

# Amateur Radio

## LEVEL 1 TECHNICIAN LICENSE SYLLABUS

For the **2022 to 2026** Question Pool

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Rev. 1.3



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# Technician License Class Syllabus

*Written by Jack Tiley AD7FO*

All questions are shown exactly as they will appear in the test with only the correct answer shown (in underlined green bold text). Question numbers have been included so you can go to the ARRL General Class License Manual, or the question pool itself at <http://www.ncvec.org/page.php?id=369>, to see the additional choices in the exam for each question.

This material is based on the published 2018 Technician Class License question pool, effective July 1, 2018, with additional information added by the author *(in italicized blue text)*.

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If you want to post this document on another site it is asked that you post the authors website [www.ad7fo.com](http://www.ad7fo.com) which will always have the latest revision instead of the entire document. Revisions will be made to correct errors, and changes made to the question pool and prevent out of date versions from being circulated.

Additional information and resources to help you study for the Technician Class License can be found on the ARRL web site ([www.arrl.net](http://www.arrl.net)). The ARRL web site has articles, resources, and reference materials on all aspects of the exam questions and Amateur Radio in general.

# Syllabus Overview

This Syllabus is copyrighted by the author.

The Syllabus is intended either as a classroom text or for self-study in pursuit of the Amateur Radio Technician License and to assist instructors in teaching a class. It may be distributed freely if no charge for the material is made. Reproduction costs associated with delivering paper or electronic copies on CD-ROM's may be charged and **the note of copyright permission on page 3 is not removed.**

Any modified copies must contain a note that the original material by the author has been modified and contain the name and contact information of the person making the changes. An MS Word version is available from the Author at [ad7fo@arrl.net](mailto:ad7fo@arrl.net) for those who want to customize this material for their class.

Question numbers are shown in bold text like this, **T1A03** so you can go to the ARRL Technician Class License Manual, or the question pool itself, to see the actual questions and other answer choices that will be in the exam. If there is an FCC (Federal Communications Commission) Part 97 rule relating to the answer it is shown following the question number. The FCC regulation reference number like this, **T1A07 [97.3(a)(45)]**

All questions are shown with only the correct answer **in bold underlined green text**, which in the authors view makes it easier when you see the other choices in your exam to identify the correct answer. Note that the letter designations of the answers in the exam will be different than that in the question pool.

Additional information has been added by the author (*in italicized blue text*) to some of the questions to further explain the answer or show calculations. In addition, some graphics have also been added for additional clarification.

You do not need a copy of the ARRL Technician Class License Manual or any other study guide. Everything you need to study for your license exam is in this syllabus. The author recommends if you want more technical background that you acquire a copy of the ARRL Handbook. The Handbook will cover your technical needs for all three license levels and will be a great reference after you are licensed. And at a cost of approximately \$50 (\$15 to \$20 if you find a used one). This will cost less than the total cost of purchasing all three license manuals Technician, General, and Extra) from ARRL or other book sellers and will provide a lot more technical information about Amateur Radio and electronics in general.

While every effort was made to ensure the accuracy of the material herein, this material was prepared by an ordinary human being and it is likely that a few typographical or other errors remain. Author welcomes corrections and can be contacted at [ad7fo@arrl.net](mailto:ad7fo@arrl.net)

Go to the author's web site [www.ad7fo.com](http://www.ad7fo.com) to be sure you have the latest revision of the syllabus. The word document version of this syllabus is available for instructors who want to customize this material for their own use.



## About the Author

### Education:

Electrical Engineering, Penn State University – Graduated in 1971

### Work Experience:

**Hewlett Packard:** Thirty-four years filling various positions (retired in 2004)

- RF Products Division in Spokane WA – 1981 to 2004 - Regional Sales Support, Application Engineering, Military sales management, Worldwide Sales Management, Systems Development and Product Management
- Valley Forge PA - from 1969 until 1981 - Engineering Technical Support, Technical Customer Training and Field Sales Engineer

### American Electronics Laboratories:

- Nine years working in and managing a Metrology (Calibration Standards) Laboratory in Colmar PA, Responsible for managing a Metrology lab and team of Technicians that maintained a wide range of test instruments and their calibration traceability to the National Bureau of Standards (**NBS**) [now the National Institute of Standards and Technology (**NIST**)] in accordance with MIL STD 45662.

### Jerrold Electronics:

- Two years as a Technician at the Jerrold Electronics R&D Laboratory in Hatboro, PA working on Cable TV Products and RF test equipment.

### Hobbies:

- Amateur Radio
- Test Equipment
- Electronics in general.

### Amateur Radio Activities:

- Amateur radio teaching and mentoring
- Developing and teaching Technician, General and Extra License Classes
- Developed and teach ARRL EMCOMM class with a power point presentation I developed.
- Written and presented many short (30-60 minute) technical talks for local ham radio clubs (Available from the Authors web page [www.ad7fo.com](http://www.ad7fo.com) ).
- Attending many Pacific Northwest Hamfest's

### ARRL Appointments:

- ARRL Technical Specialist Eastern Washington Section
- ARRL VE (Volunteer Examiner)
- ARRL Registered Instructor
- ARRL Certified EMCOMM Instructor

### Other:

- Member of the Inland Empire VHF Club
- Member of the Spokane County ARES-RACES-ACS

## Class Requirements for Students attending my in person classes

1. You will need a copy of this syllabus (printed or online) for study prior to the class. The Class will be taught directly from a PowerPoint version of this syllabus. The syllabus can be downloaded from the author's web site [www.ad7fo.com](http://www.ad7fo.com). All the possible questions and the correct answer in the license exam are covered in this syllabus.
2. A copy of Part 97 of the FCC rules is recommended and can be downloaded for free from the ARRL website at <http://www.arrl.org/part-97-amateur-radio> or purchased in printed form from amateur radio stores or Amazon. The FCC rules require that you to have access to a copy of the part 97 rules (a printed copy or online on your computer) after you receive your license.
3. You will need a basic scientific calculator that you are familiar with operating that is capable of normal math functions, square roots, trigonometry, and Base 10 Log functions (all basic scientific calculators have these functions). Scientific calculators like the Texas Instruments TI30 or similar are available from office supply stores for around \$20 or less if you do not already have one. **It is recommended you do not purchase a programmable calculator as it will not be allowed in the test session because it can store information and equations. Cellular phone calculators and cell phones are never allowed in test sessions.**
4. Come with a desire to learn and to ask questions. If you do not understand something that is being taught, be sure you ask the instructor(s) to explain further.
5. You must take and pass the Technician Class written exam (element 2)
  - There are 35 questions on the exam. All questions are multiple choice (4 choices).
  - Questions only come from the published Question Pool (all possible questions are covered in this syllabus).
  - The number of possible questions for each topic area is fixed and shown for each question group in the test.
  - You must have 26 correct answers to pass the exam (no more than 9 incorrect answers).
  - There are online sites with the actual test questions where you can take practice exams. Listed below are a few of the sites where you can find practice exams:
    - <http://aa9pw.com/radio/>
    - <http://www.arrl.org/exam-practice>
    - <http://www.eham.net/exams>
    - <http://www.hamradionation.com>
    - <http://www.qrz.com/hamtest>
    - <http://www.hamexam.org>
    - <http://www.hamstudy.org>
    - <http://www.hamradiolicenseexam.com>
6. You should read through this syllabus before the class. You are not expected to learn and understand everything you read, but by being familiar with what will be covered, you can identify those areas where you need to focus on and/or bring up questions during the class. Do not be intimidated. The material will be made easy to understand by your instructor(s). You can check for ham radio clubs in your area for a local Ham (known as Elmer's) that can help you or the go to the ARRL web site to find a local Technical Specialist.
7. You do not need a copy of the current ARRL Technician Class License Manual. Everything you need to study for your license exam is in this syllabus.

# ELECTRICAL AND ELECTRONIC BASICS

## (Background information for the technical questions in the exam)

### Metric system prefixes and suffixes used in Ham Radio

Giga **XXXX** = 1,000,000,000 (one thousand million)

Mega **XXXX** = 1,000,000 (one million times)

Kilo **XXXX** = 1,000 (one thousand times)

Centi **XXXX** = 1/100 (one hundredth)

Milli **XXXX** = 1/1,000 (one thousandth)

Micro **XXXX** = 1/1,000,000 (one millionth)

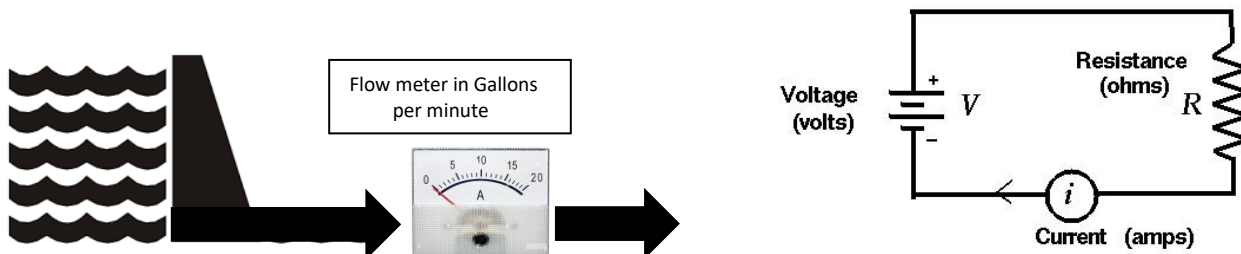
Nano **XXXX** = 1/1,000,000,000 (one thousandth of a Micro)

Pico **XXXX** = 1/1,000,000,000,000 (one millionth of a millionth)

Example: **XXXX** is the value you are expressing such as Volts, Amperes, Ohms, Watts, etc. One Kilo**volt** would be 1,000 Volts, one mega**ohms** would be 1,000,000 ohms , one milli**volt** would be 0.001 volts

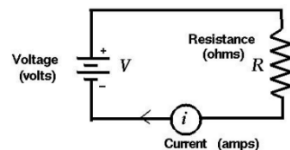
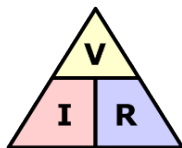
### Voltage, Resistance and Current Flow:

Everything we use in our amateur station requires a power source that delivers a specific **Voltage** and **Current** capability. **Voltage** is commonly referred to as **Electro Motive Force (EMF)** instead of volts. This is like the water pressure at the bottom of a dam. The higher the water in the dam, the more pressure at the bottom of the dam. Current, the flow of electricity, is measured in **amperes** and is commonly represented by the letter **I**. This is like the flow of water in a pipe at the bottom of the dam. The amount of water flowing would be limited by the diameter of the pipe and the pressure exerted by the height of the water in the dam. In an electronic circuit the current flow would be limited by the **EMF (voltage)** and the **resistance** to current flow measured in ohms.



If we know the voltage and the resistance in a circuit, we can calculate the current that would be flowing using Ohms Law :

**Current in amperes (I) is equal to the EMF in volts (E) divided by the resistance in ohms (R).**

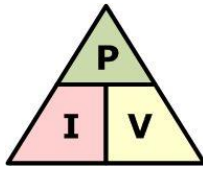


This Triangle can help you solve for Current, Voltage and Resistance in a circuit. For example: if you have a 12-volt battery connected across a 6-ohm resistor the current flowing would be 2 amperes. You can determine this by covering the value with your thumb to see what you need to do. Cover the **I** and you will see that it is **V (Voltage)** divided by **R (Resistance)** therefore:

**Current = 12 volts ÷ 6 Ohms or Current = 2 Amperes**

## Power

Power is work done by electricity and is defined as the voltage across a circuit multiplied by the current flowing through the circuit.



This Triangle can help you solve for Power (in watts) if Voltage and voltage and Current are known. You can determine by covering the P with your thumb to see it is equal to the current (I) times the voltage (V). Here are a couple of examples:

*A circuit connected to 120-volt power outlet that draws 10 amperes would be consuming ? watts.*

*Power = voltage times the current or Power =  $120 \times 10$  or 1200 watts*

A circuit powered by a 12-volt battery that draws 200 milliamperes (ma) would consume 2.4 watts.

*Power = voltage times the current or Power =  $12 \times 0.20$  or 2.4 watts*

## Current Sources:

In the electronic world we have two kinds of commonly encountered sources of electric power:

### Direct Current:

Direct Current (DC) is a voltage that has two terminals, one positive and one negative. Typically, DC power is available from batteries, accessory jacks in vehicles, and plug-in power supplies

Some commonly used batteries for amateur radio applications include the following:

- Alkaline and Zinc Carbon cells that produce 1.5 V - available in AAA, AA, C and D cells. These batteries are not rechargeable.



- Lithium batteries that produce 1.5 or 3 volts. A typical example would be AAA, AA and coin cells. These batteries are not rechargeable.

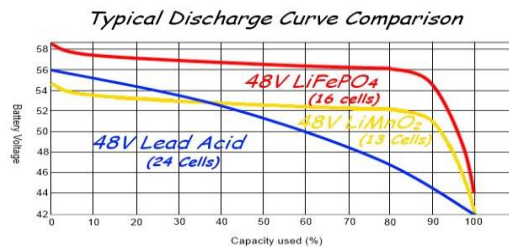




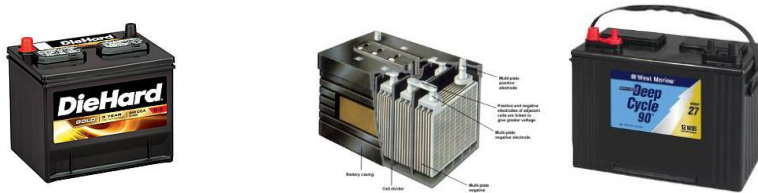
- Nickel Cadmium (NICAD) and Nickel Metal Hydride (NIMH) that produce 1.2 volts, and are available in AAA, AA, C, D cells, and custom shapes. These batteries are rechargeable.



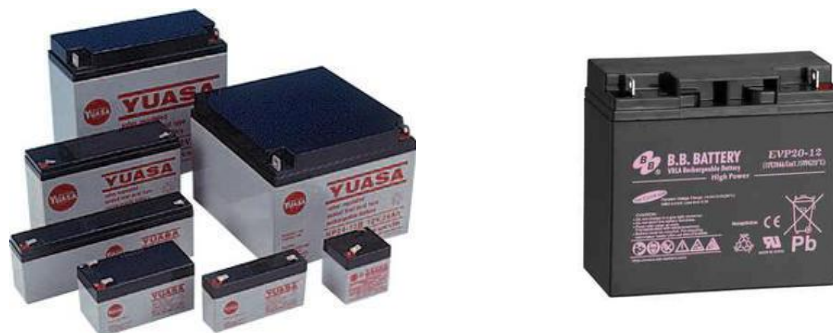
- LiFePO<sub>4</sub>, Lithium Iron Phosphate Batteries a newer Light weight , longer life rechargeable batteries with flatter discharge voltage characteristic, but the initial cost is higher.



- Flooded Lead Acid batteries that produce 12 volts. Examples are automotive batteries and deep cycle marine batteries. These contain a liquid electrolyte (Sulphuric acid) and must be operated in an upright position. These batteries are rechargeable. These batteries release Hydrogen gas while charging so ventilation is required.



- Sealed Lead Acid batteries – Gel Cells and AGM (Absorbed Glass Mat) batteries that are available in 6-volt and 12-volt versions. They are sealed and use a “gelled” electrolyte and they can be operated in any position. They have high current ratings ranging from smaller ones with a 1 ampere hour rating up to 80 ampere hours and more. These batteries are rechargeable.

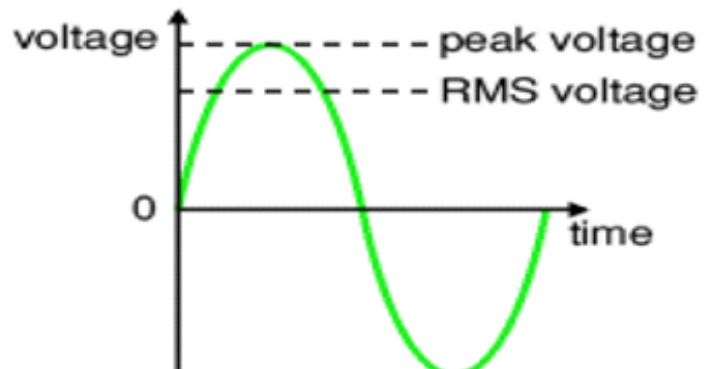
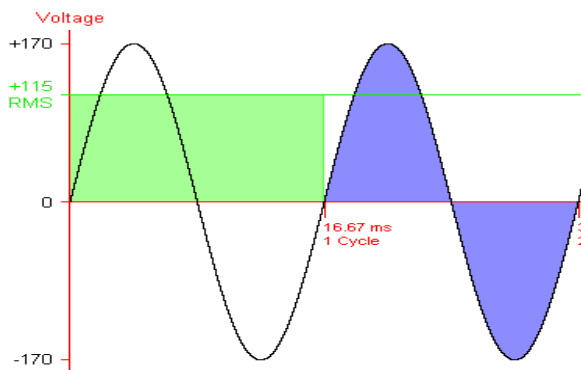




## Alternating Current

Alternating current is a voltage that alternates between equal positive and negative values. This is what is available from the 120 VAC wall outlet in your home.

The 120 Volts we normally associate with the outlets in our home is the equivalent of a DC value that would provide the same heating effect (or work) as a 120-volt DC voltage. This is known as the RMS value of the AC voltage. The heating effect of AC is less than the peak value because the voltage is continuously changing over the time for each cycle. The peak value of an AC voltage is **1.414 times the RMS value**. Therefore the peak voltage for a 120 Volt RMS coming from the outlet in our homes would be 1.414 times 120 volts or **169.68 volts Peak** or **339.36 volts peak to peak** (measured from the positive peak to the negative peak).



For a pure sine wave the equivalent RMS value is 0.707 times the peak value. Conversely the peak voltage can be calculated as 1.414 times the RMS Value.

### Examples:

The peak voltage present in standard 120V RMS AC line voltage is  $1.414 \times 120\text{V}$  or approx. 170 volts peak. The peak to peak (maximum negative to maximum positive peaks) would be two times the peak voltage or approx. 340 V Peak to Peak.

$$PP = 2 \times \text{Peak} \quad \text{or} \quad PP = 2 \times (120 \times 1.414) \quad \text{or} \quad PP = 2 \times 169.7 \quad \text{or} \quad PP = 339.4 \text{ Volts}$$

An AC voltage that reads 65 volts on an RMS meter will have a peak to peak voltage of 184 Volts.

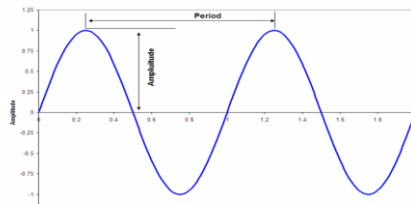
$$\text{Peak to peak Voltage} = 2 \times \text{RMS} \times 1.414 \quad \text{or} \quad PP = 2 \times 65 \times 1.414 \quad \text{or} \quad PP = 183.8 \text{ V PP}$$

## FREQUENCY:

If we start at the first positive peak to the next positive peak of one cycle of our sine wave you will observe that it crosses through Zero twice in the cycle.

The time it takes for one cycle of a sine wave is the period of the sine wave. A 100 Hz sine wave has a period of .01 Seconds (or 10 milliseconds).

Frequency is the number of times that an event happens in one second of time. Shown below is a single cycle of a sine wave, as it would be displayed on an oscilloscope. To determine its frequency, you would divide the time in seconds for one cycle into 1.00.



### Examples:

What is the frequency of a sine wave with a 10 ms (millisecond) period for one cycle?

$$F = 1 \div \text{time} \text{ or } F = 1 \div 0.010 \text{ or } F = 100\text{Hz}$$

What is the frequency of a sine wave with a 1  $\mu$ s (microsecond) period for one cycle?

$$F = 1 \div \text{time} \text{ or } F = 1 \div 0.000001 \text{ or } F = 1,000,000 \text{ Hz or } 1 \text{ MHz}$$

What is the frequency of a sine wave with a 16.666 millisecond period for one cycle?

$$F = 1 \div \text{time} \text{ or } F = 1 \div 0.016666 \text{ or } F = 60.000 \text{ Hz}$$

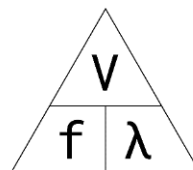
## Wavelength:

Wavelength is the physical distance a wave will travel during one cycle usually expressed in meters. Radio waves in free space travel at the speed of light. Light travels at a speed of approximately 300 million meters per second (*actual speed of light is 299,792,458 meters every second in free space*) in free space. Wavelength is important in amateur radio when designing and building antennas.

V = Velocity (speed of Light)

F = Frequency (in Hertz)

$\lambda$  = Wavelength (in Meters)



We frequently refer to the frequency bands in amateur radio by their wavelength in meters. For instance, 146 Megahertz (MHz) would be the 2-meter band. Wavelength is easily calculated as using the following equation:

*Wavelength equals the speed of light (in meters per second) divided by the frequency*

*Wavelength = 300,000,000  $\div$  frequency; or to simplify,*

*Wavelength = 300  $\div$  Frequency (in megahertz)*

For the 146 MHz example above this would be:

*300,000,000 divided by 146,000,000; or since both values are in millions simply,*

*300  $\div$  146 or 2.054 meters*

This is an important relationship to remember since there are questions in the exam relating to wavelength for a specific frequency or the frequency for a given wavelength.

In amateur radio we frequently refer to our frequencies in terms of approximate wavelength. Since we frequently operating in the Megahertz frequency range, we can simplify our conversion to wavelength by dividing the frequency in megahertz (MHz) into 300. For example:

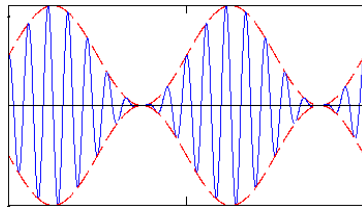
**A 146 MHz signal would be in the 2 meter band ---  $300 \div 146 = 2.054\text{-meters}$**

**A 4.0 MHz signal would be in the 75 meter band ---  $300 \div 4 = 75\text{-meters}$**

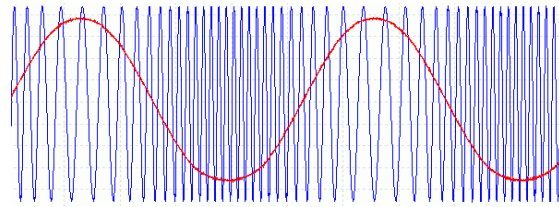
## RF Signals and Modulation

Radio frequencies are simply sine waves like we see coming out of the outlet at home except at a much higher Repetition rate (frequency) Radio signals in the AM Broadcast band are operating from 500,000 hertz to 1,700,000 Hertz. This frequency range can be expressed in kilohertz (thousands of hertz as 500 KHz to 1,700 KHz), or in megahertz (millions of hertz) as 0.500 MHz to 1.700 MHz

The frequency of a signal is just the carrier frequency, that is the frequency with no information applied. When we add voice or data to the carrier we are “modulating” or adding information. Simple modulation can be accomplished by varying the frequency of the carrier (Frequency Modulation or FM) or varying the amplitude of the carrier amplitude (Amplitude Modulation or AM).



Amplitude Modulation



Frequency Modulation

## Exam Overview:

**SUBELEMENT T1** – COMMISSION’S RULES - [6 Exam Questions - 6 Groups] 67 Questions

**SUBELEMENT T2** - OPERATING PROCEDURES - [3 Exam Questions - 3 Groups] 36 Questions

**SUBELEMENT T3** – RADIO WAVE PROPAGATION – [3 Exam Questions - 3 Groups] 34 Questions

**SUBELEMENT T4** – AMATEUR RADIO PRACTICES – [2 Exam Questions - 2 Groups] 24 Questions

**SUBELEMENT T5** – ELECTRICAL PRINCIPLES – [4 Exam Questions - 4 Groups] 52 Questions

**SUBELEMENT T6** – ELECTRONIC AND ELECTRICAL COMPONENTS – [4 Exam Questions - 4 Groups] 47 Questions

**SUBELEMENT T7** – PRACTICAL CIRCUITS – [4 Exam Questions - 4 Groups] 44 Questions

**SUBELEMENT T8** – SIGNALS AND EMISSIONS – [4 Exam Questions - 4 Groups] 48 Questions

**SUBELEMENT T9** – ANTENNAS AND FEED LINES - [2 Exam Questions - 2 Groups] 24 Questions

**SUBELEMENT T0** – SAFETY – [3 Exam Questions - 3 Groups] 36 Questions

There are a total of 412 possible questions in the element 2 (Technician License) pool. They are organized into Ten Elements (numbered 1 thru 0). There groups in each element for a combined total to 35 Groups of questions. For the exam only one question will be taken from each of the 35 groups for a total of 35 questions.

Questions in this study syllabus are word for word what will appear in your actual 35 question exam. The exam will be multiple choice with four answer choices (A. thru D. ). The questions and answers shown in this syllabus are word for word what you will see in your exam. Only the correct answer is shown for each question in this syllabus which in the authors opinion will make it easier to pick out the correct answer when you take the exam.

The question pools are valid for four years. The question pool used for this syllabus will be valid from July 1st, 2022, thru June 30<sup>th</sup>, 2026. The published question pool and four answer choices can be viewed and downloaded from the ARRL web site at <http://www.arrl.org/news/new-technician-question-pool-released-effective-july-1-2022>

This syllabus is based on the 2022-2026 Element 2 Question pool which is effective July 1, 2022 thru June 30, 2022 NCVEC Public Release on January 3, 2022

## SUBELEMENT T1 – COMMISSION’S RULES

### [6 Exam Questions - 6 Groups]

#### T1A - Purpose and permissible use of the Amateur Radio Service; Operator/primary station license grant; Meanings of basic terms used in FCC rules; Interference; RACES rules; Phonetics; Frequency Coordinator

##### T1A01 [97.1]

Which of the following is part of the Basis and Purpose of the Amateur Radio Service? Advancing skills in the technical and communication phases of the radio art

##### T1A02 [97.1]

Which agency regulates and enforces the rules for the Amateur Radio Service in the United States? **The FCC**



##### T1A03 [97.119(b)(2)]

What do the FCC rules state regarding the use of a phonetic alphabet for station identification in the Amateur Radio Service? It is encouraged

##### Phonetic Alphabet

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

##### T1A04 [97.5(b)(1)]

How many operator/primary station license grants may be held by any one person? One

##### T1A05 [97.7]

What proves that the FCC has issued an operator/primary license grant? The license appears in the FCC ULS database

*FCC ULS is the Federal Communications Commission Universal Licensing System*

##### T1A06 [97.3(a)(9)]

What is the FCC Part 97 definition of a beacon? An amateur station transmitting communications for the purposes of observing propagation or related experimental activities

##### T1A07 [97.3(a)(41)]

What is the FCC Part 97 definition of a space station An amateur station located more than 50 km above Earth's surface

**T1A08 [97.3(a)(22)]**

Which of the following entities recommends transmit/receive channels and other parameters for auxiliary and repeater stations? [Volunteer Frequency Coordinator recognized by local amateurs](#)

*The frequency coordinator for Eastern Washington state is Ken Rau email- [IACC.COORDINATOR@nwi.net](mailto:IACC.COORDINATOR@nwi.net)*

**T1A09 [97.3(a)(22)]**

Who selects a Frequency Coordinator? [Amateur operators in a local or regional area whose stations are eligible to be repeater or auxiliary stations](#)

**T1A10 [97.3(a)(38), 97.407]**

What is the Radio Amateur Civil Emergency Service (RACES)?

- A. A radio service using amateur frequencies for emergency management or civil defense communications
- B. A radio service using amateur stations for emergency management or civil defense communications
- C. An emergency service using amateur operators certified by a civil defense organization as being enrolled in that organization

**D. All these choices are correct**

**T1A11 [97.101 (d)]**

When is willful interference to other amateur radio stations permitted [At no time](#)

## **T1B - Frequency allocations; Emission modes; Spectrum sharing; Transmissions near band edges; Contacting the International Space Station; Power output**

**T1B01 [97.301 (e)]**

Which of the following frequency ranges are available for phone operation by Technician licensees?

[28.300 MHz to 28.500 MHz](#)

*See ARRL Band Plan*

**T1B02 [97.301, 97.207(c)]**

Which amateurs may contact the International Space Station (ISS) on VHF bands? [Any amateur holding a Technician class or higher license](#)

**T1B03 [97.301(a)]**

Which frequency is in the 6 meter amateur band? [52.525 MHz](#)

*Actual Wavelength is  $300 \div 52.525$  or 5.71 Meters. All other choices are much farther away from 6 Meters.*

**T1B04 [97.301(a)]**

Which amateur band includes 146.52 MHz? [2 meters](#)

*The 2 meter band is extends from 144 to 148 MHz (see ARRL Band Plan)*

**T1B05 [97.305(c)]**

How may amateurs use the 219 to 220 MHz segment of 1.25 meter band? [Fixed digital message forwarding systems only \(see Band Plan\) \(see Band Plan\)](#)

**T1B06 [97.301(e), 97.305]**

On which HF bands does a Technician class operator have phone privileges? [10 meter band only](#)  
(see [ARRL Band Plan](#))

**T1B07 [97.305(a), (c)]**

Which of the following VHF/UHF band segments are limited to CW only? [50.0 MHz to 50.1 MHz and 144.0 MHz to 144.1 MHz](#)  
(see [ARRL Band Plan](#))

**T1B08 [97.303]**

How are US amateurs restricted in segments of bands where the Amateur Radio Service is secondary? [U.S. amateurs may find non-amateur stations in those segments, and must avoid interfering with them](#)  
(see [ARRL Band Plan](#))

**T1B09 [97.101(a), 97.301(a-e)]**

Why should you not set your transmit frequency to be exactly at the edge of an amateur band or sub-band?

- A. To allow for calibration error in the transmitter frequency display
- B. So that modulation sidebands do not extend beyond the band edge
- C. To allow for transmitter frequency drift
- D. [All these choices are correct](#)

**T1B10 ( [97.305(c)]**

Where may SSB phone be used in amateur bands above 50 MHz? [In at least some segment of all these bands](#)  
(see [ARRL Band Plan](#))

**T1B11 [97.313]**

What is the maximum peak envelope power output for Technician class operators in their HF band segments?  
[200 watts](#)  
(see [ARRL Band Plan](#))

**T1B12 [97.313(b)]**

Except for some specific restrictions, what is the maximum peak envelope power output for Technician class operators using frequencies above 30 MHz? [1500 watts](#)  
(see [Band Plan](#))

## **T1C - Licensing: classes, sequential and vanity call sign systems, places where the Amateur Radio Service is regulated by the FCC, name and address on FCC license database, term, renewal, grace period, maintaining mailing address; International communications**

**T1C01 [97.9(a), 97.17(a)]**

For which license classes are new licenses currently available from the FCC? [Technician, General, Amateur Extra](#)  
*Those holding an advanced class license can keep it as long as it is continuously renewed*

**T1C02 [97.19]**

Who may select a desired call sign under the vanity call sign rules? [Any licensed amateur](#)



**T1C03 [97.117]**

What types of international communications are an FCC-licensed amateur radio station permitted to make?

Communications incidental to the purposes of the Amateur Radio Service and remarks of a personal character

**T1C04 [97.23]**

What may happen if the FCC is unable to reach you by email?

Revocation of the station license or suspension of the operator license

**T1C05**

Which of the following is a valid Technician class call sign format? KF1XXX

*All the other choices have a 1 or 2 letter Suffix that is limited to extra class operators*

**T1C06 [97.5(a)(2)]**

From which of the following locations may an FCC-licensed amateur station transmit? From any vessel or craft located in international waters and documented or registered in the United States

*You will need approval by the ships captain if that is not you*

**T1C07 [97.23]**

Which of the following can result in revocation of the station license or suspension of the operator license?

Failure to provide and maintain a correct email address with the FCC

**T1C08 [97.25]**

What is the normal term for an FCC-issued amateur radio license? Ten years

**T1C09 [97.21(a)(b)]**

What is the grace period for renewal if an amateur license expires? Two years

**T1C10 [97.5a]**

How soon after passing the examination for your first amateur radio license may you transmit on the amateur radio bands? As soon as your operator/station license grant appears in the FCC's license database

**T1C11 [97.21(b)]**

If your license has expired and is still within the allowable grace period, may you continue to transmit on the amateur radio bands? No, you must wait until the license has been renewed

**T1D - Authorized and prohibited transmissions: communications with other countries, music, exchange of information with other services, indecent language, compensation for operating, retransmission of other amateur signals, encryption, sale of equipment, unidentified transmissions, one-way transmission**

**T1D01 (A) [97.111(a)(1)]**

With which countries are FCC-licensed amateur radio stations prohibited from exchanging communications?

Any country whose administration has notified the International Telecommunication Union (ITU) that it objects to such communications

*Yemen and North Korea currently do not allow ham radio operation by its citizens*

**T1D02 [97.113(b), 97.111(b)]**

Under which of the following circumstances are one-way transmissions by an amateur station prohibited?

**Broadcasting**

**Broadcasting is the electronic transmission of radio and television signals that are intended for general public reception, as distinguished from private signals that are directed to specific receivers.**

**T1D03 [97.211(b), 97.215(b), 97.113(a)(4)]**

When is it permissible to transmit messages encoded to obscure their meaning? Only when transmitting control commands to space stations or radio control craft

**T1D04 [97.113(a)(4), 97.113(c)]**

Under what conditions is an amateur station authorized to transmit music using a phone emission? When incidental to an authorized retransmission of manned spacecraft communications

**T1D05) [97.113(a)(3)(ii)]**

When may amateur radio operators use their stations to notify other amateurs of the availability of equipment for sale or trade? When selling amateur radio equipment and not on a regular basis

**T1D06 [97.113(a)(4)]**

What, if any, are the restrictions concerning transmission of language that may be considered indecent or obscene? Any such language is prohibited

**T1D07 [97.113(d)]**

What types of amateur stations can automatically retransmit the signals of other amateur stations? Repeater, auxiliary, or space stations

**T1D08 [97.113(a)(3)(iii)]**

In which of the following circumstances may the control operator of an amateur station receive compensation for operating that station? When the communication is incidental to classroom instruction at an educational institution

**T1D09 [97.113(5)(b)]**

When may amateur stations transmit information in support of broadcasting, program production, or news gathering, assuming no other means is available? When such communications are directly related to the immediate safety of human life or protection of property

**T1D10 [97.3(a)(10)]**

How does the FCC define broadcasting for the Amateur Radio Service? Transmissions intended for reception by the general public

**T1D11 [97.119(a)]**

When may an amateur station transmit without identifying on the air? When transmitting signals to control model craft

**T1E - Control operator: eligibility, designating, privileges, duties, location, required; Control point; Control types: automatic, remote**

**T1E01 [97.7(a)]**

When may an amateur station transmit without a control operator? [Never](#)

**T1E02 [97.301, 97.207(c)]**

Who may be the control operator of a station communicating through an amateur satellite or space station?  
[Any amateur allowed to transmit on the satellite uplink frequency](#)

**T1E03 [97.103(b)]**

Who must designate the station control operator? [The station licensee](#)

**T1E04 [97.103(b)]**

What determines the transmitting frequency privileges of an amateur station? [The class of operator license held by the control operator](#)

**T1E05 [97.3(a)(14)]**

What is an amateur station's control point? [The location at which the control operator function is performed](#)

**T1E06 [97.301]**

When, under normal circumstances, may a Technician class licensee be the control operator of a station operating in an Amateur Extra Class band segment? [At no time](#)

**T1E07 [97.103(a)]**

When the control operator is not the station licensee, who is responsible for the proper operation of the station? [The control operator and the station licensee](#)

**T1E08 [97.3(a)(6), 97.205(d)]**

Which of the following is an example of automatic control? [Repeater operation](#)  
*A Repeater automatically re-transmits the received signal on another frequency*

**T1E09 [97.109(c)]**

Which of the following are required for remote control operation?

- A. The control operator must be at the control point
- B. A control operator is required at all times
- C. The control operator must indirectly manipulate the controls
- [D. All these choices are correct](#)

**T1E10 [97.3(a)(39)]**

Which of the following is an example of remote control as defined in Part 97? [Operating the station over the internet](#)

**T1E11 [97.103(a)]**

Who does the FCC presume to be the control operator of an amateur station, unless documentation to the contrary is in the station records? [The station licensee](#)

## **T1F - Station identification; Repeaters; Third party communications; Club stations; FCC inspection**

**T1F01 [97.103(c)]**

When must the station and its records be available for FCC inspection? At any time upon request by an FCC representative

**T1F02 [97.119 (a)]**

How often must you identify with your FCC-assigned call sign when using tactical call signs such as "Race Headquarters"? At the end of each communication and every ten minutes during a communication

**T1F03 [97.119(a)]**

When are you required to transmit your assigned call sign? At least every 10 minutes during and at the end of a communication

**T1F04 [97.119(b)(2)]**

What language may you use for identification when operating in a phone sub-band? English

**T1F05 [97.119(b)(2)]**

What method of call sign identification is required for a station transmitting phone signals? Send the call sign using a CW or phone emission

**T1F06 [97.119(c)]**

Which of the following self-assigned indicators are acceptable when using a phone transmission?

- A. KL7CC stroke W3
- B. KL7CC slant W3
- C. KL7CC slash W3
- D. All these choices are correct

**T1F07 [97.115(a)(2)]**

Which of the following restrictions apply when a non-licensed person is allowed to speak to a foreign station using a station under the control of a licensed amateur operator? The foreign station must be in a country with which the U.S. has a third party agreement

**T1F08 [97.3(a)(47)]**

What is the definition of third party communications? A message from a control operator to another amateur station control operator on behalf of another person

**T1F09 [97.3(a)(40)]**

What type of amateur station simultaneously retransmits the signal of another amateur station on a different channel or channels? Repeater station

**T1F10 [97.205(g)]**

Who is accountable if a repeater inadvertently retransmits communications that violate the FCC rules? The control operator of the originating station

**T1F11 [97.5(b)(2)]**

Which of the following is a requirement for the issuance of a club station license grant? The club must have at least four members

## SUBELEMENT T2 - OPERATING PROCEDURES

### [3 Exam Questions - 3 Groups]

**T2A - Station operation: choosing an operating frequency, calling another station, test transmissions; Bandplans: calling frequencies, repeater offsets**

#### T2A01

What is a common repeater frequency offset in the 2 meter band? Plus or minus 600 kHz  
*Repeater offset is the difference between the repeaters listen and transmit frequency*

#### T2A02

What is the national calling frequency for FM simplex operations in the 2 meter band?

146.520 MHz

*A calling frequency is one that many operators monitor and if you are in a new area or on the road calling on this frequency has a high probability of making a contact*

#### T2A03

What is a common repeater frequency offset in the 70 cm band? Plus or minus 5 MHz

#### T2A04

What is an appropriate way to call another station on a repeater if you know the other station's call sign?

Say the station's call sign, then identify with your call sign

#### T2A05

How should you respond to a station calling CQ? Transmit the other station's call sign followed by your call sign

*Example: W3JIN this is AD7FO or W3JIN AD7FO*

#### T2A06

Which of the following is required when making on-the-air test transmissions? Identify the transmitting station

*Identifying means transmitting your call sign*

#### T2A07

What is meant by "repeater offset"? The difference between a repeater's transmit and receive frequencies

#### T2A08

What is the meaning of the procedural signal "CQ"? Calling any station

*Procedure signs or prosigns are shorthand signals used in Morse code transmissions for the purpose of simplifying and standardizing radio communication protocol. They are several from Morse code abbreviations, which consist mainly of brevity codes that convey messages to other parties with greater speed and accuracy.*

#### T2A09

Which of the following indicates that a station is listening on a repeater and looking for a contact? The station's call sign followed by the word "monitoring"

**T2A10**

What is a band plan, beyond the privileges established by the FCC? [A voluntary guideline for using different modes or activities within an amateur band](#)

**T2A11**

What term describes an amateur station that is transmitting and receiving on the same frequency? [Simplex](#)  
*Think simple communication where both parties use the same frequency, and no repeater is involved*

**T2A12**

What should you do before calling CQ?

- A. Listen first to be sure that no one else is using the frequency
- B. Ask if the frequency is in use
- C. Make sure you are authorized to use that frequency
- D. [All these choices are correct](#)

## **T2B – VHF/UHF operating practices: FM repeater, simplex, reverse splits; Access tones: CTCSS, DTMF; DMR operation; Resolving operational problems; Q signals**

**T2B01**

How is a VHF/UHF transceiver's "reverse" function used? [To listen on a repeater's input frequency](#)

**T2B02**

What term describes the use of a sub-audible tone transmitted along with normal voice audio to open the squelch of a receiver? [CTCSS](#)  
*Continuous Tone Coded Squelch System or CTCSS is a type of in band signaling that is used to reduce the annoyance of listening to other users on a shared two way radio communications channel and to tell the receiving station that this the correct signal that you want to hear, The tone frequencies used are between 67 and 257 Hz.*

**T2B03**

Which of the following describes a linked repeater network? [A network of repeaters in which signals received by one repeater are transmitted by all the repeaters in the network](#)

**T2B04**

Which of the following could be the reason you are unable to access a repeater whose output you can hear?

- A. Improper transceiver offset
- B. You are using the wrong CTCSS tone
- C. You are using the wrong DCS code
- D. [All these choices are correct](#)

*Digital Code Squelch (DCS) is a digital code similar to the purpose of the continuous tone-coded squelch system or CTCSS. It uses a slow-speed, binary data stream passed as sub-audible data along with the transmission. You need the correct Digital password in the transmitter and receiver to receive the signal.*

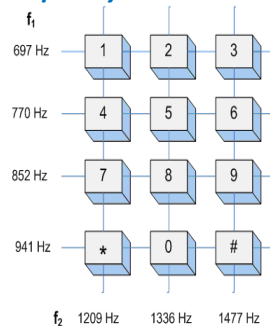
**T2B05**

What would cause your FM transmission audio to be distorted on voice peaks? [You are talking too loudly](#)

**T2B06**

What type of signaling uses pairs of audio tones? [DTMF](#)

*DTMF is "Dual Tone Multi-Frequency"*

**T2B07**

How can you join a digital repeater's "talkgroup"? [Program your radio with the group's ID or code](#)

**T2B08**

Which of the following applies when two stations transmitting on the same frequency interfere with each other?

[The stations should negotiate continued use of the frequency](#)

**T2B09**

Why are simplex channels designated in the VHF/UHF band plans? [So stations within range of each other can communicate without tying up a repeater](#)

**T2B10**

Which Q signal indicates that you are receiving interference from other stations? [QRM](#)

*Q signals are procedurals used originally for CW (Morse Code) to reduce the number of words needed to communicate a message.*

**T2B11**

Which Q signal indicates that you are changing frequency? [QSY](#)

**T2B12**

What is the purpose of the color code used on DMR repeater systems? [Establishes groups of users](#)

**T2B13**

What is the purpose of a squelch function? [Mute the receiver audio when a signal is not present](#)

## **T2C – Public service: emergency operations, applicability of FCC Rules, RACES and ARES, net and traffic procedures, operating restrictions during emergencies, use of phonetics in message handling**

**T2C01 [97.103(a)]**

When do FCC rules NOT apply to the operation of an amateur station? [FCC rules always apply](#)



**T2C02**

Which of the following are typical duties of a Net Control Station? Call the net to order and direct communications between stations checking in

**T2C03**

What technique is used to ensure that voice messages containing unusual words are received correctly?

Spell the words using a standard phonetic alphabet

*The Standard phonetic alphabet (see answer to T1A03) used in Amateur radio worldwide is the Military / NATO one.*

**T2C04**

What is RACES? An FCC part 97 amateur radio service for civil defense communications during national emergencies

**T2C05**

What does the term “traffic” refer to in net operation? Messages exchanged by net stations

**T2C06**

What is the Amateur Radio Emergency Service (ARES)? A group of licensed amateurs who have voluntarily registered their qualifications and equipment for communications duty in the public service

**T2C07**

Which of the following is standard practice when you participate in a net? Unless you are reporting an emergency, transmit only when directed by the net control station

*Once you are checked in the net control operator assumes you are there and listening unless you inform him or her you are leaving the net.*

**T2C08**

Which of the following is a characteristic of good traffic handling? Passing messages exactly as received

**T2C09**

Are amateur station control operators ever permitted to operate outside the frequency privileges of their license class? Yes, but only in situations involving the immediate safety of human life or protection of property



## SUBELEMENT T3 – RADIO WAVE PROPAGATION

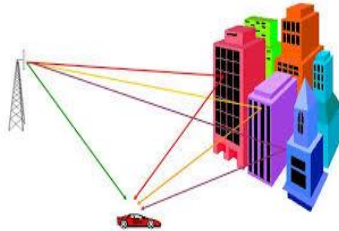
### [3 Exam Questions - 3 Groups]

#### T3A - Radio wave characteristics: how a radio signal travels, fading, multipath, polarization, wavelength vs absorption; Antenna orientation

##### T3A01

Why do VHF signal strengths sometimes vary greatly when the antenna is moved only a few feet?

Multipath propagation cancels or reinforces signals



##### T3A02

What is the effect of vegetation on UHF and microwave signals? Absorption

*In the winter VHF and UHF signals may go farther when the trees do not have leaves.*

##### T3A03

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

Horizontal

##### T3A04

What happens when antennas at opposite ends of a VHF or UHF line of sight radio link are not using the same polarization? Received signal strength is reduced

*Reduced by as much as 20 dB (reduced by a factor of 100)*

##### T3A05

When using a directional antenna, how might your station be able to communicate with a distant repeater if buildings or obstructions are blocking the direct line of sight path? Try to find a path that reflects signals to the repeater

##### T3A06

What is the meaning of the term “picket fencing”? Rapid flutter on mobile signals due to multipath propagation

##### T3A07

What weather condition might decrease range at microwave frequencies? Precipitation

##### T3A08

What is a likely cause of irregular fading of signals propagated by the ionosphere? Random combining of signals arriving via different paths

**T3A09**

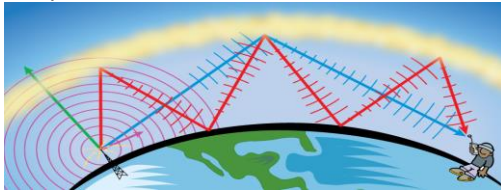
Which of the following results from the fact that signals propagated by the ionosphere are elliptically polarized?  
Either vertically or horizontally polarized antennas may be used for transmission or reception

**T3A10**

What effect does multi-path propagation have on data transmissions? Error rates are likely to increase

**T3A11**

Which region of the atmosphere can refract or bend HF and VHF radio waves? The ionosphere



**T3A12**

What is the effect of fog and rain on signals in the 10 meter and 6 meter bands? There is little effect  
*There will be an effect the shorter wavelength microwave frequencies*

## **T3B - Electromagnetic wave properties: wavelength vs frequency, nature and velocity of electromagnetic waves, relationship of wavelength and frequency; Electromagnetic spectrum definitions: UHF, VHF, HF**

**T3B01**

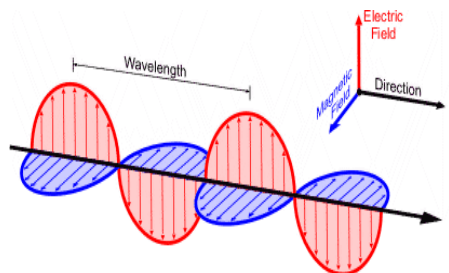
What is the relationship between the electric and magnetic fields of an electromagnetic wave?  
They are at right angles

**T3B02**

What property of a radio wave defines its polarization? The orientation of the electric field

**T3B03**

What are the two components of a radio wave? Electric and magnetic fields



**T3B04**

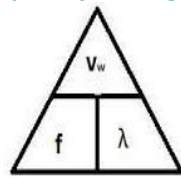
What is the velocity of a radio wave traveling through free space? Speed of light  
Approximately 300,000,000 meters per second

**T3B05**

What is the relationship between wavelength and frequency? Wavelength gets shorter as frequency increases

T3B06

What is the formula for converting frequency to approximate wavelength in meters? Wavelength in meters equals 300 divided by frequency in megahertz



$v_w$  = wave speed  
 $f$  = frequency  
 $\lambda$  = wavelength

T3B07

In addition to frequency, which of the following is used to identify amateur radio bands? The approximate wavelength in meters

T3B08

What frequency range is referred to as VHF? 30 MHz to 300 MHz



0.3 MHz

3 MHz

30 MHz

300 MHz

3,000 MHz

T3B09

What frequency range is referred to as UHF? 300 to 3000 MHz

T3B10

What frequency range is referred to as HF? 3 to 30 MHz

T3B11

What is the approximate velocity of a radio wave in free space? 300,000,000 meters per second

## T3C - Propagation modes: sporadic E, meteor scatter, auroral propagation, tropospheric ducting; F region skip; Line of sight and radio horizon

T3C01

Why are simplex UHF signals rarely heard beyond their radio horizon? UHF signals are usually not propagated by the ionosphere

T3C02

What is a characteristic of HF communication compared with communications on VHF and higher frequencies? Long-distance ionospheric propagation is far more common on HF

T3C03

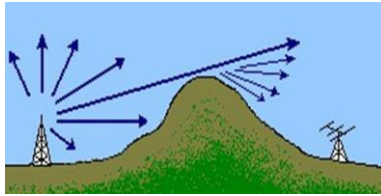
What is a characteristic of VHF signals received via auroral backscatter? They are distorted and signal strength varies considerably

T3C04

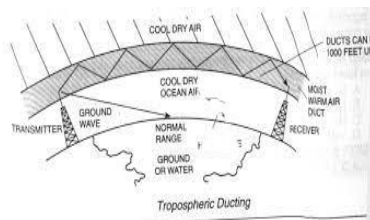
Which of the following types of propagation is most commonly associated with occasional strong signals on the 10, 6, and 2 meter bands from beyond the radio horizon? Sporadic E

**T3C05**

Which of the following effects may allow radio signals to travel beyond obstructions between the transmitting and receiving stations? [Knife-edge diffraction](#)

**T3C06**

What type of propagation is responsible for allowing over-the-horizon VHF and UHF communications to ranges of approximately 300 miles on a regular basis? [Tropospheric ducting](#)

**T3C07**

What band is best suited for communicating via meteor scatter? [6 meters](#)

**T3C08**

What causes tropospheric ducting? [Temperature inversions in the atmosphere](#)

**T3C09**

What is generally the best time for long-distance 10 meter band propagation via the F region?

[From dawn to shortly after sunset during periods of high sunspot activity](#)

**T3C10**

Which of the following bands may provide long-distance communications via the ionosphere's F region during the peak of the sunspot cycle? [6 and 10 meters](#)

**T3C11**

Why is the radio horizon for VHF and UHF signals more distant than the visual horizon? [The atmosphere refracts radio waves slightly](#)

## SUBELEMENT T4 – AMATEUR RADIO PRACTICES

### [2 Exam Questions - 2 Groups]

#### T4A – Station setup: connecting a microphone, a power source, a computer, digital equipment, an SWR meter; bonding; Mobile radio installation

##### T4A01

Which of the following is an appropriate power supply rating for a typical 50 watt output mobile FM transceiver?

13.8 volts at 12 amperes

*The current required if the transmitter output stage is 50% efficient (50 watts of output requires 100 watts of input power) would be approx. 8 amperes. The other circuits in the transmitter (frequency oscillator and multiplier, audio amplifier, modulator and other) need additional power.*

##### T4A02

Which of the following should be considered when selecting an accessory SWR meter? The frequency and power level at which the measurements will be made

##### T4A03

Why are short, heavy-gauge wires used for a transceiver's DC power connection? To minimize voltage drop when transmitting

##### T4A04

How are the transceiver audio input and output connected in a station configured to operate using FT8?

To the audio input and output of a computer running WSJT-X software

*WSJT is an open-source program designed for amateur radio weak-signal digital communication*

##### T4A05

Where should an RF power meter be installed? In the feed line, between the transmitter and antenna



##### T4A06

What signals are used in a computer-radio interface for digital mode operation? Receive audio, transmit audio, and transmitter keying

##### T4A07

Which of the following connections is made between a computer and a transceiver to use computer software when operating digital modes? Computer "line in" to transceiver speaker connector



**T4A08**

Which of the following conductors is preferred for bonding at RF? [Flat copper strap](#)

**T4A09**

How can you determine the length of time that equipment can be powered from a battery?

[Divide the battery ampere-hour rating by the average current draw of the equipment](#)

**T4A10**

What function is performed with a transceiver and a digital mode hot spot? [Communication using digital voice or data systems via the internet](#)

**T4A11**

Where should the negative power return of a mobile transceiver be connected in a vehicle? [At the 12 volt battery chassis ground](#)

**T4A12**

What is an electronic keyer? [A device that assists in manual sending of Morse code](#)

## **T4B - Operating controls: frequency tuning, use of filters, squelch function, AGC, memory channels, noise blanker, microphone gain, receiver incremental tuning (RIT), bandwidth selection, digital transceiver configuration**

**T4B01**

What is the effect of excessive microphone gain on SSB transmissions? [Distorted transmitted audio](#)

**T4B02**

Which of the following can be used to enter a transceiver's operating frequency? [The keypad or VFO knob](#)

**T4B03**

How is squelch adjusted so that a weak FM signal can be heard? [Set the squelch threshold so that receiver output audio is on all the time](#)

**T4B04**

What is a way to enable quick access to a favorite frequency or channel on your transceiver? [Store it in a memory channel](#)

**T4B05**

What does the scanning function of an FM transceiver do? [Tunes through a range of frequencies to check for activity](#)

**T4B06**

Which of the following controls could be used if the voice pitch of a single-sideband signal returning to your CQ call seems too high or low? [The RIT or Clarifier](#)  
*RIT is "Receiver Incremental Tuning". Think of it as a fine tuning control*

**T4B07**

What does a DMR "code plug" contain? [Access information for repeaters and talkgroups](#)

**T4B08**

What is the advantage of having multiple receive bandwidth choices on a multimode transceiver?  
[Permits noise or interference reduction by selecting a bandwidth matching the mode](#)

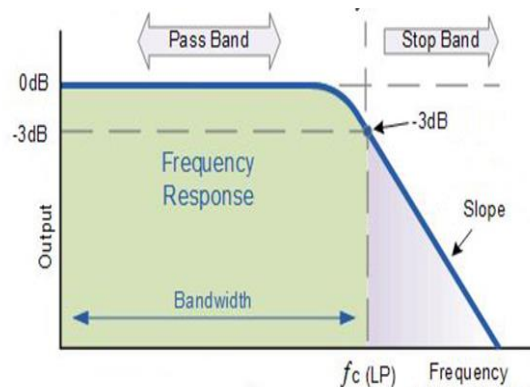
**T4B09**

How is a specific group of stations selected on a digital voice transceiver? [By entering the group's identification code](#)

**T4B10**

Which of the following receiver filter bandwidths provides the best signal-to-noise ratio for SSB reception?  
[2400 Hz](#)

*A 2400 Hz Low pass filter will be ½ power (-3dB) At 2400 Hz and will pass frequencies above that at levels continuously reduced as the frequency increases*

**T4B11**

Which of the following must be programmed into a D-STAR digital transceiver before transmitting?  
[Your call sign](#)

**T4B12**

What is the result of tuning an FM receiver above or below a signal's frequency? [Distortion of the signal's audio](#)

## SUBELEMENT T5 – ELECTRICAL PRINCIPLES

### [4 Exam Questions - 4 Groups]

#### T5A – Current and voltage: terminology and units, conductors, and insulators, alternating and direct current

**T5A01**

Electrical current is measured in which of the following units? Amperes

**T5A02**

Electrical power is measured in which of the following units? Watts

**T5A03**

What is the name for the flow of electrons in an electric circuit? Current

**T5A04**

What are the units of electrical resistance? Ohms

**T5A05**

What is the electrical term for the force that causes electron flow? Voltage

**T5A06**

What is the unit of frequency? Hertz

**T5A07**

Why are metals generally good conductors of electricity? They have many free electrons

**T5A08**

Which of the following is a good electrical insulator? Glass

**T5A09**

Which of the following describes alternating current? Current that alternates between positive and negative directions

**T5A10**

Which term describes the rate at which electrical energy is used? Power

**T5A11**

What type of current flow is opposed by resistance?

- A. Direct current
- B. Alternating current
- C. RF current

D. All these choices are correct

**T5A12**

What describes the number of times per second that an alternating current makes a complete cycle? Frequency

## **T5B Math for electronics: conversion of electrical units, decibels**

**T5B01**

How many milliamperes is 1.5 amperes? 1,500 milliamperes

$1500 \div 0.001$  or 1500

**T5B02**

Which is equal to 1,500,000 hertz? 1,500 kHz

**T5B03**

Which is equal to one kilovolt? One thousand volts

**T5B04**

Which is equal to one microvolt? One one-millionth of a volt

**T5B05**

Which is equal to 500 milliwatts? 0.5 watts

**T5B06**

Which is equal to 3000 milliamperes? 3 amperes

**T5B07**

Which is equal to 3.525 MHz? 3,525 kHz check

$3.525 \text{ MHz} \div 1,000$  or 3,525 KHz

**T5B08**

Which is equal to 1,000,000 picofarads? 1 microfarad

A picofarad is 1 millionth of a microfarad or  $\text{Mfd} = \text{pf} \div 1,000,000$  or  $1,000,000 \div 1,000,000$  or 1

**T5B09**

Which decibel value most closely represents a power increase from 5 watts to 10 watts? +3 dB

A simple way to remember this is that a + 2 times change is +3 dB and a change of 1 half is -3dB therefore the change from 5 to 10 watts is a + two times change or +3dB

By using this table

+	dB	-
2 x	3	.5 x
10 x	10	.1 x

The actual change can be calculated using the following equation:

$\text{dB} = 10 \times \log_{10} (\text{Power (1)} \div (\text{Power (2)}))$  or  $\text{dB} = 10 \times \log_{10} (10 \div 5)$  or  $\text{dB} = 10(.301)$  or  $\text{dB} = 3.01$

**T5B10**

Which decibel value most closely represents a power decrease from 12 watts to 3 watts? -6 dB

*A simple way to remember this is that a change of 2 times is +3 dB and a change of 1 half is -3dB therefore a change from 12 to 6 watts is one half or change is -3dB an additional change from 6 to 3 watts is again one half the change is an additional change of -3dB for a total change of -6dB*

*The actual change can be calculated using the following equation:*

$$dB = 10 \times \log_{10} (\text{Power (1)} \div \text{Power (2)}) \text{ or } dB = 10 \times \log_{10} (12 \div 3) \text{ or } dB = 10(.602) \text{ or } dB = 6.02$$

**T5B11**

Which decibel value represents a power increase from 20 watts to 200 watts? 10 dB

*A simple way to remember this is that a change of 10 times is +10 dB and a change of one tenth is -10 dB therefore the change from 20 to 200 watts is change of 10m times or a +10 dB change*

*The actual change can be calculated using the following equation:*

$$dB = 10 \times \log_{10} (\text{Power (1)} \div \text{Power (2)}) \text{ or } dB = 10 \times \log_{10} (200 \div 20) \text{ or } dB = (10)(1) \text{ or } dB = +10$$

**T5B12**

Which is equal to 28,400

kHz? 28.400 MHz

$$MHz. = KHz \div 1,000 \text{ or } 28,400 \div 1,000 \text{ or } 28.400$$

**T5B13**

Which is equal to 2425 MHz?

2.425 GHz

$$GHz. = MHz \div 1,000 \text{ or } 2,425 \div 1,000 \text{ or } 2.425$$

## **T5C – Capacitance and inductance terminology and units; Radio frequency definition and units; Impedance definition and units; Calculating power**

**T5C01**

What describes the ability to store energy in an electric field? Capacitance

**T5C02**

What is the unit of capacitance? The farad

**T5C03**

What describes the ability to store energy in a magnetic field? Inductance

**T5C04**

What is the unit of inductance? The henry

**T5C05**

What is the unit of impedance? The ohm

**T5C06**

What does the abbreviation “RF” mean? Radio frequency signals of all types

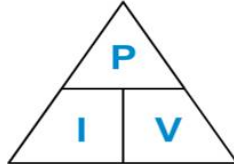
**T5C07**

What is the abbreviation for megahertz? MHz

**T5C08**

What is the formula used to calculate electrical power (P) in a DC circuit?  $P = E \times I$

*Power = E (Voltage) x I (current)*

**T5C09**

How much power is delivered by a voltage of 13.8 volts DC and a current of 10 amperes? 138 watts

*Power = E (Voltage) x I (current) or  $P = 13.8 \times 10$  or  $P = 138$  watts*

**T5C10**

How much power is delivered by a voltage of 12 volts DC and a current of 2.5 amperes? 30 Watts

*Power = E (Voltage) x I (current) or  $P = 12 \times 2.5$  or Power = 30 Watts*

**T5C11**

How much current is required to deliver 120 watts at a voltage of 12 volts DC? 10 amperes

*Power = E (Voltage) x I (current) or  $120 = 12 \times I$  (current) or  $120 \div 12 = I$  (current) or  $10 = I$  (current)*

**T5C12**

What is impedance? The opposition to AC current flow

*Measured in Ohms*

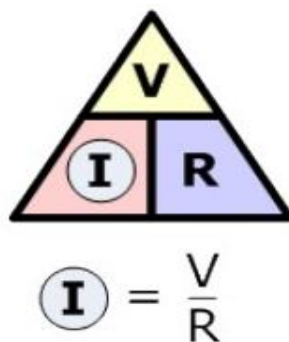
**T5C13**

What is the abbreviation for kilohertz? kHz

## T5D – Ohm’s Law; Series and parallel circuits

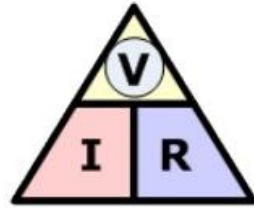
**T5D01**

What formula is used to calculate current in a circuit?  $I = E / R$



**T5D02**

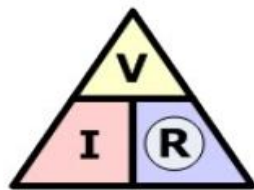
What formula is used to calculate voltage in a circuit?  $E = I \times R$



$$\textcircled{V} = I \times R$$

**T5D03**

What formula is used to calculate resistance in a circuit?  $R = E / I$



$$\textcircled{R} = \frac{V}{I}$$

**T5D04**

What is the resistance of a circuit in which a current of 3 amperes flows when connected to 90 volts? 30 ohms

$R = E / I$  or  $R = 90 \div 3$  or  $R = 30 \text{ Ohms}$

**T5D05**

What is the resistance of a circuit for which the applied voltage is 12 volts and the current flow is 1.5 amperes?

$R = E / I$  or  $R = 12 \div 1.5$  or  $R = 8 \text{ Ohms}$

**T5D06**

What is the resistance of a circuit that draws 4 amperes from a 12-volt source? 3 ohms

$R = E / I$  or  $R = 12 \div 4$  or  $R = 3 \text{ Ohms}$

**T5D07**

What is the current in a circuit with an applied voltage of 120 volts and a resistance of 80 ohms? 1.5 Amperes

$I = E / R$  or  $I = 120 \div 80$  or  $I = 1.5 \text{ Amperes}$

**T5D08**

What is the current through a 100-ohm resistor connected across 200 volts? 2 amperes

$I = E / R$  or  $I = 200 \div 100$  or  $I = 2 \text{ Amperes}$

**T5D09**

What is the current through a 24-ohm resistor connected across 240 volts? 10 Amperes

$I = E / R$  or  $I = 240 \div 24$  or  $I = 10 \text{ Amperes}$



**T5D10**

What is the voltage across a 2-ohm resistor if a current of 0.5 amperes flows through it? 1 Volt

$$E = I \times R \text{ or } E = 0.5 \times 2 \text{ or } 1 \text{ Volts}$$

**T5D11**

What is the voltage across a 10-ohm resistor if a current of 1 ampere flows through it? 10 Volts

$$E = I \times R \text{ or } E = 1 \times 10 \text{ or } 10 \text{ Volts}$$

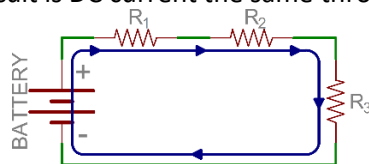
**T5D12**

What is the voltage across a 10-ohm resistor if a current of 2 amperes flows through it? 20 Volts

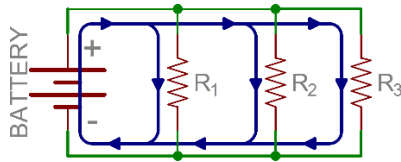
$$E = I \times R \text{ or } E = 2 \times 10 \text{ or } 20 \text{ Volts}$$

**T5D13**

In which type of circuit is DC current the same through all components? Series

**T5D14**

In which type of circuit is voltage the same across all components? Parallel



# SUBELEMENT T6 – ELECTRONIC AND ELECTRICAL COMPONENTS

## [4 Exam Questions - 4 Groups]

### T6A - Fixed and variable resistors; Capacitors; Inductors; Fuses; Switches; Batteries

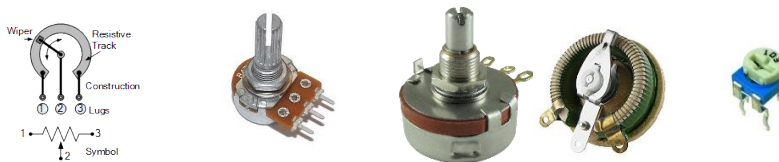
#### T6A01

What electrical component opposes the flow of current in a DC circuit? [Resistor](#)



#### T6A02

What type of component is often used as an adjustable volume control? [Potentiometer](#)

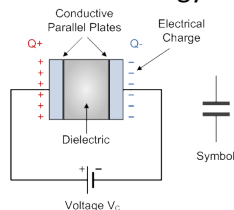


#### T6A03

What electrical parameter is controlled by a potentiometer? [Resistance](#)

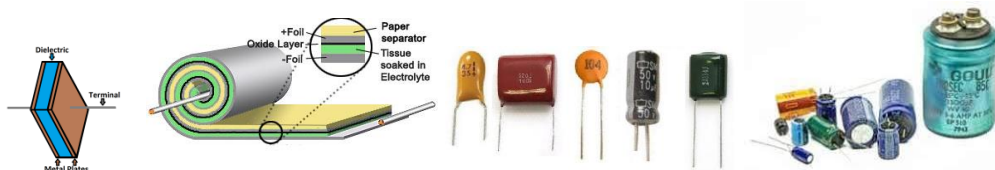
#### T6A04

What electrical component stores energy in an electric field? [Capacitor](#)



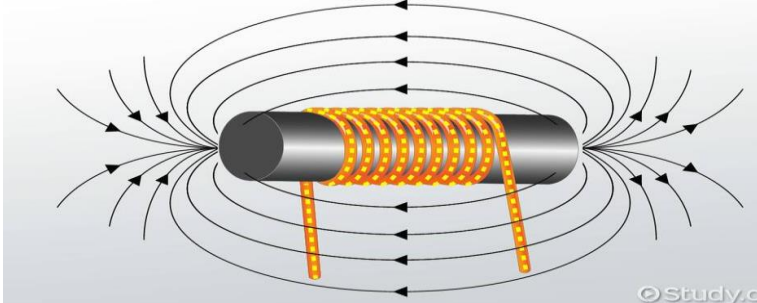
#### T6A05

What type of electrical component consists of conductive surfaces separated by an insulator? [Capacitor](#)



**T6A06**

What type of electrical component stores energy in a magnetic field? [Inductor](#)



**T6A07**

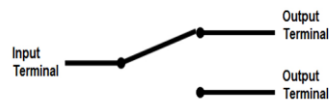
What electrical component is typically constructed as a coil of wire? [Inductor](#)



**T6A08**

What is the function of an SPDT switch? [single circuit is switched between one of two other circuits](#)

**Single Pole Double Throw Switch**



**T6A09**

What electrical component is used to protect other circuit components from current overloads? [Fuse](#)



**T6A10**

Which of the following battery chemistries is rechargeable?

- A. Nickel-metal hydride
- B. Lithium-ion
- C. Lead-acid

[D. All these choices are correct](#)

**T6A11**

Which of the following battery chemistries is not rechargeable? [Carbon-zinc](#)

**T6A12**

What type of switch is represented by component 3 in figure T-2? **Single-pole single-throw**

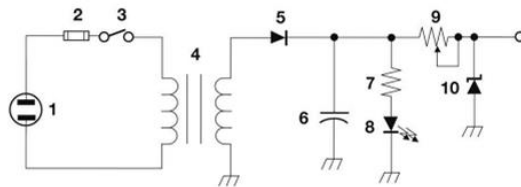


Figure T-2

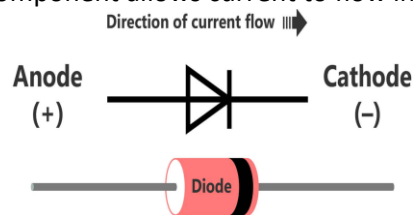
## T6B – Semiconductors: basic principles and applications of solid state devices, diodes, and transistors

**T6B01**

Which is true about forward voltage drop in a diode? **It is lower in some diode types than in others**  
*Germanium diodes have a 0.5 volt forward voltage drop and Silicone diodes have a 0.7 volt forward voltage drop*

**T6B02**

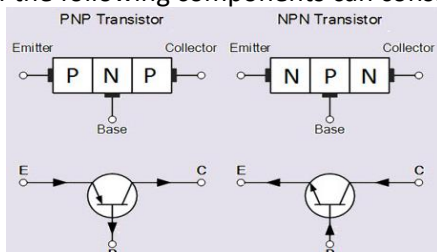
What electronic component allows current to flow in only one direction? **Diode**

**T6B03**

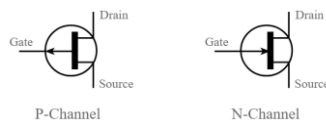
Which of these components can be used as an electronic switch? **Transistor**

**T6B04**

Which of the following components can consist of three regions of semiconductor material? **Transistor**

**T6B05**

What type of transistor has a gate, drain, and source? **Field-effect**



**T6B06**

How is the cathode lead of a semiconductor diode often marked on the package? [With a stripe](#)  
[See T6B02 illustration](#)

**T6B07**

What causes a light-emitting diode (LED) to emit light? [Forward DC current](#)

**T6B08**

What does the abbreviation FET stand for? [Field Effect Transistor](#)

**T6B09**

What are the names for the electrodes of a diode? [Anode and cathode](#)  
[See T6B02 illustration](#)

**T6B10**

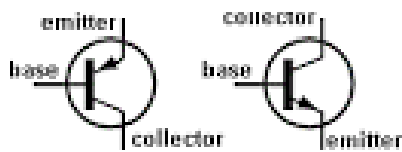
Which of the following can provide power gain? [Transistor](#)

**T6B11**

What is the term that describes a device's ability to amplify a signal? [Gain](#)

**T6B12**

What are the names of the electrodes of a bipolar junction transistor? [Emitter, base, collector](#)



## T6C - Circuit diagrams: use of schematics, basic structure;

### Schematic symbols of basic components

**T6C01**

What is the name of an electrical wiring diagram that uses standard component symbols? [Schematic](#)

**T6C02**

What is component 1 in figure T-1? [Resistor](#)

**T6C03**

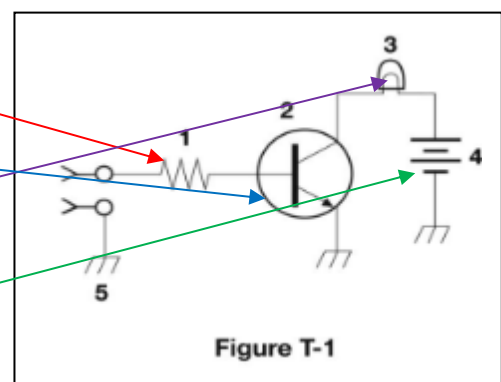
What is component 2 in figure T-1? [Transistor](#)

**T6C04**

What is component 3 in figure T-1? [Lamp](#)

**T6C05**

What is component 4 in figure T-1? [Battery](#)



**T6C06**

What is component 6 in figure T-2? Capacitor

**T6C07**

What is component 8 in figure T-2? Light emitting diode

**T6C08**

What is component 9 in figure T-2? Variable resistor  
A. Variable transformer

**T6C09**

What is component 4 in figure T-2? Transformer

**T6C10**

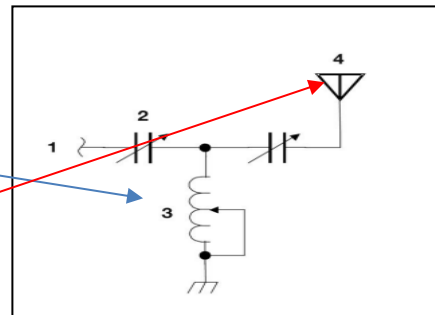
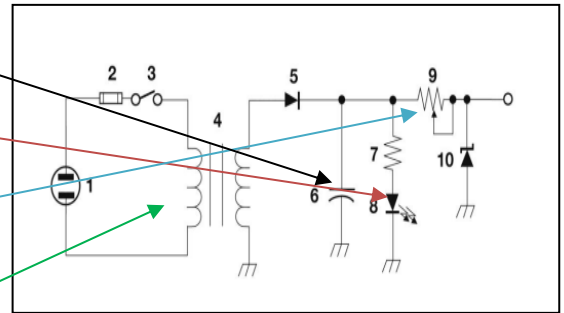
What is component 3 in figure T-3? Variable inductor

**T6C11**

What is component 4 in figure T-3? Antenna

**T6C12**

Which of the following is accurately represented in electrical schematics? Component connections



## T6D - Component functions: rectifiers, relays, voltage regulators, meters, indicators, integrated circuits, transformers; Resonant circuit; Shielding

**T6D01**

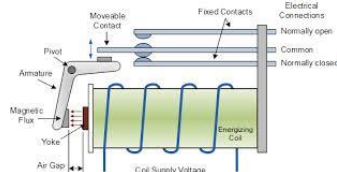
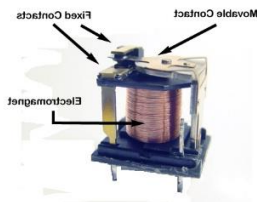
Which of the following devices or circuits changes an alternating current into a varying direct current signal

Rectifier

*Rectifier is another name for a diode used in a power supply*

**T6D02**

What is a relay? An electrically-controlled switch



T6D03

Which of the following is a reason to use shielded wire? To prevent coupling of unwanted signals to or from the wire



T6D04

Which of the following displays an electrical quantity as a numeric value? Meter

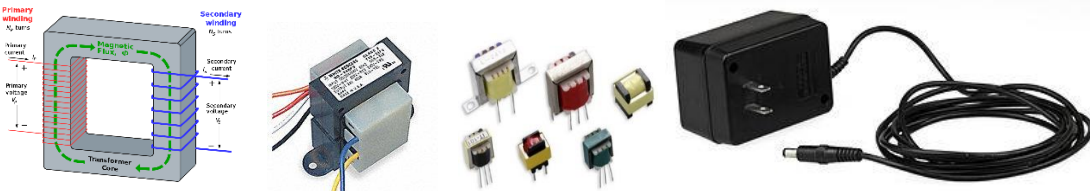


T6D05

What type of circuit controls the amount of voltage from a power supply? Regulator

T6D06

What component changes 120 V AC power to a lower AC voltage for other uses? Transformer



T6D07

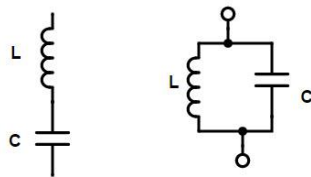
Which of the following is commonly used as a visual indicator? LED

*Light Emitting Diode*



T6D08

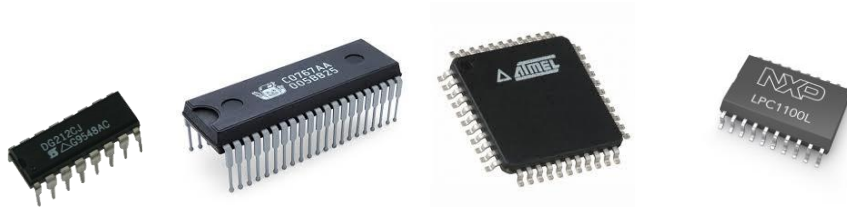
Which of the following is combined with an inductor to make a resonant circuit? Capacitor



**T6D09**

What is the name of a device that combines several semiconductors and other components into one package?

Integrated circuit

**T6D10**

What is the function of component 2 in figure T-1? Control the flow of current

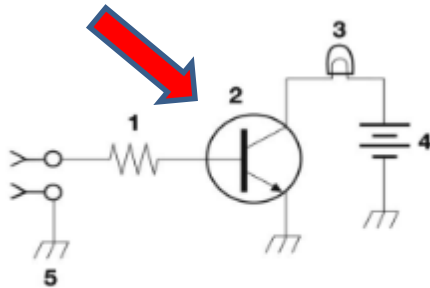


Figure T-1

**T6D11**

Which of the following is a resonant or tuned circuit? An inductor and a capacitor in series or parallel

*See graphic in T6D08*



## SUBELEMENT T7 – PRACTICAL CIRCUITS

### [4 Exam Questions - 4 Groups]

**T7A – Station equipment: receivers, transceivers, transmitter amplifiers, receive amplifiers, transverters; Basic radio circuit concepts and terminology: sensitivity, selectivity, mixers, oscillators, PTT, modulation**

#### T7A01

Which term describes the ability of a receiver to detect the presence of a signal? [Sensitivity](#)

#### T7A02

What is a transceiver? [A device that combines a receiver and transmitter](#)



#### T7A03

Which of the following is used to convert a signal from one frequency to another? [Mixer](#)

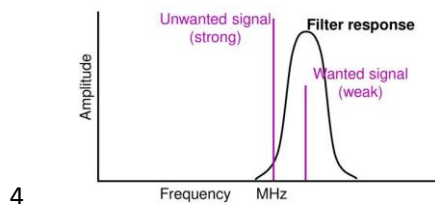
*A mixer takes two RF signals in and outputs frequencies that the sum and difference of those two signals*



#### T7A04

Which term describes the ability of a receiver to discriminate between multiple signals? [Selectivity](#)

**Selectivity** is the ability to separate the wanted signal from nearby unwanted signals (other stations)



#### T7A05

What is the name of a circuit that generates a signal at a specific frequency? [Oscillator](#)

**T7A06**

What device converts the RF input and output of a transceiver to another band? [Transverter](#)

**T7A07**

What is the function of a transceiver's PTT input? [Switches transceiver from receive to transmit when grounded](#)

*PTT stands for Push To Talk control*

**T7A08**

Which of the following describes combining speech with an RF carrier signal? [Modulation](#)

*Modulation is the process of adding analog or digital information on a carrier wave.*

**T7A09**

What is the function of the SSB/CW-FM switch on a VHF power amplifier? [Set the amplifier for proper operation in the selected mode](#)

**T7A10**

What device increases the transmitted output power from a transceiver? [An RF power amplifier](#)

**T7A11**

Where is an RF preamplifier installed? [Between the antenna and receiver](#)



## T7B – Symptoms, causes, and cures of common transmitter and receiver problems: overload and overdrive, distortion, interference and consumer electronics, RF feedback

### T7B01

What can you do if you are told your FM handheld or mobile transceiver is over-deviating?

[Talk farther away from the microphone](#)

### T7B02

What would cause a broadcast AM or FM radio to receive an amateur radio transmission unintentionally?

[The receiver is unable to reject strong signals outside the AM or FM band](#)

### T7B03

Which of the following can cause radio frequency interference?

- A. Fundamental overload
- B. Harmonics
- C. Spurious emissions

[D. All these choices are correct](#)

### T7B04

Which of the following could you use to cure distorted audio caused by RF current on the shield of a microphone cable? [Ferrite choke](#)



### T7B05

How can fundamental overload of a non-amateur radio or TV receiver by an amateur signal be reduced or eliminated? [Block the amateur signal with a filter at the antenna input of the affected receiver](#)

### T7B06

Which of the following actions should you take if a neighbor tells you that your station's transmissions are interfering with their radio or TV reception? [Make sure that your station is functioning properly and that it does not cause interference to your own radio or television when it is tuned to the same channel](#)

### T7B07

Which of the following can reduce overload of a VHF transceiver by a nearby commercial FM station? [Installing a band-reject filter](#)



**T7B08**

What should you do if something in a neighbor's home is causing harmful interference to your amateur station?

- A. Work with your neighbor to identify the offending device
- B. Politely inform your neighbor that FCC rules prohibit the use of devices that cause interference
- C. Make sure your station meets the standards of good amateur practice
- D. All these choices are correct

**T7B09**

What should be the first step to resolve non-fiber optic cable TV interference caused by your amateur radio transmission? Be sure all TV feed line coaxial connectors are installed properly

**T7B10**

What might be a problem if you receive a report that your audio signal through an FM repeater is distorted or unintelligible?

- A. Your transmitter is slightly off frequency
- B. Your batteries are running low
- C. You are in a bad location
- D. All these choices are correct

**T7B11**

What is a symptom of RF feedback in a transmitter or transceiver? Reports of garbled, distorted, or unintelligible voice transmissions

## **T7C – Antenna and transmission line measurements and troubleshooting: measuring SWR, effects of high SWR, causes of feed line failures; Basic coaxial cable characteristics; Use of dummy loads when testing**

**T7C01**

What is the primary purpose of a dummy load? To prevent transmitting signals over the air when making tests  
*A dummy load is basically a shielded resistor that matchless the transmitter output impedance (Usually 50 Ohms) capable of absorbing the output of the transmitter and dissipating it as heat*



## T7C02

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

An antenna analyzer



## T7C03

What does a dummy load consist of? A non-inductive resistor mounted on a heat sink

## T7C04

What reading on an SWR meter indicates a perfect impedance match between the antenna and the feed line?

1:1

## T7C05

Why do most solid-state transmitters reduce output power as SWR increases beyond a certain level? To protect the output amplifier transistors

*Any power reflected back from a mismatch (worst case a short or open) will come back to the output transistors forcing them to dissipate additional power. If the transmitter senses high reflected power it will automatically reduce its output power.*

## T7C06

What does an SWR reading of 4:1 indicate? Impedance mismatch

*A load of either 200 ohms or 12.5 ohms would result in a 4:1 VSWR*

## T7C07

What happens to power lost in a feed line? It is converted into heat

## T7C08

Which instrument can be used to determine SWR? Directional wattmeter



## T7C09

Which of the following causes failure of coaxial cables? Moisture contamination

**T7C10**

Why should the outer jacket of coaxial cable be resistant to ultraviolet light? Ultraviolet light can damage the jacket and allow water to enter the cable

**T7C11**

What is a disadvantage of air core coaxial cable when compared to foam or solid dielectric types? It requires special techniques to prevent moisture in the cable



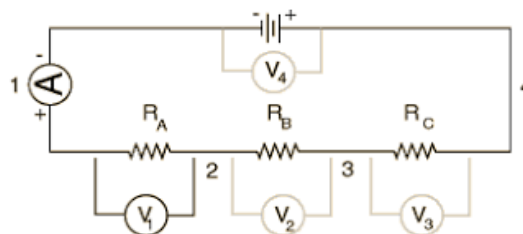
## **T7D – Using basic test instruments: voltmeter, Ammeter, and ohmmeter; Soldering**

**T7D01**

Which instrument would you use to measure electric potential? A voltmeter

**T7D02**

How is a voltmeter connected to a component to measure applied voltage? In parallel



**T7D03**

When configured to measure current, how is a multimeter connected to a component? [In series](#)  
*See graphic for T7D02 above*

**T7D04**

Which instrument is used to measure electric current? [An ammeter](#)

**T7D05**

How is an ohmmeter connected to a component to measure its resistance? [In parallel](#)

**T7D06**

Which of the following can damage a multimeter? [Attempting to measure voltage when using the resistance setting](#)

**T7D07**

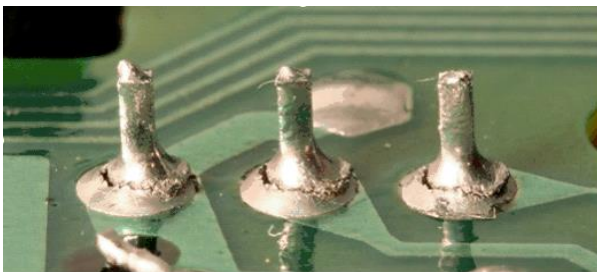
Which of the following measurements are made using a multimeter? [Voltage and resistance](#)

**T7D08**

Which of the following types of solder should not be used for radio and electronic applications? [Acid-core solder](#)

**T7D09 (C)**

What is the characteristic appearance of a cold tin-lead solder joint? [A rough or lumpy surface](#)

**T7D10**

What reading indicates that an ohmmeter is connected across a large, discharged capacitor?  
[Increasing resistance with time](#)

**T7D11**

Which of the following precautions should be taken when measuring in-circuit resistance with an ohmmeter?  
[Ensure that the circuit is not powered](#)  
*Also insure there are no charged capacitors in the circuit you are measuring*



## SUBELEMENT T8 – SIGNALS AND EMISSIONS

### [4 Exam Questions - 4 Groups]

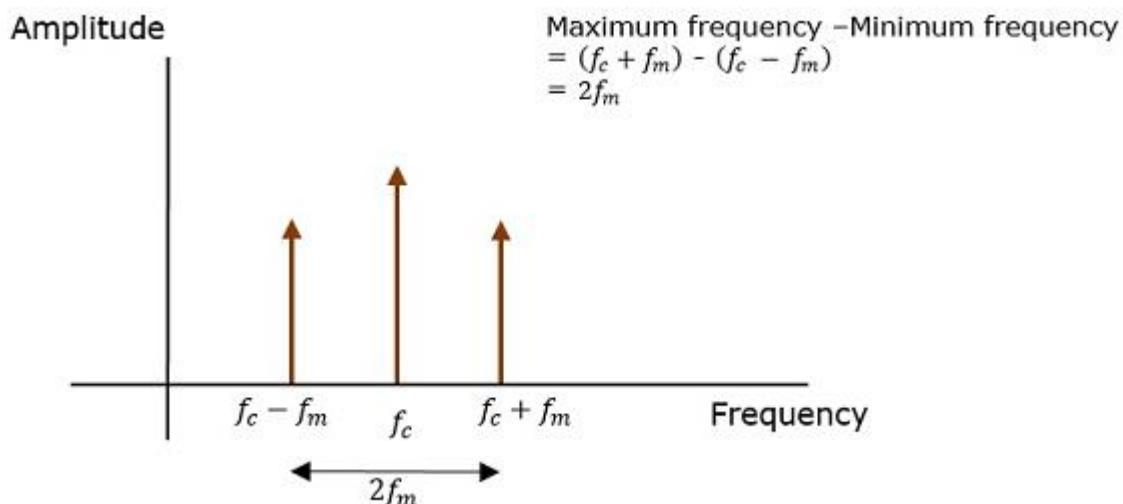
**T8A – Basic characteristics of FM and SSB; Bandwidth of various modulation modes: CW, SSB, FM, fast-scan TV; Choice of emission type: selection of USB vs LSB, use of SSB for weak signal work, use of FM for VHF packet and repeaters**

**T8A01**

Which of the following is a form of amplitude modulation? [Single sideband](#)

#### **Brief SSB (single sideband) modulation tutorial**

In the process of Amplitude Modulation, the modulated wave consists of the carrier wave and two sidebands. The Graphic below shows a representation of an amplitude modulated signal in the frequency domain with the carrier and its two sidebands. The carrier makes up 50% of the transmitted signal power and each sideband has 25% of the power making up the total of 100%. Both the sidebands contain the same information. So it is only necessary to send one of them and since the carrier does not contain any information it can also be eliminated. Doing this reduces the transmit power requirement to decrease by 75%. The disadvantage is a more complex recovery process in the receiver and a requirement for very stable Transmit frequency and receiver frequency stability.



**T8A02**

What type of modulation is commonly used for VHF packet radio transmissions? [FM or PM](#)

*FM is frequency modulation and PM is phase modulation*



**T8A03**

Which type of voice mode is often used for long-distance (weak signal) contacts on the VHF and UHF bands?  
SSB

**T8A04**

Which type of modulation is commonly used for VHF and UHF voice repeaters? FM or PM

**T8A05**

Which of the following types of signal has the narrowest bandwidth? CW  
*Morse Code (CW) takes up approx. 150 Hz of spectrum and a receive bandwidth of 300 to 500 Hz is sufficient to receive it.*

**T8A06**

Which sideband is normally used for 10 meter HF, VHF, and UHF single-sideband communications?  
Upper sideband  
*As a general rule Upper Sideband (USB) is used for transmissions above 10 MHz and Lower Sideband (LSB) is used for transmissions Below 10 MHz*

**T8A07**

What is a characteristic of single sideband (SSB) compared to FM? SSB signals have narrower bandwidth  
*FM transmissions requires 15 KHz of spectrum and SSB signal requires 3 KHz of spectrum . Five SSB transmissions can fit in the spectrum needed for a single FM Transmission.*

**T8A08**

What is the approximate bandwidth of a typical single sideband (SSB) voice signal? 3 kHz

**T8A09**

What is the approximate bandwidth of a VHF repeater FM voice signal? Between 10 and 15 kHz

**T8A10**

What is the approximate bandwidth of AM fast-scan TV transmissions? About 6 MHz  
*Fast scan TV is the old Analog NTSC (National Television Standards Committee) format.*

**T8A11**

What is the approximate bandwidth required to transmit a CW signal? 150 Hz

**T8A12**

Which of the following is a disadvantage of FM compared with single sideband? Only one signal can be received at a time

**T8B - Amateur satellite operation: Doppler shift, basic orbits, operating protocols, modulation mode selection, transmitter power considerations, telemetry and telecommand, satellite tracking programs, beacons, uplink and downlink mode definitions, spin fading, definition of “LEO”, setting uplink power**

**T8B01**

What telemetry information is typically transmitted by satellite beacons? Health and status of the satellite

**T8B02**

What is the impact of using excessive effective radiated power on a satellite uplink? Blocking access by other users

*If your uplink power is too high you could "blind" the satellite to other signals, blocking them from using it because the satellite receiver will AGC (automatic gain control) to prevent overload therefore reducing the sensitivity to other received signals.*

**T8B03**

Which of the following are provided by satellite tracking programs?

- A. Maps showing the real-time position of the satellite track over Earth
- B. The time, azimuth, and elevation of the start, maximum altitude, and end of a pass
- C. The apparent frequency of the satellite transmission, including effects of Doppler shift
- D. All these choices are correct

**T8B04**

What mode of transmission is commonly used by amateur radio satellites?

- A. SSB
- B. FM
- C. CW/data
- D. All these choices are correct

**T8B05**

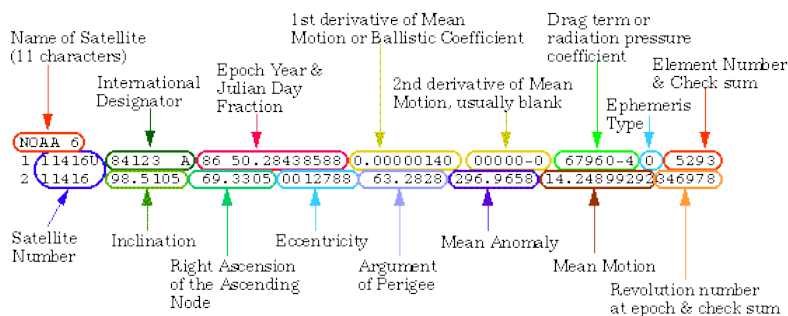
What is a satellite beacon? A transmission from a satellite that contains status information

*Most of the satellites have a beacon which normally located at the top or bottom end of the frequency spread for that satellite. Health and status of the satellite is the telemetry information typically transmitted by satellite beacons. Some satellites may transmit additional information.*

**T8B06**

Which of the following are inputs to a satellite tracking program? The Keplerian elements

*Satellite Orbital Elements are numbers that tell us the orbit of each satellite. Elements for common satellites are distributed through amateur radio bulletin boards, and other means.*

**T8B07**

What is Doppler shift in reference to satellite communications? An observed change in signal frequency caused by relative motion between the satellite and Earth station

**T8B08**

What is meant by the statement that a satellite is operating in U/V mode? The satellite uplink is in the 70 centimeter band and the downlink is in the 2 meter band

*The satellite uplink is in the 70 centimeter **U**HF band and the downlink is in the 2 meter **V**HF band*

**T8B09**

What causes spin fading of satellite signals? Rotation of the satellite and its antennas

**T8B10**

What is a LEO satellite? A satellite in low earth orbit

*A low Earth orbit (LEO) is an orbit around Earth with an altitude of 2,000 kilometers (1,200 mi) or less, and an orbital period of between about 84 and 127 minutes. Objects below approximately 160 kilometers (99 mi) will experience very rapid orbital decay and altitude loss due to atmospheric drag.*

**T8B11**

Who may receive telemetry from a space station? Anyone

**T8B12**

Which of the following is a way to determine whether your satellite uplink power is neither too low nor too high? Your signal strength on the downlink should be about the same as the beacon

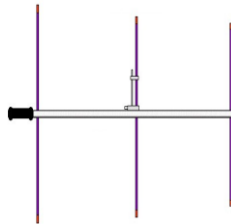
## **T8C – Operating activities: radio direction finding, contests, linking over the internet, exchanging grid locators**

**T8C01**

Which of the following methods is used to locate sources of noise interference or jamming? Radio direction finding

**T8C02**

Which of these items would be useful for a hidden transmitter hunt? A directional antenna

**T8C03**

What operating activity involves contacting as many stations as possible during a specified period? Contesting

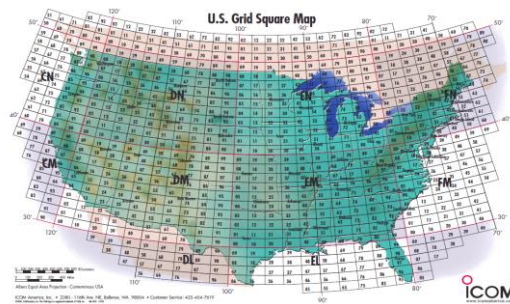
**T8C04**

Which of the following is good procedure when contacting another station in a contest? Send only the minimum information needed for proper identification and the contest exchange

**T8C05**

What is a grid locator? A letter-number designator assigned to a geographic location

Spokane Washington in  
located in Grid Square DN17

**T8C06**

How is over the air access to IRLP nodes accomplished? By using DTMF signals  
*IRLP is the Internet Radio Linking Project. The aim of this project is to link amateur radio systems reliably and inexpensively without the use of RF links, leased lines, or satellites. The IRLP uses Voice-Over-IP (VoIP) custom software and hardware. Coupled with the power of the Internet, IRLP will link your repeater site or simplex station to the world in a simple and cost effective way.*

**T8C07**

What is Voice Over Internet Protocol (VoIP)? A method of delivering voice communications over the internet using digital techniques

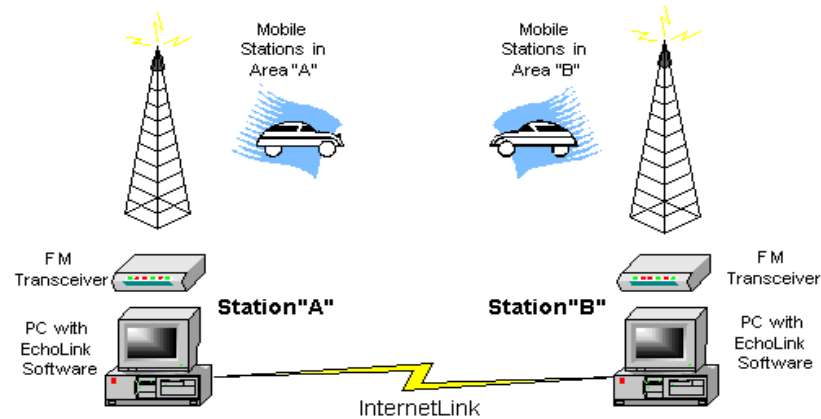
**T8C08**

What is the Internet Radio Linking Project (IRLP)? A technique to connect amateur radio systems, such as repeaters, via the internet using Voice Over Internet Protocol (VoIP)

**T8C09**

Which of the following protocols enables an amateur station to transmit through a repeater without using a radio to initiate the transmission? EchoLink

*EchoLink® software allows licensed Amateur Radio stations to communicate with one another over the Internet, using streaming-audio technology. The program allows worldwide connections to be made between stations, or from computer to station, greatly enhancing Amateur Radio's communications capabilities.*

**T8C10**

What is required before using the EchoLink system? [Register your call sign and provide proof of license](#)

**T8C11**

What is an amateur radio station that connects other amateur stations to the internet? [A gateway](#)

## **T8D – Non-voice and digital communications: image signals and definition of NTSC, CW, packet radio, PSK, APRS, error detection and correction, amateur radio networking, Digital Mobile Radio, WSJT modes, Broadband-Hamnet**

**T8D01**

Which of the following is a digital communications mode?

- A. Packet radio
- B. IEEE 802.11
- C. FT8
- D. [All these choices are correct](#)

**T8D02**

What is a “talkgroup” on a digital repeater? [A way for groups of users to share a channel at different times without hearing other users on the channel](#)

**T8D03**

What kind of data can be transmitted by APRS?

- A. GPS position data
- B. Text messages
- C. Weather data
- D. [All these choices are correct](#)

**T8D04**

What type of transmission is indicated by the term "NTSC?" [An analog fast-scan color TV signal](#)  
*NTSC is the National Television Standards Committee, the old analog TV system.*

**T8D05**

Which of the following is an application of APRS? Providing real-time tactical digital communications in conjunction with a map showing the locations of stations

**T8D06**

What does the abbreviation "PSK" mean? Phase Shift Keying

**T8D07**

Which of the following describes DMR? A technique for time-multiplexing two digital voice signals on a single 12.5 kHz repeater channel

*DMR stands for Digital Mobile Radio and is an international standard that has been defined for two-way radios. The DMR standard allows equipment developed by different manufacturers to operate together on the same network for all the functions defined within the standard.*

**T8D08**

Which of the following is included in packet radio transmissions?

- A. A check sum that permits error detection
- B. A header that contains the call sign of the station to which the information is being sent
- C. Automatic repeat request in case of error
- D. All these choices are correct**

**T8D09**

What is CW? Another name for a Morse code transmission

**T8D10**

Which of the following operating activities is supported by digital mode software in the WSJT-X software suite?

- A. Earth-Moon-Earth
- B. Weak signal propagation beacons
- C. Meteor scatter

**D. All these choices are correct**

*WSJT software facilitates basic digital communication using protocols explicitly optimized for a number of different propagation modes:*

*JTMS, FSK441 for meteor scatter*

*ISCAT, JT6M for ionospheric scatter*

*JT65 for EME at VHF/UHF, and for QRP operation at MF/HF*

*JT4: for EME on the microwave bands*

**T8D11**

What is an ARQ transmission system? An error correction method in which the receiving station detects errors and sends a request for retransmission

*Automatic Repeat ReQuest (ARQ) is a group of error – control protocols for transmission of data over noisy or unreliable communication network. They are named so because they provide for automatic retransmission of frames that are corrupted or lost during transmission.*

**T8D12**

Which of the following best describes an amateur radio mesh network? [An amateur-radio based data network using commercial Wi-Fi equipment with modified firmware](#)

*Simply, it's hams using our radio privileges to operate a private, self-contained wireless computer network. Anything that can be done on a regular network/internet can be done on this private Wi-Fi network. The HAM Mesh Network uses off-the-shelf Wi-Fi equipment that has been modified to permit equipment to be used on HAM frequencies under Part 97 rules. Links between nodes can be achieved for miles and miles limited by line-of-site.*

**T8D13**

What is FT8? [A digital mode capable of low signal-to-noise operation](#)

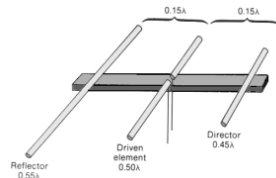
## SUBELEMENT T9 – ANTENNAS AND FEED LINES

### [2 Exam Questions - 2 Groups]

**T9A – Antennas: vertical and horizontal polarization, concept of antenna gain, definition and types of beam antennas, antenna loading, common portable and mobile antennas, relationships between resonant length and frequency, dipole pattern**

**T9A01**

What is a beam antenna? An antenna that concentrates signals in one direction



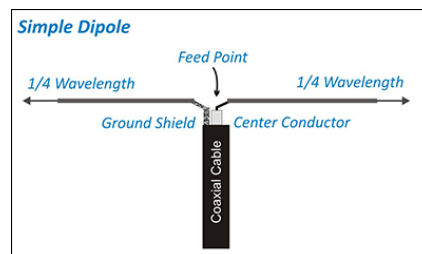
**T9A02**

Which of the following describes a type of antenna loading? Electrically lengthening by inserting inductors in radiating elements



**T9A03**

Which of the following describes a simple dipole oriented parallel to Earth's surface? A horizontally polarized antenna



**T9A04**

What is a disadvantage of the short, flexible antenna supplied with most handheld radio transceivers, compared to a full-sized quarter-wave antenna? It has low efficiency

**T9A05**

Which of the following increases the resonant frequency of a dipole antenna? Shortening it



T9A06

Which of the following types of antenna offers the greatest gain? Yagi



T9A07

What is a disadvantage of using a handheld VHF transceiver with a flexible antenna inside a vehicle?

Signal strength is reduced due to the shielding effect of the vehicle

T9A08

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

19

$WL = ((300 \div 146) \div 4)$  or  $(2.05 \div 4)$  or  $.5134$  meters or  $51.34$  cm

Divide cm by 2.54 to get inches or  $51.34 \div 2.54$  or 20.2 Inches, the closest answer is 19 inches

**Directly in inches:**

$\frac{1}{4} WL = ((492 \div 146) \div 2)$  or  $3.369 \div 2$  or  $1.684$  FT or in inches  $1.684$  FT x 12 or 20.21 inches. 19 is the closest answer show in the choices.

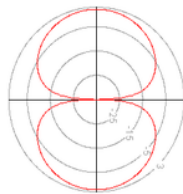
T9A09

What is the approximate length, in inches, of a half-wavelength 6 meter dipole antenna? 112

$\frac{1}{2} WL = (492 \div 50)$  or  $9.840$  FT or in inches  $9.360 \times 12$  or  $112.0$  inches 112 inches is the closest answer

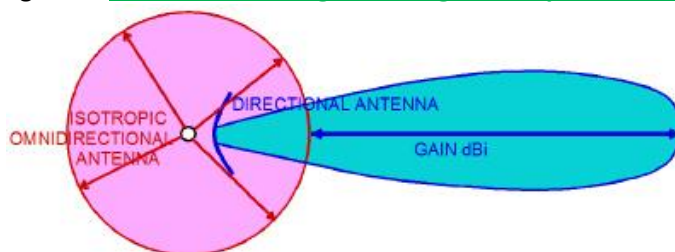
T9A10

In which direction does a half-wave dipole antenna radiate the strongest signal? Broadside to the antenna



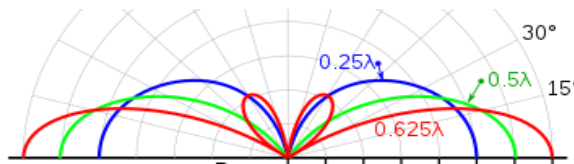
T9A11

What is antenna gain? The increase in signal strength in a specified direction compared to a reference antenna



**T9A12**

What is an advantage of a 5/8 wavelength whip antenna for VHF or UHF mobile service? It has more gain than a 1/4-wavelength antenna



## **T9B – Feed lines: types, attenuation vs frequency, selecting; SWR concepts; Antenna tuners (couplers); RF Connectors: selecting, weather protection**

**T9B01**

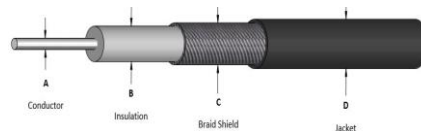
What is a benefit of low SWR? Reduced signal loss

**T9B02**

What is the most common impedance of coaxial cables used in amateur radio? 50 ohms

**T9B03**

Why is coaxial cable the most common feed line for amateur radio antenna systems? It is easy to use and requires few special installation considerations

**T9B04**

What is the major function of an antenna tuner (antenna coupler)? It matches the antenna system impedance to the transceiver's output impedance

**T9B05**

What happens as the frequency of a signal in coaxial cable is increased? The loss increases

**T9B06**

Which of the following RF connector types is most suitable for frequencies above 400 MHz? Type N



**T9B07**

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

frequencies

They are commonly used at HF and VHF



**T9B08**

Which of the following is a source of loss in coaxial feed line?

A. Water intrusion into coaxial connectors

B. High SWR

C. Multiple connectors in the line

D. All these choices are correct

**T9B09**

What can cause erratic changes in SWR?

Loose connection in the antenna or feed line

**T9B10**

What is the electrical difference between RG-58 and RG-213 coaxial cable?

RG-213 cable has less loss at a given frequency

Coax Cable Signal Loss (Attenuation) in dB per 100ft								
Loss*	<a href="#">RG-174</a>	<a href="#">RG-58</a>	<a href="#">RG-8X</a>	<a href="#">RG-213</a>	<a href="#">RG-6</a>	<a href="#">RG-11</a>	<a href="#">RF-9914</a>	<a href="#">RF-9913</a>
1MHz	1.9dB	0.4dB	0.5dB	0.2dB	0.2dB	0.2dB	0.3dB	0.2dB
10MHz	3.3dB	1.4dB	1.0dB	0.6dB	0.6dB	0.4dB	0.5dB	0.4dB
50MHz	6.6dB	3.3dB	2.5dB	1.6dB	1.4dB	1.0dB	1.1dB	0.9dB
100MHz	8.9dB	4.9dB	3.6dB	2.2dB	2.0dB	1.6dB	1.5dB	1.4dB
200MHz	11.9dB	7.3dB	5.4dB	3.3dB	2.8dB	2.3dB	2.0dB	1.8dB
400MHz	17.3 B	11.2dB	7.9dB	4.8dB	4.3dB	3.5dB	2.9dB	2.6dB
700MHz	26.0dB	16.9dB	11.0dB	6.6dB	5.6dB	4.7dB	3.8dB	3.6dB
900MHz	27.9 B	20.1dB	12.6dB	7.7dB	6.0dB	5.4dB	4.9dB	4.2dB
1GHz	32.0dB	21.5dB	13.5dB	8.3dB	6.1dB	5.6dB	5.3dB	4.5dB

**T9B11**

Which of the following types of feed line has the lowest loss at VHF and UHF? [Air-insulated hardline](#)

**T9B12**

What is standing wave ratio (SWR)? [A measure of how well a load is matched to a transmission line](#)

*SWR (Standing Wave Ratio), is a measure of how efficiently radio-frequency power is transmitted from a power source, through a transmission line, into a load (for example, from a power from a transmitter through a transmission line, to an antenna).*

## SUBELEMENT T0 – SAFETY

### [3 Exam Questions - 3 Groups]

**T0A – Power circuits and hazards: hazardous voltages, fuses and circuit breakers, grounding, electrical code compliance; Lightning protection; Battery safety**

#### T0A01

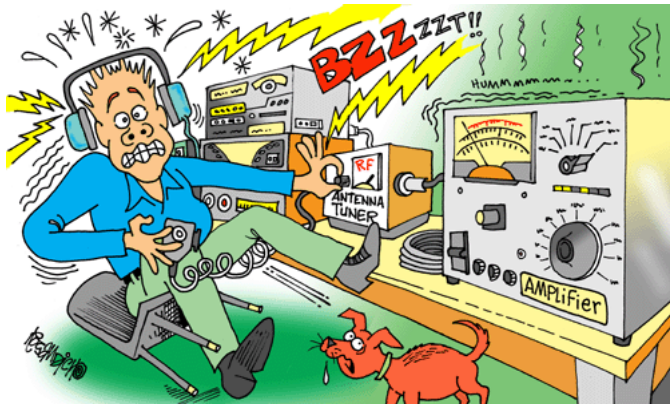
Which of the following is a safety hazard of a 12-volt storage battery? Shorting the terminals can cause burns, fire, or an explosion



#### T0A02

What health hazard is presented by electrical current flowing through the body?

- A. It may cause injury by heating tissue
- B. It may disrupt the electrical functions of cells
- C. It may cause involuntary muscle contractions
- D. All these choices are correct



#### T0A03

In the United States, what circuit does black wire insulation indicate in a three-wire 120 V cable? Hot  
*Keep in mind that in DC Circuits black is minus or ground. In AC wiring black is the HOT line, White in neutral and green is ground*

**T0A04**

What is the purpose of a fuse in an electrical circuit? To remove power in case of overload

**T0A05**

Why should a 5-ampere fuse never be replaced with a 20-ampere fuse? Excessive current could cause a fire

**T0A06**

What is a good way to guard against electrical shock at your station?

- A. Use three-wire cords and plugs for all AC powered equipment
- B. Connect all AC powered station equipment to a common safety ground
- C. Install mechanical interlocks in high-voltage circuits
- D. All these choices are correct

**T0A07**

Where should a lightning arrester be installed in a coaxial feed line? On a grounded panel near where feed lines enter the building

**T0A08**

Where should a fuse or circuit breaker be installed in a 120V AC power circuit? In series with the hot conductor only

**T0A09**

What should be done to all external ground rods or earth connections? Bond them together with heavy wire or conductive strap

**T0A10**

What hazard is caused by charging or discharging a battery too quickly? Overheating or out-gassing  
*The gas generated is hydrogen and if the battery is in a closed space the Hydrogen gas can accumulate creating an explosion hazard*

**T0A11**

What hazard exists in a power supply immediately after turning it off? Charge stored in filter capacitors

**T0A12**

Which of the following precautions should be taken when measuring high voltages with a voltmeter? Ensure that the voltmeter and leads are rated for use at the voltages to be measured

## T0B – Antenna safety: tower safety and grounding, installing antennas, antenna supports

### T0B01

Which of the following is good practice when installing ground wires on a tower for lightning protection?

Ensure that connections are short and direct

### T0B02

What is required when climbing an antenna tower?

- A. Have sufficient training on safe tower climbing techniques
- B. Use appropriate tie-off to the tower at all times
- C. Always wear an approved climbing harness
- D. All these choices are correct

### T0B03

Under what circumstances is it safe to climb a tower without a helper or observer? Never

### T0B04

Which of the following is an important safety precaution to observe when putting up an antenna tower?

Look for and stay clear of any overhead electrical wires

### T0B05

What is the purpose of a safety wire through a turnbuckle used to tension guy lines? Prevent loosening of the turnbuckle from vibration

### T0B06

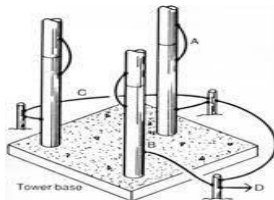
What is the minimum safe distance from a power line to allow when installing an antenna? Enough so that if the antenna falls, no part of it can come closer than 10 feet to the power wires

### T0B07

Which of the following is an important safety rule to remember when using a crank-up tower? This type of tower must not be climbed unless it is retracted, or mechanical safety locking devices have been installed

### T0B08

Which is a proper grounding method for a tower? Separate eight-foot ground rods for each tower leg, bonded to the tower and each other



### T0B09

Why should you avoid attaching an antenna to a utility pole? The antenna could contact high-voltage power lines

*In addition it is against the law and the power company will remove them and may send you a bill for their labor*

**T0B10**

Which of the following is true when installing grounding conductors used for lightning protection?

Sharp bends must be avoided

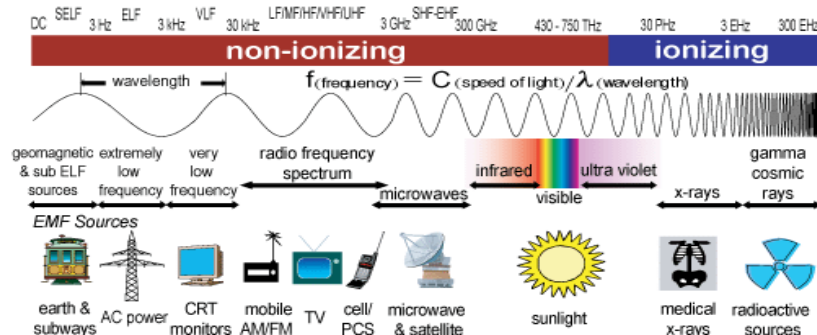
**T0B11**

Which of the following establishes grounding requirements for an amateur radio tower or antenna? Local electrical codes

## **T0C - RF hazards: radiation exposure, proximity to antennas, recognized safe power levels, radiation types, dutycycle**

**T0C01**

What type of radiation are radio signals? Non-ionizing radiation

**T0C02**

At which of the following frequencies does maximum permissible exposure have the lowest value? 50 MHz

Band	Power (W) into Antenna
160-meters	500
80-meters	500
40-meters	500
30-meters	425
20-meters	225
17-meters	125
15-meters	100
12-meters	75
10-meters	50
6-meters	50
2-meters	50
1.25-meters	50
70-centimeters	70
33-centimeters	150
23-centimeters	200
13-centimeters	250
SHF (all bands)	250
EHF (all bands)	250

**T0C03**

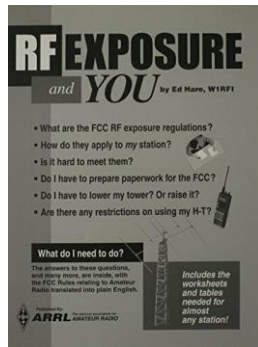
How does the allowable power density for RF safety change if duty cycle changes from 100 percent to 50 percent? It increases by a factor of 2



#### TOC04

What factors affect the RF exposure of people near an amateur station antenna?

- A. Frequency and power level of the RF field
- B. Distance from the antenna to a person
- C. Radiation pattern of the antenna
- D. All these choices are correct



#### TOC05

Why do exposure limits vary with frequency? The human body absorbs more RF energy at some frequencies than at others

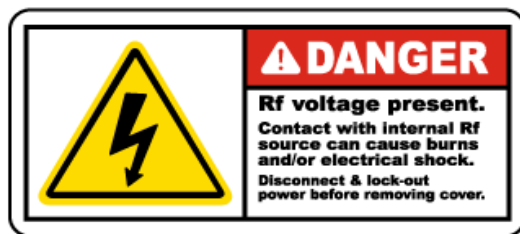
#### TOC06

Which of the following is an acceptable method to determine whether your station complies with FCC RF exposure regulations?

- A. By calculation based on FCC OET Bulletin 65
- B. By calculation based on computer modeling
- C. By measurement of field strength using calibrated equipment
- D. All these choices are correct

#### TOC07

What hazard is created by touching an antenna during a transmission? RF burn to skin



#### TOC08

Which of the following actions can reduce exposure to RF radiation? Relocate antennas

#### TOC09

How can you make sure your station stays in compliance with RF safety regulations? By re-evaluating the station whenever an item in the transmitter or antenna system is changed

*You can quickly determine if your station is following RF safety Regulations by using the ARRL On-line calculator <http://arrl.org/rf-exposure-calculator> . Then print a copy and keep it with your station records*

**T0C10**

Why is duty cycle one of the factors used to determine safe RF radiation exposure levels?

It affects the average exposure to radiation

**T0C11**

What is the definition of duty cycle during the averaging time for RF exposure? The percentage of time that a transmitter is transmitting

**T0C12**

How does RF radiation differ from ionizing radiation (radioactivity)? RF radiation does not have sufficient energy to cause chemical changes in cells and damage DNA

**T0C13**

Who is responsible for ensuring that no person is exposed to RF energy above the FCC exposure limits?

The station licensee