OH-KY-IN GENERAL CLASS EXAM NOTES (2019-2023 QUESTION POOL)

QUESTION 1 - G1A

Generals get full access to authorized frequencies (same as Extras) except on the old traditional bands of 80, 40, 20 and 15 meters. On those 4 bands, the special Extra frequencies are lower and the ones open to Generals are at the upper frequency end.

G1A01, 11

There are special limitations for 30 and 60 meters, where hams have secondary privileges – if you find you are interfering with a primary user on those bands, you must stop. In addition, phone and image transmissions are prohibited on 30 meters, and on 60 meters you must operate only on 5 specified channels.

G1A12, 13, 02, 03, 04, G1E04

There are several questions relating to specific band frequencies. Memorize the relevant portions of the chart if you prefer, but I think that it is easier just to remember the answers, which are – 3560 kHz, 3900 kHz, 7.250 MHz, 14305 kHz, 21300 kHz. Recall that you divide the frequency in MHz or the wavelength into 300 to get the other one – in case you forget these answers, some of the responses listed are not even in the right band so you can easily eliminate them if you have to guess.

G1A05, 06, 07, 08, 09

There are also two questions about the 10 meter (28 MHz) band. All 3 of the frequencies listed are valid for Generals so the answer is All of these choices are correct. The segment for repeater use is above 29.5 MHz.

G1A10, 15

The frequency allocation table that we use is valid for ITU Region 2, where the continental U.S. is located. If operating in a different ITU Region, some frequency allocations will differ.

G1A14, G1E06

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QUESTION 2 – G1B

Antenna structures more than 200 feet high, or close to an airport, require special approval. State and local governments have only limited power to regulate amateur antenna structures and must use the "minimum practical" restrictions.

G1B01, 06

Generally one-way transmission by hams (broadcasting) is not permitted. The major exceptions are the "ARRL exception" for transmitting Morse code practice, "occasional" retransmission of certain U.S. government stations, and beacons.

A beacon transmits a continuous signal for the purpose of monitoring propagation – by listening for beacons, you can find out if a band is open to the area of the beacon. Beacons are limited to 100 watts and you can only transmit one beacon per band from one location. The only HF beacons permitted by the rule are in the 10 meter band from 28.20 to 28.30 MHz.

G1B02, 03, 04, 05, 09, 10

FCC has given special approval for certain beacons to operate on HF bands at 14.100, 18.110, 21.150, 24. 930 (in addition to 28.200 which is permitted as discussed above). Hams should not operate on those frequencies.

G1E10

Hams may use Q signals or other non-secret codes but may not use codes that obscure the meaning of the message.

G1B07, G1C13

Hams should follow good practices as to all matters not specifically regulated. The FCC determines what is good practice if a question arises.

G1B11

You may communicate with any ham in any other country unless that country has notified the ITU that it objects to such communications.

G1B12

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QUESTION 3 – G1C

Generally the allowed transmission power is 1500 watts PEP – but only the minimum power needed for the communication should be used. All power limits are based on peak envelope power (PEP). Once again, there are special exceptions for 30 and 60 meters:

30 meters – 200 watts PEP
60 meters – 100 watts PEP relative to a dipole (if antenna is other than a dipole, operator must maintain a record of antenna gain). Also SSB signal width limited to 2.8 kHz.

G1C01, 02, 03, 04, 05, 06, 12, 14, 15

Spread spectrum emissions are limited to 10 watts. This includes use of modified commercial Wi-Fi equipment.

G1E08

The FCC limits how fast data can be transmitted ("symbol rate") in order to control bandwidth of emissions. The relevant limits are:

12 meters and below (i.e. below 28 MHz)	300
10 meters	1200
2 meters	19600 (19.6 kilobaud)
1.25 meters and 70 cm.	56000 (56 kilobaud)

G1C07, 08, 09, 10, 11

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QUESTION 4 – G1D

Anyone who previously held an expired General or higher license that was not revoked can get credit for elements previously passed, but must take the current Element 2 exam.

G1D01, 11

Exams are administered by at least three Volunteer Examiners (VEs), not the FCC. A VE must be accredited by a VEC (VE Coordinator), hold a General or higher class license and be at least 18 years old; there are no nationality restrictions. A General class VE may only administer Technician exams.

G1D 02, 04, 05, 07, 08, 10

After passing an exam, the applicant receives a CSCE (Certificate of Successful Completion of Examination) which is valid for 365 days. Before the new license class shows up online in the FCC database, the General class upgrade applicant may go ahead and use all of the privileges of the new class but must append /AG to his or her callsign when using General privileges.

G1D03, 06, 09

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QUESTION 5 – G1E

Generally a ham can allow an unlicensed person to speak on a radio where the licensed ham is the control operator, but not if the speaker is a former ham whose license was revoked.

G1E01

If the control operator has the proper class of license for the repeater frequency, a repeater can retransmit a signal originally transmitted on a different band by a ham not licensed for the repeater frequency.

G1E02

The limits on band segments available to automatically-controlled stations do not apply to repeaters which are retransmitting “live”, non-automated communications.

G1E03

Generally hams may retransmit messages for third parties as long as they are not of prohibited types, such as business communications. However, if the third party is in a foreign country, only messages relating to Amateur Radio or remarks of a personal character, or messages relating to emergencies or disaster relief are permitted. It does not matter if the communications are digital, the rules are the same.

G1E05, 09

Amateur stations may never communicate with unlicensed stations, such as low-power unlicensed devices including Wi-Fi routers that have not been modified for ham operations.

G1E07

The maximum bandwidth that can be used by an automatically-controlled digital station is 500 Hz.

G1E11

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QUESTION 6 – G2A

By typical practice, not mandated by FCC rule, SSB is the mode most commonly used for voice communications on all bands other than 2 meter FM repeaters. SSB has greater power efficiency and uses much less bandwidth than FM and AM because only one sideband is transmitted; the other sideband and carrier are suppressed.

Lower sideband is typically used on the lower HF bands for voice communications and upper sideband is typically used on the upper HF bands (20 meters and above) as well as VHF and UHF.

G2A01, 02, 03, 04, 05, 06, 07, 09

The proper way to ask to join a phone contact is to say your callsign once.

G2A08

VOX stands for “voice operation” and allows hands-free communications by activating the transmitter whenever you speak.

G2A10

Only stations outside the continental U.S. should respond to a station calling CQ DX from within the 48 states.

G2A11

ALC (Automatic Level Control) is a “safety valve” on SSB transmitters to prevent overmodulation and splattering signals. If it activates, turn down the transmit audio or microphone gain control.

G2A12

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QUESTION 7 – G2B

During non-emergency operations, no one has priority for use of any frequency. If a station in distress breaks in, acknowledge the call and determine what assistance is needed. There are no limits on the frequencies or modes that can be used to communicate an emergency message. However, an emergency such as RACES activation does not allow someone who is not a licensed ham to operate a ham station to assist relief operations.

G2B01, 02, 09, 10, 11

When deciding where on a band to transmit, good practice is to transmit only where your license class allows (obviously), listen before transmitting, and follow generally-accepted band plans agreed to by the amateur community – so the answer to that question is All these choices are correct.

G1B08, G2B07

Amplifying the "listen before transmitting" point, it is good practice to send QRL? on CW or to ask by voice if the frequency is in use before starting to use it. If propagation changes later and you start to hear interference on your frequency, try to work it out with the other operator.

G2B03, 06

When you hear another station and want to start operating adjacent to that other person, how much space do you leave in order to avoid overlapping signals? 150 to 500 Hz on CW, 3 kHz on SSB.

G2B04, 05

What does the voluntary band plan call for in the 50.1 to 50.125 MHz band segment? This is a "DX window" that should only be used for communications with stations outside the continental U.S.

G2B08

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QUESTION 8 – G2C

Amateurs use many Q signals and other standard codes, many of which relate to CW. Just a few of them are potentially on the exam.

QSK refers to break-in telegraphy, where the transmitter stops completely between code elements (so the sender can hear someone else transmitting during the small gaps)
QRS means “send slower”
QRL? means “is this frequency in use?”
QSL means “I acknowledge receipt” (it also refers to cards that hams exchange to confirm contacts, but that is not on the exam)
QRN means “there is static”
QRV means “I am ready to operate”
QRP means low-power transmission.

AR sent at the end of a CW transmission means that the formal message is finished
KN sent at the end of a CW transmission means that the operator wants a response only from a specific station
C added at the end of a signal (RST) report means a chirpy signal

G2C01, 02, 03, 04, 07, 08, 09, 10, 11, G2D10

What is the proper CW speed to use in answering a CQ? The highest speed that you are comfortable copying, but not higher than the speed that the CQ was sent.

G2C05

What does the term “zero beat” mean in CW operation? Matching your transmit frequency to the other party’s sending frequency.

G2C06

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QUESTION 9 – G2D

The Volunteer Monitoring Program consists of hams who have volunteered to monitor for rules violations. Its formal purpose is to encourage amateur radio operators to self-regulate and comply with the rules. Many hams involved in this program participate in hidden transmitter hunts to gain skill in direction finding used to locate violating stations.

G2D01, 02, 03

Due to the curvature of the Earth, standard maps do not show correct directions from one point to another over long distances. An azimuthal projection map is drawn differently to show directions and distances correctly.

G2D04

On HF voice bands, you signify a desire to talk to any station by calling CQ and giving your callsign, each several times, then repeat if necessary. Note this is different from situations discussed earlier, such as breaking into a conversation, where you want to keep your transmission as short as possible.

G2D05

"Long path" means that your signal goes all around the world in the opposite direction (180 degrees) from the shortest path to your target location.

G2D06

Alpha is the standard phonetic for the letter A. The correct answer is the only one that includes Alpha.

G2D07

The rules do not require keeping a detailed station log but it is normal practice to do so, to help with a reply if the FCC requests information. There are many other obvious reasons to do it, but that's the only one that could be on the exam.

G2D08

While it is polite and good practice to submit a log to the contest sponsor and to QSL any contacts that you make with stations participating in a contest, you are not required by rule to do so. Thus the answer to this question is just to identify yourself as usual.

G2D09

Lower HF bands like 160 and 80 in the summer typically have high levels of static.

G2D11

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QUESTION 10 – G2E

LSB is normally used in sending RTTY via AFSK on SSB. The standard frequency shift is 170 Hz. RTTY failure to connect can be based on having the mark and space reversed, the wrong speed (baud rate), or the wrong sideband, so the answer to that question is All these choices are correct.

G2E01, 06, 14

However, the much more common FT8 and other JT modes use USB. These modes are not for chatting - typical exchanges are limited to call signs, grid locators, and signal reports. Each station listens and transmits in predefined time slots, so time must be synchronized between the two stations within one second.

G2E05, 11, 15

PACTOR is a protocol for sending email and other large messages on HF. Only one PACTOR "conversation" can occur at a time on a frequency, no one else can break in and join. If anyone tries to call or there is other interference, it can cause frequent retries, long pauses or failure to connect, so the answer to that question is All these choices are correct. To find out if a channel is open for use, put the controller into "monitoring" mode. To connect with an open digital messaging system gateway station, transmit a connect message on the station's published frequency.

G2E02, 03, 09, 10

Band segments typically used for digital communications:
20 meters – 14.070 to 14.112 MHz – PSK31, near the bottom, 14.070
80 meters – 3570 to 3600 kHz

G2E04, 07, 08

A DE-9 (9-pin) connector is standard for an old-fashioned, non-USB serial data port.

G2E12

The hybrid system that often uses the Internet (in addition to ham radio) to transfer messages is Winlink.

G2E13

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QUESTION 11 – G3A

During periods of low solar activity (no or low sunspots), the ionosphere is not very energized and the upper HF bands like 15, 12 and 10 meters are unreliable for long-distance communication. However, 20 meters is in the sweet spot and is usually open in the daytime during all parts of the solar cycle. Propagation tends to follow a 28-day cycle due to rotation of the Sun.

G3A04, 07, 10

Higher sunspot numbers indicate greater chances of good propagation at higher frequencies.

G3A01

However, there can be too much of a good thing – a Sudden Ionospheric Disturbance, solar coronal hole or other geomagnetic storm (a temporary disturbance in the magnetosphere) can sometimes open up propagation even into the VHF range but at the same time, degrade lower HF performance. In other words, disturbances disrupt signals on lower frequencies more than higher frequencies. For example, high geomagnetic activity may spawn auroras that can reflect VHF while shutting down many HF communications.

G3A02, 06, 08, 09, 14

Particles emitted from the Sun, such as those causing the disturbances discussed in the preceding paragraph, take 20 to 40 hours to reach the Earth, but ultraviolet and X-rays travel at the speed of light and reach us in about 8 minutes.

G3A03, G3A11

Solar flux index is a measure of solar radiation at 10.7 centimeters wavelength. The A-index is the long -term stability of the Earth's geomagnetic field; the K-index is the short-term stability.

G3A05, 12, 13

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QUESTION 12 – G3B

MUF means the Maximum Usable Frequency between two points; LUF is the Lowest Usable Frequency. Many factors affect these frequencies including path location and distance, time of day and season, and solar radiation and disturbances, so the answer to that question is All these choices are correct.

G3B02, 07, 08

Radio waves are successfully propagated (bent back to the Earth) if between the LUF and the MUF. Below the LUF they are absorbed by the ionosphere. If the numbers become inverted (LUF above the MUF) then no radio frequency will support skywave transmission over that path. To determine if the MUF is high enough for what you want to do, listen for a beacon. The best propagation (least attenuation) is slightly below the MUF.

G3B03, 04, 05, 06, 11

Occasionally signals may be received by both short path and long path at the same time. Since long path has traveled farther, it is delayed and an echo may be heard.

G3B01

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QUESTION 13 – G3C

The layers of the ionosphere are labeled in alphabetical order, moving away from the Earth – D closest, then E, then F1 and F2. A hop from the E layer can cover 1200 miles on the ground, while the higher F2 layer can provide a 2500-mile hop. The longest propagation comes from the highest layer, F2. Layers reach maximum height during maximum solar intensity, when the Sun is directly overhead.

G3B09, 10, G3C01, 02, 03

The D-layer absorbs most low-HF signals during daylight – so AM broadcast band and lower ham bands like 160 and 80 are usually only available for long-distance transmission at night.

G3C05, 11

In addition to ”reflecting” the bulk of a signal back down to Earth far away, the ionosphere scatters a little of it. This results in weak, fluttering signals being received in the skip zone. They often sound distorted because energy is scattered into the skip zone through multiple paths.

G3C06, 07, 08, 09

In most situations, a radio wave must take off close to the Earth and strike the ionosphere on a relatively flat trajectory in order to be returned to Earth. The highest takeoff angle that will work at any given time is called the critical angle.

G3C04

An exception to the critical angle model is a different type of propagation called Near-Vertical Incidence Skywave (NVIS), which is short-distance propagation using high elevation angles.

G3C10

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QUESTION 14 – G4A

To tune a vacuum tube RF power amplifier, you adjust the plate tuning control to dip the plate current and then adjust the load control for maximum power output without exceeding allowable plate current.

G4A04, 08

Excessive drive applied to an RF power amplifier can cause distortion or even permanent damage to a solid-state amplifier. Automatic Level Control (ALC) is used to reduce those risks. If a transceiver's ALC system is not set properly, it can cause distortion and spurious emissions.

G4A05, 07, 14

A "notch filter" reduces interference from carriers in the receiver passband. An IF shift control is used to avoid interference from stations very close to the receive frequency. A dual VFO feature allows listening to two frequencies at once. An attenuator function is used to reduce signal overload from strong incoming signals. A noise blanker works by reducing receiver gain during a noise pulse. A noise reduction control can reduce various kinds of noise but when cranked up, can cause reception to be distorted.

G4A01, 11, 12, 13, 16, 17

Sometimes selecting the opposite or "reverse" sideband when receiving CW can reduce interference from other signals. Operating in split mode means transmitting and receiving on different frequencies.

G4A02, 03

An antenna tuner is used to match a transmitter to an antenna that does not match 50 ohms.

G4A06

A time delay is often included in a transmitter keying circuit to assure that the receive to transmit changeover is completed before high power is applied to the circuit. An electronic keyer automatically generates strings of dots and dashes to reduce the physical effort needed to send CW.

G4A09, 10

When connecting a computer to a transceiver, the cable can act as an antenna and if it picks up transmitted RF, numerous things can go wrong including the VOX circuit does not un-key the transmitter, the transmitter signal is distorted, and frequent connection timeouts. So the answer to that one is All these choices are correct.

G4A15

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QUESTION 15 – G4B

An oscilloscope is valuable since it can measure complex waveforms, including the keying waveform of a CW transmitter. An oscilloscope has horizontal and vertical channel amplifiers, the vertical input usually being attenuated RF output of the transmitter for ham radio purposes.

G4B01, 02, 03, 04

High input impedance is desirable for a voltmeter so it does not load circuits being measured. A digital voltmeter is preferable to an analog one for many uses since it has better precision. However, an analog readout is preferred over digital when adjusting tuned circuits.

G4B05, 06, 14

A field strength meter can monitor relative RF output when making antenna and transmitter adjustments. It can measure the radiation pattern of an antenna.

G4B08, 09

A directional wattmeter can determine SWR.

G4B10

An antenna analyzer can also determine SWR, when it is connected to the feed line and antenna. It can give a false reading if there are strong signals from nearby transmitters. Another antenna analyzer use is to determine the impedance of a coaxial cable.

G4B11, 12, 13

A two-tone test measures transmitter linearity. The two tones must be non-harmonically related audio signals.

G4B07, 15

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QUESTION 16 – G4C

As discussed under a previous question concerning a computer connection, any wire in the vicinity of a transmitter can act as an antenna and pick up RF; this is called common-mode current. This often happens with audio devices, which emit the sound of distorted speech if affected by an SSB transmitter and emit off and on humming or clicking when affected by CW transmission. These problems can be treated with bypass capacitors and ferrite chokes.

G4C01, 03, 04, 08

Arcing at a poor connection can cause interference on a wide range of frequencies.

G4C02

All metal enclosures of ham station equipment must be grounded to prevent hazardous voltages and should be bonded together. However, even if grounded, RF can appear on the chassis, causing burns, if the ground wire is resonant or has high impedance at the relevant frequency.

G4C05, 06, 11, 13

Ground wires should not be soldered since a solder joint is likely to be destroyed by the heat of a lightning strike.

G4C07

All grounds should be connected to a single point, not arranged in a "daisy chain" since that is likely to result in a "ground loop", which can cause hum on your station's transmitted signal.

G4C09, 10

A DSP filter is more effective than an analog filter because a wide range of filter bandwidths and shapes can be created.

G4C12

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QUESTION 17 – G4D

A speech processor increases the "punch", i.e. intelligibility, of phone transmissions under poor conditions, by increasing the average power of the signal. However, if incorrectly adjusted, it can cause distortion, splatter, and pickup of room noises so the answer to that question is All these choices are correct.

G4D01, 02, 03

An S meter in a receiver measures received signal strength. An increase of one S unit means a signal 4 times as powerful. A signal that reads 20 dB over S9 is 100 times more powerful than one at S9.

G4D04, 05, 06, 07

> Decibels (dB) are a logarithmic scale. The math can get complicated but fortunately, there are only 3 possible questions on the exam concerning dB – a decrease of 1 dB is minus 20.6%, an increase of 3 dB is double, and an increase of 20 dB is 100 times the power. That's all you need to know about dB for the exam. There is one other question about dBi being 2.15 dB lower than dBd, but you don't have to know what power ratio 2.15 dB means.

When transmitting SSB, the single sideband is either above the dial (suppressed carrier) frequency (USB) or below it (LSB). For a typical sideband that is 3 kHz wide, with a dial frequency of 7.178 MHz on LSB, the signal occupies 7.175 to 7.178 MHz. With a dial frequency of 14.347 MHz on USB, the signal occupies 14.347 to 14.350 MHz. On LSB, the dial frequency has to be at least 3 kHz above the band edge to keep the signal within the band limit. On USB, the dial frequency has to be at least 3 kHz below the band edge.

G4D08, 09, 10, 11

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QUESTION 18 – G4E

The major issue with mobile HF installations is the need to use a short antenna. Operating bandwidth of a short antenna may be very limited. A "capacitance hat" on a mobile antenna is designed to electrically lengthen a physically short antenna. A "corona ball" on a mobile antenna is designed to reduce RF voltage discharge from the tip of the antenna.

G4E01, 02, 05, 06

A 100-watt mobile transmitter must be connected directly to the battery using heavy wire. It will NOT work to run it from the auxiliary power socket (formerly known as cigarette lighter) because it is not wired to support that much current.

G4E03, 04

All kinds of vehicle electronics and electric motors can interfere with ham reception, such as the battery charging system, the fuel delivery system, and the vehicle control computer, so the answer to that question is All these choices are correct.

G4E07

The process by which sunlight is changed directly into electricity in a solar cell is photovoltaic conversion. An unloaded silicon photovoltaic cell produces about 0.5 V. A series diode is used between a solar panel and the battery that it is charging to prevent the current from flowing backwards and discharging the battery during times of low illumination.

G4E08, 09, 10

Wind is not a good primary source of power for a ham station since a large storage system is needed to supply power when the wind is not blowing.

G4E11

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QUESTION 19 – G5A

Resistance is the opposition to flow of a DC current. Reactance is the opposition to flow of an AC current caused by capacitance or inductance. Impedance is the overall opposition to flow of an AC current, consisting of the combination of resistance and reactance. These are all measured in ohms.

G5A01, 02, 03, 04, 09

Capacitors and inductors react to the frequency of the applied AC current in opposite ways. As the frequency of the AC increases, capacitive reactance decreases while inductive reactance increases.

G5A05, 06

An AC source like a ham transmitter delivers maximum power to the load when the impedance of the load equals the output impedance of the source. So if the impedances are not already equal, a matching transformer can be used to equalize them.

G5A07, 08

An LC network – one type of which is a pi-network -- and a length of transmission line can also be used to equalize impedance at radio frequencies so the answer to that question is All these choices are correct.

G5A10, 11

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QUESTION 20 – G5B

3 dB is a factor of two increase or decrease.

G5B01

In a parallel circuit, the total current equals the sum of the currents through each branch.

G5B02

A reduction of 1 dB is 20.6%.

G5B10

Remember Ohm's Law – E = IR – or -- Voltage = Current times Resistance. For the remainder of this section, I have included the questions for easy reference due to complexity of referring back and forth for these subjects.

G5B03 How many watts of electrical power are used if 400 VDC is supplied to an 800 ohm load?

400 volts DC across 800 ohms is a current of half an ampere. Wattage = Voltage times Current = 400 volts times 0.5 amps = 200 watts

G5B04 How many watts of electrical power are used by a 12 VDC light bulb that draws 0.2 amperes?

Wattage = 12 volts DC times 0.2 amperes = 2.4 watts

G5B05 How many watts are dissipated when a current of 7.0 milliamperes flows through a 1250 ohm resistance?

7 milliamps across 1250 ohms implies 8.75 volts. Wattage = 8.75 volts times .007 amps = 0.06125 watts = 61.25 milliwatts

Following is by far the most confusing section of the material. I find it easier to just recall the right answers than to remember all of the formulas and do the calculations, but I include the explanations in case they are desired.

Peak voltage is half of the peak to peak voltage shown on an oscilloscope (because peak to peak goes from the positive peak to the negative peak, and for calculations we want to take only the positive part). RMS voltage (which causes the same heating as the same DC voltage) is .707 times the peak positive voltage. Then by Ohm's Law, reduced voltage also implies reduced current over a given resistance, so the power (equal to voltage times current) is twice affected by these ratios.

G5B07

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PEP (Peak Envelope Power), however, is based on RMS not peak readings. It is also the same thing as average power for unmodulated carriers. So peak is not really peak, and peak is sometimes the same as average. Now do you see why it is easier to just learn the answers?

G5B11, 13 (#13 is a trick question – no computation involved, just recognizing that PEP equals "average power" in the circumstances given).

G5B06 What is the output PEP from a transmitter if an oscilloscope measures 200 volts peak-to-peak across a 50 ohm dummy load connected to the transmitter output?

To change peak to peak to RMS we have to divide by 2 and multiply by .707, so that is 70.7 volts RMS. 70.7 volts across 50 ohms is 1.414 amps. Wattage (PEP) = 70.7 volts times 1.414 = 100 watts

G5B08 What is the peak-to-peak voltage of a sine wave with an RMS voltage of 120.0 volts?

Here we have to reverse the process. To go from RMS up to peak we have to divide by .707, and then to get to peak to peak we have to multiply by 2, so we get 339.4.

G5B09 What is the RMS voltage of a sine wave with a value of 17 volts peak?

Here we are dealing with just the peak, rather than peak to peak, so it is just 17 volts times .707 = 12 volts

G5B12 What would be the RMS voltage across a 50 ohm dummy load dissipating 1200 watts?

So 1200 watts = volts times amps, and amps = volts divided by 50 ohms, so
1200 = volts squared divided by 50; therefore volts squared = 60000 and volts = 245

G5B14 What is the output PEP from a transmitter if an oscilloscope measures 500 volts peak-to-peak across a 50 ohm resistive load connected to the transmitter output?

500 volts peak to peak is 250 volts positive peak and 176.75 volts RMS. That voltage across 50 ohms produces 3.535 amps. Therefore wattage = 176.75 times 3.535 which is 625.

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QUESTION 21 – G5C

A transformer involves two separate windings (primary and secondary) and their mutual inductance causes current to flow in the secondary when AC is applied to the primary. The two windings can be reversed – a 4:1 step-down transformer becomes a 1:4 (input voltage multiplied by 4) if the current is applied to the secondary instead. The voltages are proportionate to the number of turns in each winding. So if the primary is 2250 turns and the secondary is only 500 turns, it is a step-down transformer that reduces the input voltage to 22% of its original value. The wire size has to be based on the current that each winding will carry – so if it is a step-up transformer, which will have higher voltage but lower current in the secondary, the wire has to be larger in the primary to carry the higher current there.

G5C01, 02, 06, 16

While voltage is proportionate to the number of turns, impedance is proportionate to the square of the number of turns. So to make a transformer that reduces 600 ohms to 4 ohms, a factor of 150, the turns ratio is the square root of that or 12.2.

G5C07

The prefix micro- means millionths, 1000 times smaller than that is nano-, and 1000 times smaller than that is pico-. So 22,000 picofarads is 22 nanofarads, and 4700 nanofarads is 4.7 microfarads.

G5C17, 18

Resistors in series are additive – just add up the resistor values, whether equal or not. As covered in G5B, the currents of the branches in a parallel circuit are additive, so the net resistance is lower than the value of any of the resistors. If there are 3 equal resistors in parallel, just divide the resistor value by 3; if the resistances are unequal, then the net value is a little less than the lowest resistor value. The easiest way to get the exact value without remembering a complex formula is to add up the currents flowing through the branches and then get the net resistance from Ohm's Law.

G5C03, 04, 05, 15

Inductors work just like resistors – additive in series, and decreasing in net value when in parallel.

G5C10, 11, 14

Capacitors are the opposite. Their values are additive when in parallel, and decreasing in net value when in series.

G5C08, 09, 12, 13

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QUESTION 22 – G6A

10.5 volts is as low as a 12-volt lead-acid battery (such as a car battery) should be discharged to avoid damaging it. An advantage of nickel-cadmium batteries is that they can provide high discharge current.

G6A01, 02

The "threshold voltage" needed to turn on a germanium diode is 0.3 volts. For a silicon diode, it is 0.7 volts.

G6A03, 05

An advantage of an electrolytic capacitor is high capacitance. However, they are polarized and reversing the polarity can cause them to short-circuit or explode (all 3 answers are correct for that question). An advantage of a ceramic capacitor is low cost.

G6A04, 13, 14

Do not use wire-wound resistors in an RF circuit; they act as inductors and produce unpredictable results. Use toroidal inductors where high inductance is needed (the other two answers to that question are also correct – it can be optimized for specific frequencies and the magnetic field is largely contained in the core). The frequency performance of a ferrite core is determined by the "mix" of materials used. A ferrite bead reduces common-mode current by creating an impedance in the current's path.

G6A06, 08, G6B01, 10

Operating an inductor above its self-resonant frequency causes it to act like a capacitor.

G6A11

When a transistor is used as a switch, operate it in the saturation or cutoff regions where the output is constant, not between those regions where the transistor acts as an amplifier. In a MOSFET type of transistor, the gate is separated from the channel by an insulating layer.

G6A07, 09

In a triode vacuum tube, the control grid is used to regulate the current through the tube. A screen grid is added to more complex tubes to reduce control grid to plate capacitance.

G6A10, 12

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QUESTION 23 – G6B

MMIC stands for Monolithic Microwave Integrated Circuit. ROM means Read-Only Memory. ROM is a type of non-volatile memory which means that it retains its stored information when the power is removed.

G6B02, 04, 05

An advantage of CMOS over TTL integrated circuits is low power consumption.

G6B03

An Op Amp – integrated circuit operational amplifier, is an analog device.

G6B06

An LED is forward-biased when emitting light.

G6B08

A liquid crystal display requires ambient or back lighting.

G6B09

A type N connector is moisture-resistant and useful to 10 GHz. An SMA connector is a small threaded connector useful to several GHz. RCA phono connectors are used for audio. PL-259 connectors are commonly used for RF up to 150 MHz.

G6B07, 11, 12, 13

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QUESTION 24 – G7A

A full-wave rectifier converts the entire 360 degrees of the AC cycle and uses TWO diodes to do that. Its output is a series of pulses at twice the input frequency.

G7A03, 06, 07

A half-wave rectifier, as the name says, only converts half of the wave (180 degrees) and only requires ONE diode.

G7A04, 05

Capacitors and inductors are used in a power supply filter network. A power supply bleeder resistor discharges filter capacitors when power is removed, for safety.

G7A01, 02

A switchmode power supply operates at high frequency and allows use of smaller components.

G7A08

#1 is a field-effect transistor. #2 is a regular transistor (the triangle pointing away makes it NPN). #5 is a Zener diode (used for voltage regulation). #6 is a transformer. #7 is a tapped inductor.

G7A09, 10, 11, 12, 13

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QUESTION 25 – G7B

An oscillator is an amplifier operating in a feedback loop. The frequency of a standard LC oscillator is determined by the inductance and capacitance in the feedback loop ("tank circuit"). A regular amplifier is neutralized to prevent self-oscillation.

G7B01, 07

A Class C amplifier is the most efficient type, but it is NOT linear, i.e., it does not accurately reproduce the input waveform. Because it is not linear, it can only be used with modes like FM that are not sensitive to distortion.

G7B02, 10, 11

Efficiency of an amplifier means the percentage of DC input power that is converted to RF output; i.e. the RF output divided by the DC input.

G7B08

A binary bit has two states so a 3-bit counter has 8 possibilities (2 x 2 x 2).

G7B05

An AND gate output is high only if the first input AND the second input are high.

G7B03

An OR gate output is high only if either the first input OR the second input is high. A NOR gate (logical NOT-OR) reverses the output so it is low if either input is high.

G7B04

A shift register is an array that passes data in steps along the array.

G7B06

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QUESTION 26 – G7C

Single sideband transmissions are generated by a balanced modulator and filter. To receive SSB, receivers use a product detector.

G7C01, 02, 04

The detector circuit in an FM receiver is called a discriminator.

G7C08

The simplest combination of stages that implement a superheterodyne receiver is HF oscillator, mixer, detector. Note that mixer comes after oscillator, for the answer to a different question.

G7C03, 07

As an alternative to a traditional LC oscillator, modern radios use a direct digital synthesizer, because it provides a variable frequency with very high stability like a crystal-controlled oscillator.

G7C05, 16

A filter's passband is measured by its upper and lower half-power points. This upper point is called the cutoff frequency. The filter's maximum ability to reject signals outside its passband is called ultimate rejection. The filter's attenuation inside its passband is called insertion loss. To minimize insertion loss, the filter's impedance should be the same as that of the transmission line in which it is inserted.

G7C06, 12, 13, 14, 15

A software-defined radio uses software, rather than electronic components, to perform major signal processing functions. The I and Q signals generated by an SDR are 90 degrees out of phase, and can be used for all types of modulation with appropriate processing.

G7C09, 10, 11

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QUESTION 27 – G8A

The process of encoding information on a signal is “modulation”. Amplitude modulation varies the amplitude (instantaneous power level); frequency modulation varies the instantaneous frequency; phase modulation varies the phase; and single sideband uses only one sideband so it is the narrowest phone mode.

G8A02, 03, 05, 07

Frequency shift keying (FSK) uses direct digital control over the oscillator. A “modulation envelope” is a “waveform”, and “reactance modulator” goes with “phase modulation”.

G8A01, 04, 11

FT8 digital mode uses 8-tone frequency shift keying and can receive signals with very low signal to noise ratios.

G8A09, 12

Characteristics of QPSK31 include that the bandwidth is approximately the same as BPSK31, it is sideband-sensitive, and it has limited error correction capability, so the answer to that question is All these choices are correct.

G8A06

If you send too much audio power to the modulator, the resulting signal will be distorted and will “splatter”, covering excessive bandwidth; if you look at an overdriven SSB signal on an oscilloscope, it will show “flat topping”.

G8A08, 10

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QUESTION 28 – G8B

The process of combining two RF signals having different frequencies to produce a desired result is known as “mixing” or “heterodyning”. Accidental combining of two frequencies to produce an unwanted spurious output is “intermodulation”.

G8B03, 12

Mixing two RF signals results in two new RF signals, one at a frequency equal to the sum of the original two, and one equal to the difference. For example, mixing a 10 MHz signal and a 2 MHz signal results in 12 MHz (the sum) and 8 MHz (the difference). Conventional receivers generate a “local oscillator” signal which is mixed with the incoming signal in order to produce a difference signal at a specific intermediate frequency (IF) that the receiver is designed to handle. This is called a “superheterodyne” receiver. However, there is another incoming signal frequency which, when mixed with the same VFO signal, will also produce an (undesired) output at the same IF frequency – this is called an “image response”.

G8B01, 02, 11

“Bandwidth” is the width of the modulated signal (the number of kHz that the signal occupies), and faster transmission (higher symbol rate) requires more bandwidth. The bandwidth of a PACTOR3 signal at maximum data rate is 2300 Hz. For FM, the bandwidth equals two times the “deviation” (the standard frequency variation for the mode) plus two times the modulating audio frequency (the numbers are doubled because modulation occurs in both sidebands).

G8B05, 06, 10

For technical reasons, it is often better to generate VHF FM signals at relatively low frequencies and then use a multiplier circuit to increase the frequency up to the desired band. A multiple of a given frequency is called a “harmonic”. In using a multiplier to generate a desired harmonic, the “deviation” (discussed above) is also multiplied.

G8B04, 07 (the answer is 1/12 of 5 kHz since this is a 12-times multiplier). It may be easier to just remember the answer than to worry about completely understanding the process.

The receiver should be set to match the bandwidth of the signal being received, improving the signal to noise ratio.

G8B09

Duty cycle is the average percentage of the maximum RF output that is actually going out over a period of time. It’s important to know because some modes have high duty cycles that could exceed the transmitter’s average power rating.

G8B08

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QUESTION 29 – G8C

Amateurs share channels with the unlicensed Wi-Fi service on the 2.4 GHz band (but are not allowed to communicate on the air with those unlicensed devices).

G8C01

The digital mode used for beacons is WSPR.

G8C02

A bit is a single binary digit that can have the value of 0 or 1, and when transmitted by radio using Frequency Shift Keying, where one frequency represents a 0 and another frequency represents a 1, they are called mark and space. RTTY uses Baudot code, with 5 of those data bits plus start and stop bits.

G8C04, 11

PSK31 was once a very important protocol. The 31 stands for the transmitted symbol (baud) rate that it uses. PSK 31 uses "Varicode" which represents different characters with varying numbers of bits, with more common characters using fewer bits, making it more efficient than having a fixed number of bits per character like RTTY. Conversely, less common characters such as capital letters use more bits in Varicode and slow down the transmission.

G8C02, 08, 09, 12

Other data protocols use packets (like Ethernet or the Internet in the computer world). The header of a data packet contains routing and handling information. Like in a computer network, a radio-based packet network evaluates each received packet and if an error is detected, it requests retransmission.

G8C03, 05, 07,

Too many packet transmission errors cause the connection to be dropped. Some more sophisticated protocols like FT8 transmit redundant data which allow the receiver to correct some erroneous data packets without requesting retransmission; this is called forward error correction (FEC).

G8C06, 10

Digital software often uses a waterfall display to show band activity. The vertical axis on a waterfall is time – the most recent data appears at the top of the display and then falls toward the bottom with time. A waterfall clearly shows which signals are "clean" and which are distorted due to overmodulation, often with vertical lines beside the digital signal.

G8C13, 14

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QUESTION 30 – G9A

Each type of feed line has a "characteristic impedance" that depends on its construction. The two main types of feed line are two parallel conductors (like "ladder line" or old-fashioned TV twin-lead), and coaxial (a center conductor surrounded by insulation and the other conductor in the form of a metallic wrap or braid). The characteristic impedance of a parallel feed line is determined by the size (radius) of the conductors and the distance between them. The type of "window line" typically used by amateurs has a characteristic impedance of 450 ohms. Amateurs often use coaxial feedlines with impedances of 50 and 75 ohms (modern transceivers usually have 50-ohm outputs that need to be matched).

G9A01, 02, 03

An impedance mismatch will cause a portion of the transmitted power to be reflected back by the antenna.

G9A04

The amount of reflection is measured by the "standing wave ratio" (SWR). Just pretend, whenever you see SWR, that it said "impedance mismatch ratio" instead. Then it becomes very simple arithmetic. For example, where there is a 50 to 200 ohm mismatch, 200 is equal to 4 times 50, so the SWR is 4:1. It does not matter what order in which the numbers appear in the question, the larger number always goes first in the answer followed by :1 – so it's always 4:1, never 1:4. And, a perfect impedance match (1:1 SWR) prevents standing waves.

G9A07, 09, 10, 11

If a matching network (antenna tuner) is used so that a 5:1 SWR feed line - antenna system measures 1:1 at the radio, the SWR on the feed line remains at 5:1.

G9A08

Transmission lines always have losses (attenuation) and waste some of the power sent through them. This loss is usually stated as Decibels per 100 feet. Losses increase as frequency increases. If a transmission line is lossy, a high SWR will increase the loss. High transmission line losses also cause false SWR readings at the input to the line – SWR will read artificially low.

G9A05, 06, 12, 13

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QUESTION 31 – G9B

Why bother with a feedline? Why not just connect a wire to the transmitter and run it out a window? The part of the antenna inside the station would induce heavy RF currents in all of the nearby metal and cause RF burns.

G9B01

The natural impedance of a quarter wave vertical antenna is higher than the desired 50 ohms. To adjust it to be closer to 50 ohms, slope the radials downward. If the antenna is mounted on the ground, the radials can't be sloped but should be placed on the ground or buried a few inches.

G9B02, 06

The impedance of a half-wave dipole decreases as the antenna is lowered below ¼ wave above ground. Its impedance increases as the feed point is moved from the center toward an end.

G9B07, 08

The radiation pattern of a vertical antenna is omnidirectional. The theoretical ("free space") radiation pattern of a dipole antenna is a figure 8 at right angles to the antenna. However, if the antenna is less than ½ wavelength above the ground, the pattern becomes almost omnidirectional.

G9B03, 04, 05

An advantage of a horizontally-polarized HF antenna over vertical polarization is lower ground reflection losses.

G9B09

A meter is about 3.3 feet.

How long is a half-wave dipole cut for 14.25 MHz? That's the 20 meter band, half of 20 is 10, and 10 meters is about 33 feet (the answer is 32 since resonant antennas are a little shorter than the basic length calculation indicates). G9B10

How long is a half-wave dipole cut for 3.55 MHz? That's the 80 meter band, half of 80 is 40, and 40 meters is about 132 feet (the answer is 131). G9B11

How long is a quarter-wave vertical cut for 28.5 MHz? That's the 10 meter band, a quarter of 10 is 2.5, and 2.5 meters is about 9 feet (the answer is 8). G9B12

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QUESTION 32 – G9C

A Yagi antenna looks like the kind of TV antennas that people used to have on their roofs, with the longest "reflector" elements in the back, the medium-sized "driven" element (connected to the feedline) in the middle, and the shorter "director" elements in front. The driven element is about one-half wavelength.

G9C02, 03

Larger-diameter elements increase the bandwidth of the antenna. Making the boom longer and adding more directors increases the antenna gain. Front to back ratio means the power radiated in the forward direction (the "main lobe") compared to that in the opposite direction (off the back of the antenna).

G9C01, 05, 07, 08

Stacking two Yagi antennas increases the gain by 3 dB (as in prior sections, 3 db represents double the power). It does that by narrowing the main lobe in elevation. Gain can also be optimized by adjusting the length of the boom, the number or spacing of elements along the boom (answer is All these choices are correct).

G9C09, 10, G9D05

A beta or hairpin match is a shorted transmission line placed at the feed point of a Yagi antenna to provide impedance matching. An advantage of using a gamma match instead is that it does not require that the driven element be insulated from the boom.

G9C12, 16

Each element of a quad antenna, rather than being a single straight piece, is a square. In the driven element, each side of the square is ¼ wavelength and the reflector element is about 5% larger. A two-element quad has about the same forward gain as a three-element Yagi.

G9C06, 13, 14

dBi refers to a theoretical isotropic antenna which radiates equally in all directions (and therefore has no gain in any direction). dBd is the gain of a dipole antenna, which is 2.15 dB higher than dBi.

G9C04, 15

Using a directional antenna can help to reduce interference.

G9C11

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QUESTION 33 – G9D

A good antenna for NVIS is a dipole between 1/10 and ¼ wavelength above ground.

G9D01

End-fed half-wave antennas are generally not used because they have very high feel point impedance.

G9D02

A portable VHF/UHF “halo” antenna has maximum radiation in the plane of the halo.

G9D03

Antenna traps can permit an antenna to operate on multiple bands. However, a multi-band antenna is susceptible to radiating harmonics (poor harmonic rejection).

G9D04, 11

A log periodic antenna is similar to a Yagi but the element length and spacing is varied along the boom in a logarithmic pattern. This provides wider bandwidth.

G9D06, 07

The impedance of a “screwdriver” mobile antenna is adjusted by varying the base loading inductance.

G9D08

A Beverage antenna is for receiving only on low HF bands.

G9D09

An electrically small loop has nulls broadside to the loop. A large, horizontal loop antenna is omnidirectional.

G9D10, 13

A dipole with a single center support is called an inverted V.

G9D12

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QUESTION 34 – G0A

An RF signal, if strong enough, can heat human tissue and possibly cause other damage (think: microwave oven). The risk varies by RF frequency as well as power level and "duty cycle". Duty cycle is the percentage of power that your station is actually emitting, averaged over a period of time ("time averaging"), compared to a constant 100% transmission at that power level. Most amateur radio emissions have duty cycles far less than 100% -- for example, in a typical CW conversation, you are sending only about half of the time (and listening to the other ham sending the rest of the time) so the duty cycle is automatically 50% or less, and even while you are sending, the key is down only part of the time, so the overall duty cycle might be only 30 or 40%. Power density at the place where a person is located is also affected by the type of antenna and how close you are to it – you don't want to stand right in front of a directional antenna operating at high power. So the answer to that question about maximum exposure is All these choices are correct.

G0A01, 02, 04, 07

Do you have to do anything to be sure your station is not exceeding recommended RF exposure levels? Not in most cases. However, if your output power exceeds a certain level for each frequency that is published in an FCC chart (in Section 97.13 of the amateur radio rules), you have to evaluate the exposure you are causing. That evaluation can be a calculation based on an FCC method or using a website, or you can measure your emissions with a field strength meter (so the answer to that question about evaluation methods is All these choices are correct). If you are one of the few whose calculated or measured levels exceed the guidelines, you have to take common-sense measures to reduce human exposure – such as keeping people farther away from your antenna, or making sure that you don't point a directional antenna at a neighbor's house.

G0A03, 05, 08, 09, 10, 11

Touching a bare metal antenna while it is transmitting can cause a nasty RF burn – or a fall if someone is climbing a ladder or tower at the time. Avoid this by setting up ground-mounted antennas with protection against unauthorized access.

G0A06

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QUESTION 35 – G0B

The National Electrical Code governs electrical safety (in the shack and everywhere else).

G0B06

Wires are sized by gauge (AWG). Smaller gauge numbers denote larger wires. Residential wall outlets are usually on 15 amp. circuits which require 14 gauge wire – or 20 amp. circuits which require 12 gauge wiring. The correct answers have to be 15 or 20 amps. or #12 or #14 wire. If you know that, you will get these questions right even if you forget which of the two wire sizes goes with which amperage.

G0B02, 03

In addition to the wires that carry the current, heavy-duty electrical wiring always includes a ground wire. The ground wire must be present at all times for safety, so no fuse is ever placed in a ground wire (if the fuse blew, it would disconnect the ground wire). The ground wire should never carry any current and if any current leaks to the ground wire, it is called a "ground fault" and triggers any GFCI (ground fault circuit interrupter) that is in place.

G0B01, 05

All ground connections must be tied ("bonded") together – this includes lightning safety grounds on antenna lines. Also, metal equipment cases often contain "interlocks" which automatically disconnect the power to the equipment when the case is opened, for safety.

G0B11, 12

Hams often use emergency generators to power their equipment, or even their entire houses. And every year people die from carbon monoxide poisoning due to improper use of generators – which must be in a well-ventilated area. If you use a generator to power your entire house, using your house wiring and not just plugging something directly into the generator, you must disconnect the house wiring from the incoming utility power feed so you don't send power back into the grid and kill a neighbor or utility worker.

G0B04, 09, 13

Soldering is an effective way of permanently joining two wires, but a danger from lead-tin solder is that the lead can contaminate food.

G0B10

Anyone climbing a tower must use a safety harness with the right specs. for years in service and your weight; and be sure to lock out and tag all circuits that supply power to the tower. When working on an antenna, on a tower or not, turn off the transmitter and disconnect the feed line.

G0B07, 08, 14

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