# Radio Teacher
# Technician Test
# Subelement T4 Notes

**These notes cover the information needed to answer the questions on Subelement T4 of the Amateur Radio Technician Test. They can be used by instructors as a reference to make sure that all of the information in this subelement is addressed in class.**

Subelement T4 covers your knowledge of radio and electronic fundamentals. It contains many definitions of electrical terms, Ohm's Law, power calculations and the relationship between wavelength and frequency,

**Current:**
Current is the term used to describe the flow of electrons in an electric circuit. Electrical current is measured in Amperes and we use the letter **I** to express current in equations.

The flow of electrons in direct current is only in one direction. An alternating current reverses electron flow direction on a regular basis.

An Ammeter is used to measure the flow of current in an electrical circuit.

**Electromotive Force (EMF):**
The unit of measurement for Electromotive Force (EMF) is Volts. The letter **E** is used to describe voltage in equations.

A Voltmeter is the instrument used to measure Electromotive Force (EMF) between two points such as the poles of a battery.

For example an automobile battery usually supplies about 12 volts.

**Resistance:**
Resistance is the term used to describe opposition to current flow in ordinary conductors such as wires. Resistance is measured in ohms and the letter **R** is used to express resistance in equations. It is also expressed as the Greek letter omega **Ω**.

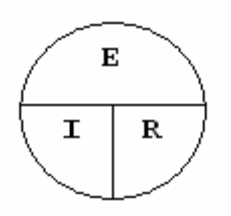
The ohm is the basic unit of resistance.

**Ohms Law:**
The relationship between voltage, current and resistance can be described mathematically in Ohms Law.

Using Ohms Law it is easy to determine circuit voltage **(E)**. Do this by multiplying the circuit current **(I)** by the circuit resistance **(R)**. **E=I*R**

You will be solving equations using Ohm's law later is this subelement. One way to remember the equation is with the circle below. If you put your finger over the part of the equation that you are trying to solve, the solution for the problem remains.

For example, if you are trying to solve for current put your finger over the **I** and it will leave visible **E** over **R**. So **I=E/R**

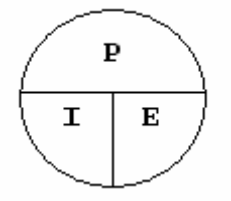



**Power:**
The Watt is the unit used to describe electrical power. The letter used for power in an equation is **P**. Power **(P)** can be calculated by multiplying the circuit current **(I)** by the circuit voltage **(E)**. This can be expressed as **P=I*E.**

You will be solving equations using the power equation later is this subelement. There is a circle for Power solving below. If you put your finger over the part of the equation that you are trying to solve, the solution for the problem remains.

For example if you are trying to solve or voltage put your finger over the **E** and it will leave visible **P** over **I**. So **E=P/I**

How can you determine how many watts are being drawn by your transceiver when you are transmitting? Just measure the DC voltage at the transceiver and multiply by the current drawn when you transmit.



**Conductors:**
Most metals make very good conductors of electricity. Some examples of conductors are Gold, Silver, Copper and Aluminum. Most house wiring is copper.

**Insulators:**
Insulators on the other hand are very poor conductors of electricity. Glass, Bakelite, Rubber and Mica are very good insulators. Railroad communication lines next to the tracks had green Glass insulators on the poles holding up the wires.

**Frequency:**
Frequency describes the number of times that an alternating current flows back and forth per second. The Hertz is the standard unit of frequency. Frequency in an equation is expressed as the lower case letter **f** but when written the abbreviation **Hz** is used.

Think of a station on 146.88 MHz as an example of a frequency. A frequency of 146.88 MHz can also be expressed as 146,880,000 Hz or cycles per second. A frequency of 60 hertz (Hz) can also be stated as 60 cycles per second.

50 to 54 MHz is the frequency range of the 6 meter band.
144 to 148 MHz is the frequency range of the 2 meter band.
420 to 450 MHz is the frequency range of the 70 centimeter band.

**Wavelength:**
Wavelength is the distance a radio wave travels during one complete cycle. Radio waves travel through space at the speed of light.

The formula for converting a frequency to a wavelength in meters is 300 divided by the frequency in megahertz. For example 300 divided into 146.88 MHz equals 2.04 meters. Thus one complete cycle of a signal at 146.88 MHz travels at the speed of light 2.04 meters.

The physical length of the wave is often used to identify the different bands amateur radio operators use. Examples are 6 meters (50 to 54 MHz), 2 meters (144 to 148 MHz) and 70 centimeters (430 MHz to 450MHz).

Electromagnetic waves that oscillate at more than 20,000 times per second as they travel through space are generally referred to as radio waves.

**Wavelength vs. Frequency:**
Wavelengths get shorter as frequencies increase. One way to think of this is: Low frequency speakers “woofers” have very long wavelengths and large speakers and enclosures. High frequency speakers “tweeters” have much shorter wavelengths and smaller speakers and enclosures. As the frequency increases the wavelength decreases.

**Audio Frequency (Voice):**
Voice frequencies are sound waves in the range between 300 and 3000 Hertz.

**Radio Basics:**
Receivers are used to convert radio signals into sounds we can hear. A transmitter is used to convert sounds from our voice into radio signals.

A receiver and a transmitter combined into one device is called a transceiver.

Radio operators use a Power Supply to convert the alternating current from a wall outlet into low-voltage direct current.

To increase the output of a 10 watt radio to 100 watts an amplifier can be added between the radio and the antenna.

**Batteries:**
Of the battery types listed below Lithium-ion offers the longest life when used with a hand-held radio, assuming each battery is the same physical size.

Lithium-ion, Lead-acid, Alkaline and Nickel-cadmium are four types of batteries used in radio equipment.

The nominal voltage per cell of a fully charged nickel-cadmium battery is 1.2 volts.

Remember that Carbon-zinc batteries are not designed to be re-charged.

To keep rechargeable batteries in good condition and ready for emergencies you should inspect them for physical damage, replace them when necessary, store them in a cool dry location and give them a maintenance recharge at least every 6 months.

The best way to get the most amount of energy from a battery is to draw current from the battery at the slowest rate needed.

**Ohms Law Practice:**
What is the resistance of a circuit when a current of 3 amperes flows through a resistor connected to 90 volts? To solve this use the Ohm's Law circle above. Covering **R** in the circle leaves **E** over **I** so **R=E/I.** 90 volts/3 amps= 30 ohms

What is the resistance in a circuit where the applied voltage is 12 volts and the current flow is 1.5 amperes? As above we would use **R=E/I**. 12 volts/ 1.5 amps= 8 ohms

What is the current flow in a circuit with an applied voltage of 120 volts and a resistance of 80 ohms? For this one would use **I=E/R** 120 volts/80 ohms=1.5 amperes

What is the current flowing through a 100 ohm resistor connected across 200 volts? As above you would use **I=E/R** 200 volts/100 ohms=2 amperes

What is the current flowing through a 24 ohm resistor connected across 240 volts? **I=E/R** 240 volts/24 ohms=10 amperes

What is the voltage across the resistor if a current of 0.5 amperes flows through a 2 ohm resistor? For this solution use **E=I*R**. 0.5 amperes multiplied by 2 ohms equals 1 volt.

What is the voltage across the resistor if a current of 1 ampere flows through a 10 ohm resistor? Again use **E=I*R** 1 ampere multiplied by 10 ohms equals 10 volts.

What is the voltage across the resistor if a current of 2 amperes flows through a 10 ohm resistor? **E=I*R** 2 amperes multiplied by 10 ohms equals 20 volts

**Power Calculation Practice:**
Power **(P)** equals voltage **(E)** multiplied by current **(I)** is the formula used to calculate electrical power in a DC circuit. **P=I*E or P=E*I**

How much power is represented by a voltage of 13.8 volts DC and a current of 10 amperes? As stated above **P=E*I**. 13.8 volts multiplied by 10 amperes equals 138 watts.

How much power is being used in a circuit when the voltage is 120 volts DC and the current is 2.5 amperes? **P=E*I** 120 volts multiplied by 2.5 amperes equals 300 watts.

How many amperes are flowing in a circuit when the applied voltage is 120 volts DC and the load is 1200 watts? Using the power circle I can see that **I=P/E**. 1200 watts divided by 120 volts equals 10 amperes.

How many milliamperes is the same as 1.5 amperes? 1500 milliamperes

What is another way to specify the frequency of a radio signal that is oscillating at 1,500,000 Hertz? 1500 kHz

How many volts are equal to one kilovolt? One thousand volts

How many volts are equal to one microvolt? One one-millionth of a volt

How many watts does a hand-held transceiver put out if the output power is 500 milliwatts? 0.5 watts