It is possible to pass the technician's license exam by just memorizing the questions and answers but some of you may want to or need to supplement your memorization with a little understanding. The following explains some of the "why" without going all the way to being a textbook. When you get a radio and get on the air, you'll have plenty of time and opportunity to understand why.

The FCC requires only that you pass the exam to get a license – they don't require that you understand *everything*. Indeed, you can miss 9 answers out of 35 and still pass. For example, you could miss every technical question or all of the safety questions and they'll still grant you a license. The FCC and the ham radio community wants you to have read all 400 questions and answers before you get on the air, but they certainly don't expect you to remember it all – that's what books are for!

Passing the exam shouldn't be the end of your ham radio education. We provide two follow-on classes to make sure you get a good start on the rest of you education and we really want you to get on the air to continue learning by doing and asking questions. The ham community is there to help you but first you have to get your license, get a radio, learn to use it and get on the air!

Here are the answers to the questions we get asked most often:

What is CW?

CW stands for *Continuous Wave*, but for the purpose of the Tech exam it simply means **Morse code**.

The FCC has rules that limit *where voice* communication may be used to allow for CW communication without interference from voice stations. The rules state that only CW may be used on the first .1 MHz of some frequency bands.

The following exam questions and/or correct answers mention CW:

T1B11 What emission modes are permitted in the mode-restricted sub-bands at 50.0 to 50.1 MHz and 144.0 to 144.1 MHz? Answer: **CW only**

T4B10 Which of the following is an appropriate receive filter to select in order to minimize noise and interference for CW reception? Answer: **500 Hz**

T8A05 Which of the following types of emission has the narrowest bandwidth? Answer: **CW** *(Because CW takes up the least space – voice signals are much wider)*

T8A11 What is the approximate maximum bandwidth required to transmit a CW signal? Answer: **150 HZ**

T8D09 What code is used when sending CW in the amateur bands? Answer: **International Morse**

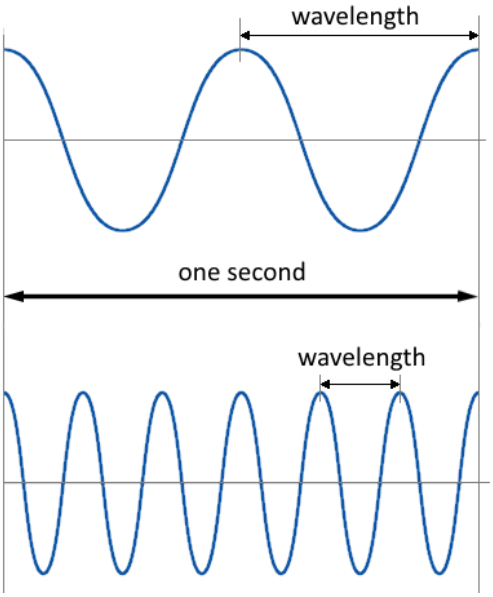
Frequency vs. Wavelength

How can I remember all those frequencies and wavelengths? **There's a relationship between frequency and wavelength.**

If you could see a radio wave it would look something like a wave traveling through water with a series of peaks and troughs.

The **length** of any wave is the **distance** it travels as it makes one cycle from any starting point up through its highest peak, down to its lowest point and back up to the starting point.
For radio waves one wavelength is the distance the wave travels through one cycle of positive and negative voltage and north-south magnetic

The **frequency** of any wave is defined as the number of cycles the wave makes during **one second**. In the figure to the right the bottom wave has a higher frequency than the wave below it. It goes through six cycles in the same length of time that the top wave goes through two.



Wavelength gets shorter as the frequency increases.

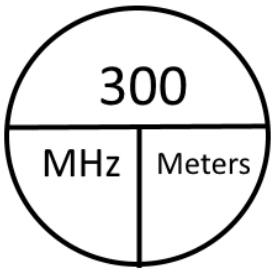
Calculating the relationship between radio frequencies and wavelengths is pretty easy:

- Radio travels at the speed of light or **300,000,000 meters per second**
- Wavelength is equal to the speed of light divided by frequency
- Frequency is equal to the speed of light divided by wavelength

Frequency is expressed in *cycles per second*. One cycle/sec is defined as one **Hertz** (Hz). One million Hz is one **Megahertz** (MHz)

$$\frac{\textbf{300,000,000 meters/second}}{\textbf{frequency in cycles/second}} = \frac{\textbf{300 meters/second}}{\textbf{frequency in millions of cycles /second}} = \textbf{Wavelength in meters/cycle}$$

Was that too much math and science? Well, you can just memorize the frequencies and wavelengths and still pass the exam. Or decide to miss those and make sure you learn the rest. It's your choice.



You can use the following diagram to figure out the math instead of learning a formula: Cover up the thing they're asking you for (MHz or Meters), and divide 300 by the thing they give you (meters or MHz):

To get **frequency** (*in MHz*) divide 300 by **wavelength** (*in meters*)

To get **wavelength** (*in meters*)**,** divide 300 by **frequency** (*in MHz*)

In the following questions and answers, of which you might get just one on the exam, the answer is ***approximately*** 300 divided by the number in the question.

T1B03 Which frequency is within the 6-meter band? Answer: **52.525** MHz (300 ÷ 6 = 50 or *approximately* 52.525 MHz.) But wait a minute: another answer choice is 49 MHz and that's even closer to 50. In order to get the right answer you have to know that the 6-meter band is defined as frequencies between 50 and 54MHz, so 49MHz isn't in the 6m band.

T1B04 Which amateur band are you using when transmitting on 146.52 MHz? Answer: **2 meter band** (300 ÷ 146.525 = 2.048 or *approximately* 2 meters)

T1B05 Which 70-centimeter frequency is authorized to a Technician class license holder operating in ITU Region 2? Answer: **443.350** MHz (300 ÷ 443.350 = .676 or *approximately* 70 cm. Remember: 1 meter = 100 centimeters so .676 meters = 67.6 centimeters.)

T1B06 Which 23 centimeter frequency is authorized to a Technician class license holder operating in ITU Region 2? Answer: **1296 MHz** (300 ÷ .23 = 1304 or approximately 1296 MHz. Note 23 centimeters = **.**23 meters so here we are dividing 300 by point 23.)

T1B07 What amateur band are you using if you are operating on 223.50 MHz? Answer: **1.25 meter band** (300÷ 223.50 = 1.34 or *approximately* 1.25 meters)

T3B01 What is the name for the distance a radio wave travels during one complete cycle? Answer: **Wavelength**

T5A12 What term describes the number of times that an alternating current flows back and forth per second? Answer: **Frequency**

T3B04 How fast does a radio wave travel through space? Answer: **At the speed of light**

T3B05 How does the wavelength of a radio wave relate to its frequency? Answer: **The wavelength gets shorter as the frequency increases.**

T3B06 What is the formula for converting frequency to wavelength in meters? Answer: **Wavelength in meters equals 300 divided by frequency in megahertz.**

T3B07 What property of radio waves is often used to identify the different frequency bands?
Answer: **The approximate wavelength**

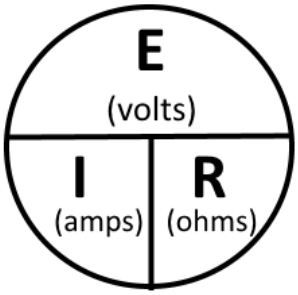
T3B11 What is the approximate velocity of a radio wave as it travels through free space?
Answer: **300,000,000 meters per second**

Ohm's Law

Ohm's Law defines the relationship between electrical **current, voltage, and resistance.**

I is the **Intensity** of the electrical Current measured in **Amperes** (or Amps)
E is the **E**lectromotive Force or **Voltage**, measured in **Volts**
R is **R**esistance, measured in **Ohms**

Current = Volts ÷ Ohms
I = E ÷ R



The diagram to the right is a good memory aid. Think of Lake Erie except we'll spell it "**ERI"**: Start at the top and write the letters **E R I** -- it doesn't matter if you write them clockwise or counter-clockwise. If an exam question gives you two of those values and asks you to provide the third you can use this diagram to figure out whether to multiply or divide to get the answer.

If they ask for **R**, put your finger over **R** and you're left with **E** "over" **I**, so divide **E** by **I**.
If they ask for **I**, put your finger over **I** and you're left with **E** "over" **R**, so divide **E** by **I**.
If they ask for **E**, cover up **E** and multiply **I** times **R** (because they're next to each other).

You can write the Ohm's Law diagram on the back or margin of your *answer sheet*, (**BUT NEVER ON YOUR TEST BOOKLET**), so you don't have to remember it very long. We keep it in front of you for most of the class, and take it down just before we hand out the answer sheets.

How can you remember the units that go with E, R and I? Think of the ***"Voice Of America" transmitting signals across Lake ERI***. VOA = Volts, Ohms, Amps, and they go with E, R and I.

You can use the "**E R I**" diagram to answer the following: (one of these questions will be on the exam).

T5D01 What formula is used to calculate current in a circuit? Answer: **current** (I) equals **voltage** (E) divided by **resistance** (R)

T5D02 What formula is used to calculate voltage in a circuit?
Answer: **voltage** (E) equals **current** (I) multiplied by **resistance** (R)

T5D03 What formula is used to calculate resistance in a circuit?
Answer: **resistance** (R) equals **voltage** (E) divided by **current** (I)

T5D04 What is the resistance of a circuit when a current of 3 amperes flows through a resistor connected to 90 volts? Answer: **30 ohms** (R = E÷I, so R = 90÷3 = 30 ohms)

T5D05 What is the resistance in a circuit where the applied voltage is 12 volts and the current flow is 1.5 amperes? Answer: **8 ohms** (R = E÷I, so R = 12÷1.5 = 8 ohms)

T5D06 What is the resistance of a circuit that draws 4 amperes from a 12 volt source?
Answer: **3 ohms** (R=E÷I, so R = 12÷4 = 3 ohms)

T5D07 What is the current flow in a circuit with an applied voltage of 120 volts and a resistance of 80 ohms? Answer: **1.5 amperes** (I = E÷R, so I = 120÷80 = 1.5 amperes)

T5D08 What is the current flowing through a 100 ohm resistor connected across 200 volts?
Answer: **2 amps** (I=E÷R, so 200÷100 = 2)

T5D09 What is the current flowing through a 24 ohm resistor connected across 240 volts?
Answer: **10 amperes** (I = E÷R, so I = 240÷24 = 10 amperes)

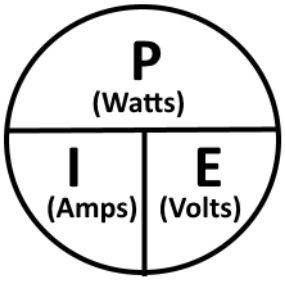
T5D10 What is the voltage across the resistor if a current of 0.5 amperes flows through a 2 ohm resistor? Answer: **1 volt** (E = IR, E = 0.5 x 2 = 1 volt)

T5D11 What is the voltage across the resistor if a current of 1 ampere flows through a 10 ohm resistor? Answer: **10 volts** (E = IR, so E = 1 x 10 = 10 volts)

T5D12 What is the voltage across the resistor if a current of 2 amperes flows through a 10 ohm resistor? Answer: **20 volts** (E = IR, so E = 2 x 10 = 20 volts)

Power

Power defined as **Current** times **Voltage** and it's measured in **Watts.** It's easy to remember that formula if you think of the diagram to the right, in fact its "Easy as PIE".



Power (watts) **= Current** (amps) x **Voltage** (volts)

P = I x E

The math formula you use to calculate **Power** applies to the following exam questions:

T5A02 Electrical Power is measured in which of the following units? Answer: **Watts**

T5C08 What is the formula used to calculate electrical power in a DC circuit?
Answer: **Power (P)** equals **voltage (E)** multiplied by **current (I)**

T5C09 How much power is being used in a circuit when the applied voltage is 13.8 volts DC and the current is 10 amperes? Answer: **138 watts**

T5C10 How much power is being used in a circuit when the voltage is 12 volts DC and the current is 2.5 amperes? Answer: **30 watts**

T5C11 How many amperes are flowing in a circuit when the applied voltage is 12 volts DC and the load is 120 watts? Answer: **10 amperes**

Decibels

A **decibel** (dB) is a *measurement of change* as compared to some given base level. In radio it measures the change in **power** in terms of watts. Every time power is doubled, the decibel level goes up 3 dB. Every time power is cut in half, the decibel level does down 3dB.

T5B09 What is the approximate amount of change, measured in decibels (dB), of a power increase from 5 watts to 10 watts? Answer: **3 dB** (because power doubled = 3dB)

T5B10 What is the approximate amount of change, measured in decibels (dB), of a power decrease from 12 watts to 3 watts? Answer: -**6 dB** (because half of 12 is 6, and half of 6 is 12; power was cut in half twice so the answer is 2 x 3 dB = -6)

T5B11 What is the approximate amount of change, measured in decibels (dB), of a power increase from 20 watts to 200 watts? Answer: **10 dB**. When power doubles from 20 to 40 watts that's an increase of 3 dB. When it increases from 40 to 80 watts that's another 3 dB for a total of 6. When you double 80 watts to 160 watts you have 3 times 3 dB = 9 dB. When you double 160 watts you get 320 watts for an increase of 4 times 3 = 12 dB. But 320 is greater than 200 so the correct answer must be between 9 and 12 dB, and closer to 9. That's why 10 dB is the correct answer and 12dB is not.

Metric Units

Mega, kilo, milli *what???* Just as a refresher here's a chart of all the metric units you *could* encounter in the exam and how to do those pesky conversions. *Important Note:* the symbol for **mega** (meaning one million) is an upper case "M"; the symbol for **milli** (meaning one-thousandth) is a lower case "m".

Metric Prefix	Symbol	Multiplication Factor
giga	G	1,000,000,000
mega	M	1,000,000
kilo	k	1,000
centi	c	10
milli	m	1/1,000 (or .001)
micro	µ	1/1,000,000 (or .000001)
pico	ρ	1/1,000,000,000,000 (or .000000000001)

One **gigahertz** (GHz) is one billion (1,000,000,000) times bigger than a **Hertz**
One **megahertz** (MHz) is one million (1,000,000) times bigger than a **Hertz**
One **kilohertz** (kHz) is one thousand (1,000) times bigger than a **Hertz**

One **milliwatt** (mA) is one thousand times smaller than one **Watt**
One **microampere** (µA) is one million times smaller than one **Amp**
One **picofarad** (ρF) is one million time smaller than a microfarad (mF) and one trillion times smaller than one **Farad**

Sample Exam Questions:

T5B01 How many milliamperes is the same as 1.5 amperes? Answer: **1500 milliamperes** (1 ampere = 1000 milliamps; 1.5 x 1000 = 1500.)

T5B02 What is another way to specify a radio signal frequency of 1,500,000 hertz? Answer: **1,500 kilohertz (kHz)**. (1,000,000 Hz = 1,000 kHz = 1 MHz = .001 GHz)

T5B03 How many volts are equal to one kilovolt? Answer: **1,000 volts**

T5B04 How many volts are equal to one microvolt? Answer: **one-millionth of a volt**

T5B05 Which of the following is equivalent to 500 milliwatts? Answer: **.5 watts** (500 ÷ 1,000 = 5)

T5B06 If an ammeter calibrated in amperes is used to measure a 3000-milliampere current what reading would it show? Answer: **3 amperes**. (An ammeter is a device that measures current. If its "*calibrated"* in amperes that means its readout is given in amps. So you need to convert 3000 mA to amperes. 3000 x 1 ÷ 1,000 = 3)

T5B07 If frequency readout calibrated in megahertz shows a reading of 3.525 MHz, what would it show if it were calibrated in kilohertz? Answer: **3525 kHz** (1 MHz is 1,000 times bigger than 1 kHz; 3.525 x 1,000 = 3525)

T5B08 How many microfarads are in 1,000,000 picofarads? Answer: **1** (a microfarad is one million times bigger than a picofarad so 1,000,000 ÷ 1,000 = 1)