This supplement to your study for the General class (Element 3) exam contains each question from the General (Element 3) Question Pool (ARRL, 2015) that requires mathematics to answer. The references that were used in the development of this supplement are listed below.[1]

Table of Contents

Table of Metric Multiplication Factors

Multiplication Factor	Prefix	Symbol
1,000,000,000 = 10^{9}	giga	G
1,000,000 = 10^{6}	mega	M
1,000 = 10^{3}	kilo	k
100 = 10^{2}	hecto	h
1		
0.01 = 10^{-2}	centi	c
0.001 = 10^{-3}	milli	m
0.000001 = 10^{-6}	micro	µ
0.000000001 = 10^{-9}	nano	η
0.000000000001 = 10^{-12}	pico	p

References

Silver N0AX, W. (2015). *The ARRL General Class License Manual for Ham Radio.* (M. Wilson K1RO, Ed.) Newington, CT: The National Association for Amateur Radio.

[1] Developed by Jamie Wright, W4ABE, If you have questions or find errors please contact me at (W4ABE@arrl.net)

Section G5: Electrical Principles

G5B03: How many watts of electrical power are used if 400 VDC is supplied to an 800 ohm load? (p. 4-2)

$$P = \frac{E^2}{R} = \frac{(400\ V)^2}{800\ \Omega} = 200\ W$$

where: P = power in Watts
E = voltage in volts
R = resistance in ohms

G5B04: How many watts of electrical power are used by a 12 VDC light bulb that draws 0.2 amperes? (p. 4-2)

$$P = E \times I = (12\ V) \times (0.2\ A) = \ 2.4\ W$$

where: P = power in Watts
E = voltage in volts
I = current in amperes

G5B05: How many watts are dissipated when a current of 7.0 milliamperes flows through 1.25 kilohms resistance? (p. 4-2)

$$P = \ I^2 \ \times R = (0.007)^2 \ \times 1250\ \Omega = \ 0.06125\ W = 61.25\ mW$$

where: P = power in Watts
R = resistance in ohms
I = current in amperes

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? (p. 4-6)

$$PEP = \frac{\left[\frac{0.707 \times V_{P-P}}{2}\right]^2}{R} = \frac{\left[\frac{0.707 \times 200\ V}{2}\right]^2}{50\ \Omega} = \frac{4999\ V}{50\ \Omega} = 100\ W$$

where: V_{P-P} = peak-to-peak voltage in volts
R = resistance in ohms
PEP = peak envelope power in Watts

G5B09: What is the RMS voltage of a sine wave with a value of 17 volts peak? (p. 4-6)

$$V_{RMS} = 0.707 \times V_{PK} = (0.707) \times 17\ V = 12\ V$$

where: V_{PK} = peak voltage in volts
V_{RMS} = root mean square voltage in volts

G5B12: What would be the RMS voltage across a 50 ohm dummy load dissipating 1200 watts? (p. 4-6)

$$V_{RMS} = \sqrt{PEP \times R} = \sqrt{1200\ W \times 50\ \Omega} = 247\ V$$

where: R = resistance in ohms
V_{RMS} = root mean square voltage in volts
PEP = peak envelope power in Watts

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? (p. 4-6)

$$PEP = \frac{\left[\frac{0.707 \times V_{P-P}}{2}\right]^2}{R} = \frac{\left[\frac{0.707 \times 500\ V}{2}\right]^2}{50\ \Omega} = \frac{31241\ V}{50\ \Omega} = 625\ W$$

where: V_{P-P} = peak-to-peak voltage in volts
R = resistance in ohms
PEP = peak envelope power in Watts

G5C04: What is the total resistance of three 100 ohm resistors in parallel? (p. 4-14)

$$R_{EQU} = R_1 + R_2 + R_3 = 100 + 100 + 100 = 300\ \Omega$$

where: R = resistance in ohms

G5C05: If three equal value resistors in series produce 450 ohms, what is the value of each resistor? (p. 4-15)

$$R_{EQU} = R_1 + R_2 + R_3 = 3R = 450\ \Omega$$

$$R_{EQU} = \frac{450\ \Omega}{3} = 150\ \Omega$$

where: R = resistance in ohms

G5C06: What is the RMS voltage across a 500-turn secondary winding in a transformer if the 2250-turn primary is connected to 120 VAC? (p. 4-16)

$$E_S = E_P \frac{N_S}{N_P} = 120\ V \frac{500}{2250} = 26.7\ V$$

where: E_S = secondary voltage in volts
E_P = primary voltage in volts
N_S = turns in the secondary winding
N_P = turns in the primary winding

G5C07: What is the turns ratio of a transformer used to match an audio amplifier having 600 ohm output impedance to a speaker having 4 ohm impedance? (p. 4-19)

$$\frac{N_P}{N_S} = \sqrt{\frac{Z_P}{Z_S}} = \sqrt{\frac{600\ \Omega}{4\ \Omega}} = 12.25$$

where: Z_S = secondary impedance in ohms
Z_P = primary impedance in ohms
N_S = turns in the secondary winding
N_P = turns in the primary winding

G5C08: What is the equivalent capacitance of two 5.0 nanofarad capacitors and one 750 picofarad capacitor connected in parallel? (p. 4-15)

Note: convert capacitance to equivalent units (e.g., picofarads)

$$C_{EQU} = C_1 + C_2 + C_3 = 5000\ pF + 5000\ pF + 750\ pF = 10.75\ \eta F$$

where: C = capacitance in picofarad and nanofarads

G5C09: What is the capacitance of three 100 microfarad capacitors connected in series? (p. 4-14)

$$C_{EQU} = \frac{1}{\frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3}} = \frac{1}{\frac{1}{100\ mF} + \frac{1}{100\ mF} + \frac{1}{100\ mF}} = 33.3\ mF$$

where: C = capacitance in microfarads

G5C10: What is the inductance of three 10 millihenry inductors connected in parallel? (p. 4-14)

$$L_{EQU} = \frac{1}{\frac{1}{L_1} + \frac{1}{L_2} + \frac{1}{L_3}} = \frac{1}{\frac{1}{10\ mH} + \frac{1}{10\ mH} + \frac{1}{10\ mH}} = 3.3\ mH$$

where: L = inductance in millihenry

G5C11: What is the inductance of a 20 millihenry inductor connected in series with a 50 millihenry inductor? (p. 4-14)

$$L_{EQU} = L_1 + L_2 = 20\ mH + 50\ mH = 70\ mH$$

where: L = inductance in millihenry

G5C12: What is the capacitance of a 20 microfarad capacitor connected in series with a 50 microfarad capacitor? (p. 4-14)

$$C_{EQU} = \frac{C_1 \times C_2}{C_1 + C_2} = \frac{20\ \mu F \times 50\ \mu F}{20\ \mu F + 50\ \mu F} = \frac{1000}{70} = 14.29\ \mu F$$

where: C = capacitance in microfarad

G5C15: What is the total resistance of a 10 ohm, a 20 ohm, and a 50 ohm resistor connected in parallel? (p. 4-14)

$$R_{EQU} = \frac{1}{\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}} = \frac{1}{\frac{1}{10\ \Omega} + \frac{1}{20\ \Omega} + \frac{1}{50\ \Omega}} = 5.9\ \Omega$$

where: R = resistance in ohms

Section G8: Signals and Emissions

G8B06: What is the total bandwidth of an FM phone transmission having 5 kHz deviation and 3 kHz modulating frequency? (p. 5-9)

$$BW = 2 \times (f_{PD} + f) = 2 \times (5\ kHz + 3\ kHz) = 16\ kHz$$

where: BW = bandwidth in kHz
f_{PD} = peak deviation of the frequency in kHz
f = modulating frequency in kHz

G8B07: What is the frequency deviation for a 12.21 MHz reactance modulated oscillator in a 5 kHz deviation, 146.52 MHz FM phone transmitter? (p. 5-9)

$$f_D = \frac{f_{TD}}{\frac{f}{f_o}} = \frac{5000\ Hz}{\frac{146.52\ MHz}{12.21\ MHz}} = 416.7\ Hz$$

where: f_D = deviation of the frequency in Hz
f_{TD} = FM phone transmitter deviation in Hz
f = frequency of phone transmitter in MHz
f_o = frequency of the modulated oscillator in MHz

Section G9: Antennas and Feed Lines

> ***Note:*** *The SWR is always greater than or equal to 1:1. The equation is arranged with the higher impedance being divided by the lesser. (Questions: G9A09 – G9A13)*

G9A09: What standing wave ratio will result when connecting a 50 ohm feed line to a non-reactive load having 200 ohm impedance? (p. 7-18)

$$SWR = \frac{Antenna\ feedpoint\ impedance}{Feed\ line\ impedance} = \frac{200\ \Omega}{50\ \Omega} = \frac{4}{1} = 4{:}1$$

G9A10: What standing wave ratio will result when connecting a 50 ohm feed line to a non-reactive load having 10 ohm impedance? (p. 7-18)

$$SWR = \frac{Feed\ line\ impedance}{Anenna\ feedpoint\ impedance} = \frac{50\ \Omega}{10\ \Omega} = \frac{5}{1} = 5{:}1$$

G9A11: What standing wave ratio will result when connecting a 50 ohm feed line to a non-reactive load having 50 ohm impedance? (p. 7-18)

$$SWR = \frac{Feed\ line\ impedance}{Anenna\ feedpoint\ impedance} = \frac{50\ \Omega}{50\ \Omega} = \frac{1}{1} = 1{:}1$$

G9A12: What standing wave ratio will result when connecting a 50 ohm feed line to a non-reactive load having 25 ohm impedance? (p. 7-18)

$$SWR = \frac{Feed\ line\ impedance}{Anenna\ feedpoint\ impedance} = \frac{50\ \Omega}{25\ \Omega} = \frac{2}{1} = 2{:}1$$

G9A13: What standing wave ratio will result when connecting a 50 ohm feed line to an antenna that has a purely resistive 300 ohm feed point impedance? (p. 7-18)

$$SWR = \frac{Antenna\ feedpoint\ impedance}{Feed\ line\ impedance} = \frac{300\ \Omega}{50\ \Omega} = \frac{6}{1} = 6{:}1$$

G9B10: What is the approximate length for a 1/2 wave dipole antenna cut for 14.250 MHz? (p. 7-3)

$$free\ space\ length = \frac{C}{f} = \frac{492}{14.250\ MHz} = 34.5\ ft$$

where: f = frequency in MHz for which the dipole is cut
C = constant, which is 492 for ½ wave dipole antenna

G9B11: What is the approximate length for a 1/2 wave dipole antenna cut for 3.550 MHz? (p. 7-3)

$$free\ space\ length = \frac{C}{f} = \frac{492}{3.550\ MHz} = 139\ ft$$

where: f = frequency in MHz for which the dipole is cut
C = constant, which is 492 for ½ wave dipole antenna

G9B12: What is the approximate length for a 1/4 wave vertical antenna cut for 28.5 MHz? (p. 7-3)

$$free\ space\ length = \frac{C}{f} = \frac{246}{28.5\ MHz} = 8.6\ ft$$

where: f = frequency in MHz for which the dipole is cut
C = constant, which is 246 for ¼ wave dipole antenna