle movement

Test Equiment

- Dummy Antenna or Dummy Load
  - A large resistor that replaces your antenna so you can test your system without actually sending a signal
  - Converts RF energy from the transmitter to heat
  - Has a constant 50 ohm load
  - Be sure it can handle the power output from your transmitter
    - A 100 watt transmitter should be connected to a dummy antenna that will handle at least 100 watts

Test Equipment

- Signal Generator
  - Produces a stable, low-level signal that can be set to a desired frequency

Exam Questions

- The following slides contain questions from the exam pool that are covered in this section of the notes

T8D03

- T8D03 What would be the length, to the nearest inch, of a half-wavelength dipole antenna that is resonant at 147 MHz?
  - A. 19 inches
  - B. 37 inches
  - C. 55 inches
  - D. 74 inches

T8D04

- T8D04 How long should you make a half-wavelength dipole antenna for 223 MHz (measured to the nearest inch)?
  - A. 112 inches
  - B. 50 inches
  - C. 25 inches
  - D. 12 inches

T8D15

- T8D15 If the ends of a half-wavelength dipole antenna (mounted at least a half- wavelength high) point east and west, which way would the antenna send out radio energy?
  - A. Equally in all directions
  - B. Mostly up and down
  - C. Mostly north and south
  - D. Mostly east and west

T8D20

- T8D20 What is one advantage to using a multiband antenna?
  - A. You can operate on several bands with a single feed line
  - B. Multiband antennas always have high gain
  - C. You can transmit on several frequencies simultaneously
  - D. Multiband antennas offer poor harmonic suppression

T8D01

- T8D01 Which of the following will improve the operation of a hand-held radio inside a vehicle?
  - A. Shielding around the battery pack
  - B. A good ground to the belt clip
  - C. An external antenna on the roof
  - D. An audio amplifier

T8D02

- T8D02 Which is true of "rubber duck" antennas for hand-held transceivers?
  - A. The shorter they are, the better they perform
  - B. They are much less efficient than a quarter-wavelength telescopic antenna
  - C. They offer the highest amount of gain possible for any hand-held transceiver antenna
  - D. They have a good long-distance communications range

T8D05

- T8D05 How long should you make a quarter-wavelength vertical antenna for 146 MHz (measured to the nearest inch)?
  - A. 112 inches
  - B. 50 inches
  - C. 19 inches
  - D. 12 inches

T8D06

- T8D06 How long should you make a quarter-wavelength vertical antenna for 440 MHz (measured to the nearest inch)?
  - A. 12 inches
  - B. 9 inches
  - C. 6 inches
  - D. 3 inches

T8D21

- T8D21 What could be done to reduce the physical length of an antenna without changing its resonant frequency?
  - A. Attach a balun at the feed point
  - B. Add series capacitance at the feed point
  - C. Use thinner conductors
  - D. Add a loading coil

T8D13

- T8D13 What does horizontal wave polarization mean?
  - A. The magnetic lines of force of a radio wave are parallel to the Earth's surface
  - B. The electric lines of force of a radio wave are parallel to the Earth's surface
  - C. The electric lines of force of a radio wave are perpendicular to the Earth's surface
  - D. The electric and magnetic lines of force of a radio wave are perpendicular to the Earth's surface

T8D14

- T8D14 What does vertical wave polarization mean?
  - A. The electric lines of force of a radio wave are parallel to the Earth's surface
  - B. The magnetic lines of force of a radio wave are perpendicular to the Earth's surface
  - C. The electric lines of force of a radio wave are perpendicular to the Earth's surface
  - D. The electric and magnetic lines of force of a radio wave are parallel to the Earth's surface

T8D16

- T8D16 What electromagnetic wave polarization do most repeater antennas have in the VHF and UHF spectrum?
  - A. Horizontal
  - B. Vertical
  - C. Right-hand circular
  - D. Left-hand circular

T8D17

- T8D17 What electromagnetic wave polarization is used for most satellite operation?
  - A. Only horizontal
  - B. Only vertical
  - C. Circular
  - D. No polarization

T8D18

- T8D18 Which antenna polarization is used most often for weak signal VHF/UHF SSB operation?
  - A. Vertical
  - B. Horizontal
  - C. Right-hand circular
  - D. Left-hand circular

T0B03

- T0B03 Why should you wear a hard hat and safety glasses if you are on the ground helping someone work on an antenna tower?
  - A. So you won't be hurt if the tower should accidentally fall
  - B. To keep RF energy away from your head during antenna testing
  - C. To protect your head from something dropped from the tower
  - D. So someone passing by will know that work is being done on the tower and will stay away

T0B04

- T0B04 What safety factors must you consider when using a bow and arrow or slingshot and weight to shoot an antenna-support line over a tree?
  - A. You must ensure that the line is strong enough to withstand the shock of shooting the weight
  - B. You must ensure that the arrow or weight has a safe flight path if the line breaks
  - C. You must ensure that the bow and arrow or slingshot is in good working condition
  - D. All of these choices are correct

T0B05

- T0B05 Which of the following is the best way to install your antenna in relation to overhead electric power lines?
  - A. Always be sure your antenna wire is higher than the power line, and crosses it at a 90-degree angle
  - B. Always be sure your antenna and feed line are well clear of any power lines
  - C. Always be sure your antenna is lower than the power line, and crosses it at a small angle
  - D. Only use vertical antennas within 100 feet of a power line

T0B06

- T0B06 What should you always do before attempting to climb an antenna tower?
  - A. Turn on all radio transmitters that use the tower's antennas
  - B. Remove all tower grounding to guard against static electric shock
  - C. Put on your safety belt and safety glasses
  - D. Inform the FAA and the FCC that you are starting work on a tower

T0B07

- T0B07 What is the most important safety precaution to take when putting up an antenna tower?
  - A. Install steps on your tower for safe climbing
  - B. Insulate the base of the tower to avoid lightning strikes
  - C. Ground the base of the tower to avoid lightning strikes
  - D. Look for and stay clear of any overhead electrical wires

T0B08

- T0B08 What should you consider before you climb a tower with a leather climbing belt?
  - A. If the leather is old, it is probably brittle and could break unexpectedly
  - B. If the leather is old, it is very tough and is not likely to break easily
  - C. If the leather is old, it is flexible and will hold you more comfortably
  - D. An unbroken old leather belt has proven its holding strength over the years

T0B09

- T0B09 What should you do before you climb a guyed tower?
  - A. Tell someone that you will be up on the tower
  - B. Inspect the tower for cracks or loose bolts
  - C. Inspect the guy wires for frayed cable, loose cable clamps, loose turnbuckles or loose guy anchors
  - D. All of these choices are correct

T0B10

- T0B10 What should you do before you do any work on top of your tower?
  - A. Tell someone that you will be up on the tower
  - B. Bring a variety of tools with you to minimize your trips up and down the tower
  - C. Inspect the tower before climbing to become aware of any antennas or other obstacles that you may need to step around
  - D. All of these choices are correct

T8D07

- T8D07 Which of the following factors has the greatest effect on the gain of a properly designed Yagi antenna?
  - A. The number of elements
  - B. Boom length
  - C. Element spacing
  - D. Element diameter

T8D08

- T8D08 Approximately how long is the driven element of a Yagi antenna?
  - A. 1/4 wavelength
  - B. 1/3 wavelength
  - C. 1/2 wavelength
  - D. 1 wavelength

T8D09

- T8D09 In Figure T8-8, what is the name of element 2 of the Yagi antenna?
  - A. Director
  - B. Reflector
  - C. Boom
  - D. Driven element

T8D10

- T8D10 In Figure T8-8, what is the name of element 3 of the Yagi antenna?
  - A. Director
  - B. Reflector
  - C. Boom
  - D. Driven element

T8D11

- T8D11 In Figure T8-8, what is the name of element 1 of the Yagi antenna?
  - A. Director
  - B. Reflector
  - C. Boom
  - D. Driven element

T8D12

- T8D12 What is a cubical quad antenna?
  - A. Four straight, parallel elements in line with each other, each approximately 1/2-electrical wavelength long
  - B. Two or more parallel four-sided wire loops, each approximately one- electrical wavelength long
  - C. A vertical conductor 1/4-electrical wavelength high, fed at the bottom
  - D. A center-fed wire 1/2-electrical wavelength long

T8D19

- T8D19 How will increasing antenna gain by 3 dB affect your signal's effective radiated power in the direction of maximum radiation?
  - A. It will cut it in half
  - B. It will not change
  - C. It will double it
  - D. It will quadruple it

T8B07

- T8B07 What minimum rating should a dummy antenna have for use with a 100-watt, single-sideband-phone transmitter?
  - A. 100 watts continuous
  - B. 141 watts continuous
  - C. 175 watts continuous
  - D. 200 watts continuous

T8B15

- T8B15 In Figure T8-3, if block 1 is a transceiver and block 2 is an antenna switch, what is block 3?
  - A. A terminal-node switch
  - B. An SWR meter
  - C. A telegraph key switch
  - D. A dummy antenna

T8F01

- T8F01 Which instrument would you use to measure electric potential or electromotive force?
  - A. An ammeter
  - B. A voltmeter
  - C. A wavemeter
  - D. An ohmmeter

T8F02

- T8F02 How is a voltmeter usually connected to a circuit under test?
  - A. In series with the circuit
  - B. In parallel with the circuit
  - C. In quadrature with the circuit
  - D. In phase with the circuit

T8F03

- T8F03 What happens inside a voltmeter when you switch it from a lower to a higher voltage range?
  - A. Resistance is added in series with the meter
  - B. Resistance is added in parallel with the meter
  - C. Resistance is reduced in series with the meter
  - D. Resistance is reduced in parallel with the meter

T8F04

- T8F04 How is an ammeter usually connected to a circuit under test?
  - A. In series with the circuit
  - B. In parallel with the circuit
  - C. In quadrature with the circuit
  - D. In phase with the circuit

T8F05

- T8F05 Which instrument would you use to measure electric current?
  - A. An ohmmeter
  - B. A wavemeter
  - C. A voltmeter
  - D. An ammeter

T8F06

- T8F06 What test instrument would be useful to measure DC resistance?
  - A. An oscilloscope
  - B. A spectrum analyzer
  - C. A noise bridge
  - D. An ohmmeter

T8F07

- T8F07 What might damage a multimeter that uses a moving-needle meter?
  - A. Measuring a voltage much smaller than the maximum for the chosen scale
  - B. Leaving the meter in the milliamps position overnight
  - C. Measuring voltage when using the ohms setting
  - D. Not allowing it to warm up properly

T8F08

- T8F08 For which of the following measurements would you normally use a multimeter?
  - A. SWR and power
  - B. Resistance, capacitance and inductance
  - C. Resistance and reactance
  - D. Voltage, current and resistance

T8F15

- T8F15 What safety step should you take when soldering?
  - A. Always wear safety glasses
  - B. Ensure proper ventilation
  - C. Make sure no one can touch the soldering iron tip for at least 10 minutes after it is turned off
  - D. All of these choices are correct

T8F18

- T8F18 What device produces a stable, low-level signal that can be set to a desired frequency?
  - A. A wavemeter
  - B. A reflectometer
  - C. A signal generator
  - D. An oscilloscope

T8F19

- T8F19 In Figure T8-9, what circuit quantity would meter B indicate?
  - A. The voltage across the resistor
  - B. The power consumed by the resistor
  - C. The power factor of the resistor
  - D. The current flowing through the resistor

T8F20

- T8F20 In Figure T8-9, what circuit quantity is meter A reading?
  - A. Battery current
  - B. Battery voltage
  - C. Battery power
  - D. Battery current polarity

T8F21

- T8F21 In Figure T8-9, how would the power consumed by the resistor be calculated?
  - A. Multiply the value of the resistor times the square of the reading of meter B
  - B. Multiply the value of the resistor times the reading of meter B
  - C. Multiply the reading of meter A times the value of the resistor
  - D. Multiply the value of the resistor times the square root of the reading of meter B